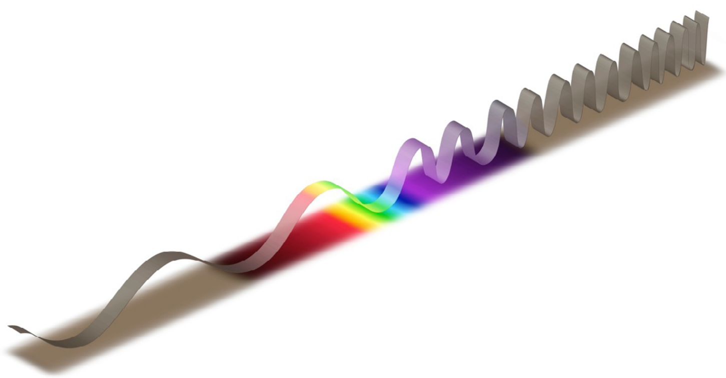
Cambridge Assessment International Education

# Example Candidate Responses – Paper 4

## Cambridge IGCSE™ / IGCSE (9-1)
## Physics 0625 / 0972

For examination from 2021



Cambridge Pathway

# Contents

# Introduction

The main aim of this booklet is to exemplify standards for those teaching Cambridge IGCSE™ / IGCSE (9-1) Physics 0625 / 0972, and to show how different levels of candidates' performance (high, middle and low) relate to the subject's curriculum and assessment objectives.

In this booklet, candidate responses have been chosen from the June 2021 series to exemplify a range of answers.

For each question, the response is annotated with a clear explanation of where and why marks were awarded or omitted. This is followed by examiner comments on how the answer could have been improved. In this way, it is possible for you to understand what candidates have done to gain their marks and what they could do to improve their answers. There is also a list of common mistakes candidates made in their answers for each question.

This document provides illustrative examples of candidate work with examiner commentary. These help teachers to assess the standard required to achieve marks beyond the guidance of the mark scheme. Therefore, in some circumstances, such as where exact answers are required, there will not be much comment

The questions and mark schemes used here are available to download from the School Support Hub. These files are:

**0625 June 2021 Question Paper 41**

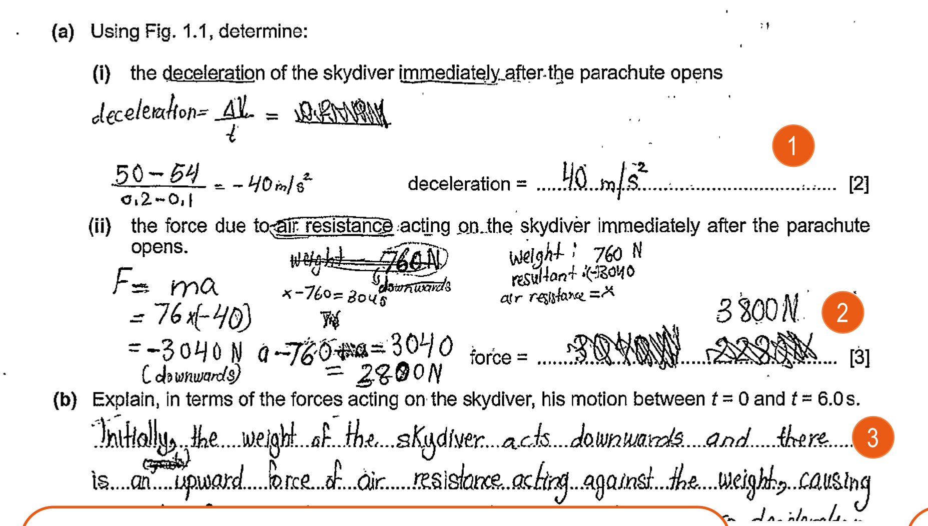
**0625 June 2021 Mark Scheme 41**

Past exam resources and other teaching and learning resources are available on the School Support Hub:

www.cambridgeinternational.org/support

## How to use this booklet

This booklet goes through the paper one question at a time, showing you the high-, middle- and low-level response for each question. The candidate answers are set in a table. In the left-hand column are the candidate answers, and in the right-hand column are the examiner comments.

| Example Candidate Response – high | Examiner comments |
|---|---|
|  | 1 The candidate selects two points close to the starting time and calculates the gradient using the coordinates of these points. The gradient is equal to the deceleration, and this gives an answer within the acceptable range.<br>Mark for (a)(i) = 2 out of 2<br><br>2 The candidate obtains the correct numerical answer.<br>Mark for (a)(ii) = 3 out of 3<br><br>3 The candidate makes two |

(a) Using Fig. 1.1, determine:

(i) the deceleration of the skydiver immediately after the parachute opens

deceleration $= \frac{\Delta V}{t}$ =

$\frac{50-54}{0.2-0.1} = -40\,m/s^2$ deceleration = 40 $m/s^{-2}$ [2]

(ii) the force due to air resistance acting on the skydiver immediately after the parachute opens.

$F = ma$
$= 76 \times (-40)$
$= -3040$ N (downwards)
weight – 760 N downwards
$x - 760 = 3040$
$a - 760 = 3040$
$= 2800$ N
weight: 760 N
resultant: 3040
air resistance = x
3800 N
force = [3]

(b) Explain, in terms of the forces acting on the skydiver, his motion between $t$ = 0 and $t$ = 6.0 s.

Initially, the weight of the skydiver acts downwards and there is an upward force of air resistance acting against the weight, causing

**Answers** are by real candidates in exam conditions. These show you the types of answers for each level. Discuss and analyse the answers with your learners in the classroom to improve their skills.

**Examiner comments** are alongside the answers. These explain where and why marks were awarded. This helps you to interpret the standard of Cambridge exams so you can help your learners to refine their exam technique.

## How the candidate could have improved their answer

- **(a)(i)** Had the candidate drawn a tangent to the very start of the curve, this would have enabled the gradient to be calculated using a larger triangle. This would have been even more likely to produce an answer within the acceptable range.
- **(a)(ii)** The working out was not well set out but since the arithmetic was correct, it was possible to see that the correct method was used.
- **(b)** The question concerned the motion of the skydiver and the candidate made reference to the initial deceleration but did not explain why there was a deceleration in the fi… …ed out that the initial air resistance, which is acting upwards…
- **(c)** The candidate referred to the situation where termin… …at zero velocity, there would be no air resistance, so the w… …be maintained.

This section explains how the candidate could have improved each answer. This helps you to interpret the standard of Cambridge exams and helps your learners to refine their exam technique.

## Common mistakes candidates made in this question

- **(a)(i)** Many candidates calculated a deceleration of some sort, gave an expression for acceleration or drew a tangent to the curve, but a very common mistake was to calculate a deceleration that was an average for an extended period rather than an instantaneous value at $t$=0.
- **(a)(ii)** The resultant force on the skydiver was very commonly calculated, but much less often was the force due to air resistance supplied; the effect of the weight of the sk… …d.
- ( … …why the … …kydiver …

Often candidates were not awarded marks because they misread or misinterpreted the questions.

Lists the common mistakes candidates made in answering each question. This will help your learners to avoid these mistakes and give them the best chance of achieving the available marks.

# Question 1

## Example Candidate Response – high

1 A skydiver of mass 76 kg is falling vertically in still air. At time $t = 0$, the skydiver opens his parachute.

Fig. 1.1 is the speed–time graph for the skydiver from $t = 0$.

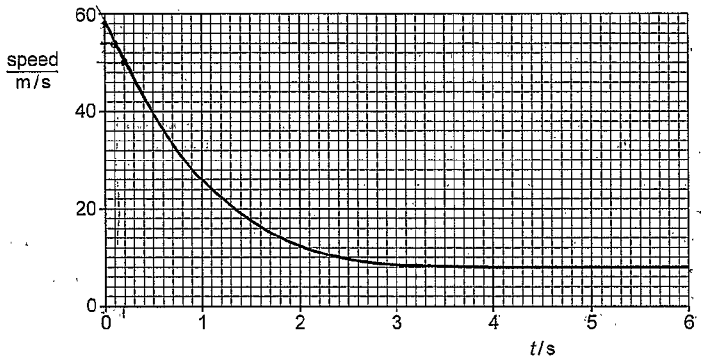



**Fig. 1.1**

**(a)** Using Fig. 1.1, determine:

(i) the deceleration of the skydiver immediately after the parachute opens

deceleration = $\frac{\Delta V}{t}$ = ~~[crossed out]~~

$\frac{50-54}{0.2-0.1} = -40\ m/s^2$

deceleration = ......40 $m/s^{-2}$...... [2]

(ii) the force due to air resistance acting on the skydiver immediately after the parachute opens.

~~weight = 760 N~~ (downwards)

weight : 760 N
resultant : (-)3040
air resistance = x

$F = ma$
$= 76 \times (-40)$
$= -3040$ N (downwards)

$x - 760 = 3040$
~~a - 760 = 3040~~
= 2800 N

force = ...~~3040N~~ ~~2280N~~ 3800 N... [3]

**(b)** Explain, in terms of the forces acting on the skydiver, his motion between $t = 0$ and $t = 6.0$ s.

Initially, the weight of the skydiver acts downwards and there is an (opposite) upward force of air resistance acting against the weight, causing deceleration. As speed decreases, air resistance also decreases, so deceleration is (decreasing) non-uniformly. At the 3rd second, air resistance = weight so there is no resultant force and the person reaches terminal velocity. [3]

**(c)** Explain why opening the parachute cannot reduce the speed of the skydiver to zero.

~~The force due to gravity of the body (weight) continues~~

As speed decreases, so does the air resistance, so it is not possible to decrease the speed to zero yet still have air resistance acting. ~~(The weight of the skydiver also continues to act downwards)~~ Terminal velocity has been reached, so air resistance [2]

[Total: 10]

## Examiner comments

1 The candidate selects two points close to the starting time and calculates the gradient using the coordinates of these points. The gradient is equal to the deceleration, and this gives an answer within the acceptable range.
Mark for (a)(i) = 2 out of 2

2 The candidate obtains the correct numerical answer.
Mark for (a)(ii) = 3 out of 3

3 The candidate makes two relevant points clearly and is awarded credit for each of them. The correct points were that air resistance decreases with decrease of speed and at terminal velocity there is no resultant force.
Mark for (b) = 2 out of 3

4 The candidate correctly identifies that, at zero velocity, there can be no air resistance, but then refers to the situation where terminal velocity has been reached, rather than concluding that, at zero velocity, there would be no air resistance so the weight would not be balanced, and so zero velocity could not be maintained.
Mark for (c) = 1 out of 2

**Total mark awarded = 8 out of 10**

## How the candidate could have improved their answer

- **(a)(i)** Had the candidate drawn a tangent to the very start of the curve, this would have enabled the gradient to be calculated using a larger triangle. This would have been even more likely to produce an answer within the acceptable range.
- **(a)(ii)** The working out was not well set out but since the arithmetic was correct, it was possible to see that the correct method was used.
- **(b)** The question concerned the motion of the skydiver and the candidate made reference to the initial deceleration but did not explain why there was a deceleration in the first place. A completely correct answer would have pointed out that the initial air resistance, which is acting upwards, is greater than the weight of the parachutist.
- **(c)** The candidate referred to the situation where terminal velocity had been reached rather than concluding that, at zero velocity, there would be no air resistance, so the weight would not be balanced, and zero velocity could not be maintained.

## Example Candidate Response – middle

1 A skydiver of mass 76 kg is falling vertically in still air. At time $t = 0$, the skydiver opens his parachute.

Fig. 1.1 is the speed-time graph for the skydiver from $t = 0$.

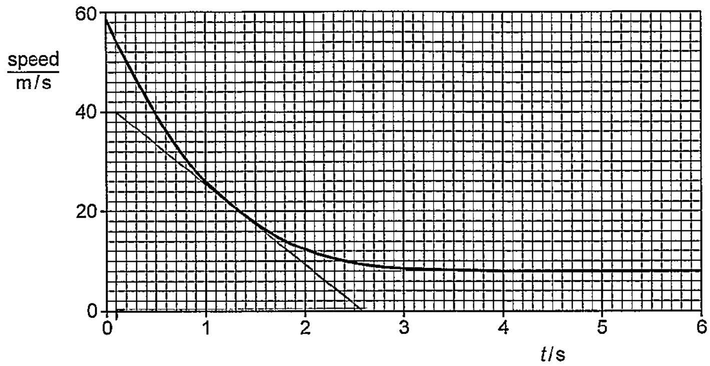



**Fig. 1.1**

**(a)** Using Fig. 1.1, determine:

**(i)** the deceleration of the skydiver immediately after the parachute opens.

x1 y1 (0.1, 40) ( x2 y2 2.6, 0) $\frac{-40}{2.5} = -16$

deceleration = 16 m/s² [2] (1)

**(ii)** the force due to air resistance acting on the skydiver immediately after the parachute opens.

$F = m \times a$

$F = 76 \times 16$

$= 1216N \approx 1220$

force = 1200N [3] (2)

**(b)** Explain, in terms of the forces acting on the skydiver, his motion between $t = 0$ and $t = 6.0$ s.

air resistance was acting upwards against his weight so the skydiver was decelerating, resultant force acting upward then air resistance and weight equal so he starts falling in a constant speed (terminal velocity) [3] (3)

**(c)** Explain why opening the parachute cannot reduce the speed of the skydiver to zero.

Because it will increase the air resistance but it will never be more than his weight, force of gravity pulls him down with a small force [2] (4)

## Examiner comments

(1) The candidate draws a tangent to the curve and uses it correctly to determine the deceleration of the skydiver. However, the question asks for the gradient immediately after the parachute opens, which is at time $t$=0.
Mark for (a)(i) = 1 out of 2

(2) The candidate correctly calculates the resultant force on the skydiver using the acceleration obtained in (a)(i). Although this is not absolutely correct, the previous erroneous answer is the only one that the candidate can use. Partial credit is awarded for calculating this force. More significantly, the weight of the skydiver was not taken into consideration in determining the resultant force.
Mark for (a)(ii) = 2 out of 3

(3) The candidate identifies the presence of an upward resultant force which explains why the skydiver decelerates. That the weight and air resistance eventually balance, and terminal velocity reached is also commented on.
A full response would be 'As the speed decreases, so does the air resistance'.
Mark for (b) = 2 out of 3

(4) The answer does not refer to the question asked. The initial statement that the air resistance is never greater than the weight is incorrect.
Mark for (c) = 0 out of 2

**Total mark awarded = 5 out of 10**

## How the candidate could have improved their answer

- **(a)(i)** The tangent was not drawn to a point on the curve immediately after the parachute was opened at $t$=0, but to a point that corresponded to a later time. The answer obtained did not lie within the acceptable range, because the question asked for the gradient immediately after the parachute opened, which was at time $t$=0. The gradient ought to be at the start of the curve at time $t$=0.
- **(a)(ii)** The question asked for the force due to air resistance and this was greater than the resultant force, and a correct response would have been to take the weight of the skydiver into consideration. Had the weight of the skydiver been added to the resultant force, the correct answer would have been obtained.
- **(b)** A simple statement such as 'As the speed decreases, so does the air resistance.' would have been sufficient.
- **(c)** The candidate should have stated that, on reaching zero velocity, the weight would still be acting, or that the skydiver stops decelerating at a velocity that is greater than zero, because the weight equals the air resistance.

## Example Candidate Response – low

1 A skydiver of mass 76 kg is falling vertically in still air. At time $t = 0$, the skydiver opens his parachute.

Fig. 1.1 is the speed–time graph for the skydiver from $t = 0$.

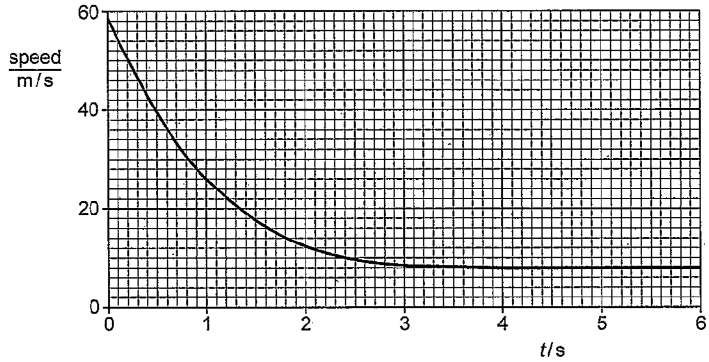



**Fig. 1.1**

**(a)** Using Fig. 1.1, determine:

**(i)** the deceleration of the skydiver immediately after the parachute opens

$a = \frac{v - u}{t}$

$a = \frac{26 - 60}{1} = -34 \text{ m/s}^2$

deceleration = 34 m/s [2]

**(ii)** the force due to air resistance acting on the skydiver immediately after the parachute opens.

F = ma

F = 76 x 34

F = 2584

force = 2584 N [3]

**(b)** Explain, in terms of the forces acting on the skydiver, his motion between $t = 0$ and $t = 6.0$ s.

At t = 0, his acceleration was zero and his speed zero but as he falls, acceleration increases and air resistance also begins to increase. At t = 3 to 6, he began to fly at a constant and steady speed because air resistance became zero. [3]

**(c)** Explain why opening the parachute cannot reduce the speed of the skydiver to zero.

This is because as he opens parachute, there is an immediate upward force as acceleration and speed increases. [2]

## Examiner comments

**1** The candidate calculates the deceleration using points from the curve. The correct expression is given, and the points are accurately determined. The calculation gives the average deceleration during the first second which is less than the deceleration immediately after the parachute is opened. The candidate's value lies outside the acceptable range and the unit of speed rather than that of acceleration is supplied.
Mark for (a)(i) = 1 out of 2

**2** The candidate uses the erroneous answer from (a)(ii) to obtain a correctly calculated value for the resultant force on the skydiver. This is not, however, the force on the skydiver due to air resistance. The force due to air resistance has to supply the resultant force by more than balancing the weight of the skydiver.
Mark for (a)(ii) = 2 out of 3

**3** The answer seems to relate to a skydiver who starts from rest and accelerates to a final terminal velocity.
Mark for (b) = 0 out of 3

**4** The candidate provides an incorrect explanation. Opening a parachute does not increase the speed of the skydiver.
Mark for (c) = 0 out of 2

**Total mark awarded = 3 out of 10**

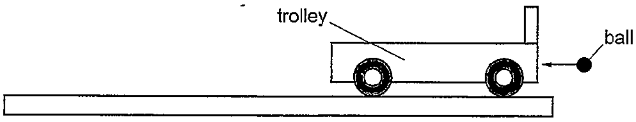
## How the candidate could have improved their answer

- **(a)(i)** The candidate might have achieved an acceptable value had the average been calculated for a much shorter period of time. A correct response requires the correct unit $m/s^2$.
- **(a)(ii)** Had the candidate added 760 N to the answer given, this would have been a correct response.
- **(b)** The answer needed to concern a skydiver who opened the parachute while falling downwards and who decelerated to a final terminal velocity. Both the motion and the explanation were quite different in the two cases. The candidate needed to explain that terminal velocity is reached when the air resistance is equal to the weight rather than when it becomes equal to zero.
- **(c)** A correct explanation was required in terms of the effect on air resistance and why the terminal velocity indicated by Fig. 1.1 was greater than zero.

## Common mistakes candidates made in this question

- **(a)(i)** Many candidates calculated a deceleration of some sort, gave an expression for acceleration or drew a tangent to the curve, but a very common mistake was to calculate a deceleration that was an average for an extended period rather than an instantaneous value at $t=0$.
- **(a)(ii)** The resultant force on the skydiver was very commonly calculated, but much less often was the force due to air resistance supplied; the effect of the weight of the skydiver on the force of air resistance was commonly omitted.
- **(b)** The most common error was not to explain why the skydiver was decelerating during this period and explanations that were more appropriate for a skydiver accelerating from rest were also seen from time to time.
- **(b)** There were many answers that suggested that the candidate did not really understand what was being asked for. A significant number of answers repeated the explanation from **(b)** often in a different way or, in some cases, contradicted it.

# Question 2

| Example Candidate Response – high | Examiner comments |
|---|---|
| **2** Fig. 2.1 shows a wooden trolley of mass 1.2 kg at rest on the rough surface of a bench.<br><br><br>**Fig. 2.1**<br>A ball of mass 0.52 g travels horizontally towards the trolley. The ball embeds itself in the wood of the trolley. The trolley moves with an initial speed of 0.065 m/s.<br>**(a)** Calculate:<br>**(i)** the impulse exerted on the trolley<br>$J = m(v - u)$ $\approx 0.078$<br>$= 1.20052(0.065)$<br>$= 0.0780338$ Ns<br>impulse = 0.078 Ns [2] | **1** The candidate needs to recognise that the impulse exerted on the trolley is equal to the change in its momentum. They do not state this in words, but the equation reveals that the fact is understood. The syllabus does not suggest a symbol for impulse and the symbol J used by this candidate is unusual. The numbers substituted into the equation are not completely correct, but the final answer is correct. The impulse exerted on the trolley is equal to the momentum gained by the trolley and so the mass used ought to have been 1.2 kg rather than 1.20052 kg. The final rounding to 2 significant figures, however, ensures that the answer is completely correct and since a suitable unit for the answer was given, full credit is awarded for this part.<br>Mark for (a)(i) = 2 out of 2 |

| Example Candidate Response – high, continued | Examiner comments |
|---|---|
| **(ii)** the speed of the ball as it hits the trolley.<br>$m_1 v_1 = m_2 v_2$ $\approx 150$ m/s<br>$5.2 \times 10^{-4}\ v_1 = 0.0780338$ (2)<br>$v_1 = 150.065$ m/s speed = 150 m/s [2]<br>**(b)** As the trolley moves across the rough surface, it slows down and stops.<br>Explain, in terms of the work done, the energy change that takes place as the trolley slows down.<br>The work done against friction by the trolley is reducing until its kinetic energy is fully transformed to gravitational potential energy and other forms of energy such as thermal / sound energy. (3) [3]<br>[Total: 7] | (2) The approach is somewhat ambiguous but again, full credit is awarded. The candidate correctly writes down an equation that suggests when the ball hits the stationary trolley, momentum is conserved, and the final answer is correct. The working out, however, is not completely clear. The value given for the final momentum of the trolley and ball is completely correct, the final answer is correct and correctly rounded to 2 significant figures. Although the value for the final momentum is completely correct, the number 0.0780338 might well have been transferred from (a)(i) where it is calculated as the momentum of the trolley and ball, but also stated to be the impulse on the trolley. Even so, full credit is appropriate.<br>Mark for (a)(ii) = 2 out of 2<br><br>(3) The candidate reveals a clear grasp of the essential point that the kinetic energy of the trolley is transferred as work is done against friction and this is awarded 2 marks. They also correctly state that the decrease in kinetic energy is accompanied by the transfer of kinetic energy to thermal and sound energy. The introduction of gravitational potential energy is incorrect and contradicts the correct transfer. It is not clear why this idea has been introduced; the diagram suggests that the trolley is on a horizontal surface and there is no mention of an upward gradient in the text.<br>Mark for (b) = 2 out of 3<br><br>**Total mark awarded = 6 out of 7** |

## How the candidate could have improved their answer

**(b)** The candidate should have written clearly that kinetic energy decreases.

## Example Candidate Response – middle

2 Fig. 2.1 shows a wooden trolley of mass 1.2 kg at rest on the rough surface of a bench.

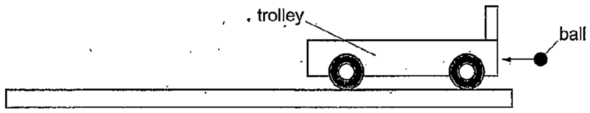



Fig. 2.1

A ball of mass 0.52 g travels horizontally towards the trolley. The ball embeds itself in the wood of the trolley. The trolley moves with an initial speed of 0.065 m/s.

(a) Calculate:

(i) the impulse exerted on the trolley

Impulse = Δ momentum

I = mv − mu

I = (1.20052 − 0) − (1.2 × 0.065)

1.2 + (0.52/1000)

1.2 + 0.00052 = 1.20052 kg

× 1.20052
× 0.078
[illegible]

impulse = 1.12 Ns [2]

(ii) the speed of the ball as it hits the trolley.

momentum before = momentum after

mv = mv

(0.52 × 0.065) − (0.52 × u) = 1.12

0.0338 − 0.52 u

1.0862 = 0.52 u

2.088846154 = u

speed = 2.1 m/s [2]

(b) As the trolley moves across the rough surface, it slows down and stops.

Explain, in terms of the work done, the energy change that takes place as the trolley slows down.

The work done was greater before the collision and then after some energy was lost to the surroundings as heat and sound when the ball collided with the trolley [3]

[Total: 7]

## Examiner comments

1 The candidate makes clear in equation form that the impulse is equal to the change of momentum, and this is awarded some compensatory credit. The candidate does not apply the equation correctly and provides an incorrect final answer. In the substitution, the candidate uses the final momentum of the trolley and ball together as the final momentum of the trolley and subtracts the final momentum of the trolley alone rather than the final momentum of the ball.
Mark for (a)(i) = 1 out of 2

2 The candidate gives both a word equation and a symbolic equation that make clear that the candidate realises that the Principal of the Conservation of Momentum is a relevant consideration. The numbers used in the calculation, however, do not relate to the question and the final answer is incorrect.
Mark for (a)(ii) = 1 out of 2

3 The answer given in the final section, only partially addresses the question asked. An energy change is asked for and this candidate only supplies what the energy is transferred to; the candidate uses the expression 'heat and sound', which is part of a correct response. The candidate does not suggest from where this energy has been transferred and the references to work done are not related to the energy change.
Mark for (b)(i) = 1 out of 3

**Total mark awarded = 3 out of 7**

## How the candidate could have improved their answer

- **(a)(i)** The correct numbers were substituted into the equation, but a correct answer requires correct evaluation.
- **(a)(ii)** Correct use of the equation initial momentum = final momentum is required for a correct answer.
- **(b)** A correct response requires statements that work is done against friction, and that kinetic energy is lost.

## Example Candidate Response – low

**2** Fig. 2.1 shows a wooden trolley of mass 1.2 kg at rest on the rough surface of a bench.

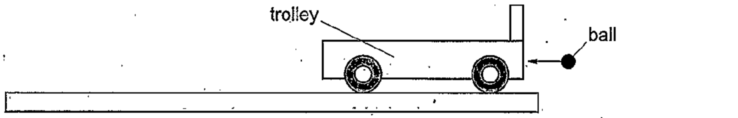



**Fig. 2.1**

A ball of mass 0.52 g travels horizontally towards the trolley. The ball embeds itself in the wood of the trolley. The trolley moves with an initial speed of 0.065 m/s.

**(a)** Calculate:

**(i)** the impulse exerted on the trolley

0·078 − 0 = 0·078

$m_1 = 1{\cdot}2 \times 0 = 0$    $m_2 = 1{\cdot}2 \times 0{\cdot}065 = 0{\cdot}078$

impulse = 0·078 ........................ [2]

(1)

**(ii)** the speed of the ball as it hits the trolley.

$1{\cdot}2 \times 0{\cdot}065 = 0{\cdot}0052 \times v$

0·52 g = 0·0052 kg

$\frac{0{\cdot}078}{0{\cdot}0052} = v$

$m_1 v_1 = m_2 v_2$

speed = 15 m/s ........................ [2]

(2)

**(b)** As the trolley moves across the rough surface, it slows down and stops.

Explain, in terms of the work done, the energy change that takes place as the trolley slows down.

Due to the rough surface the work done by the trolley increases to over come the obstacles and the force to do this work gradually decreases with distance causing it to finally come to a rest. [3]

(3)

[Total: 7]

## Examiner comments

(1) The candidate gives the correct numerical answer and uses the correct approach, but a fully correct answer requires a correct unit.
Mark for (a)(i) = 1 out of 2

(2) The calculation is performed in a largely correct fashion. It is clear that the conservation of momentum is being used and had the candidate correctly converted 0.52 g to 0.00052 kg, the final answer might have been correct to 2 significant figures. Instead, a power of ten error is made and only partial credit awarded.
Mark for (a)(ii) = 1 out of 2

(3) In the final part, the candidate does not address the energy change that is asked for, and the word energy does not appear in the answer.
Mark for (b)(i) = 0 out of 3

**Total mark awarded = 2 out of 7**

## How the candidate could have improved their answer

- **(a)(i)** The candidate did not make clear exactly what part of the subject was being applied and had the final answer not been correct numerically, no marks could have been awarded. It is possible that the candidate was using the symbol *m* to represent momentum but the use of a symbol which is almost always used to represent mass is not entirely wise. The candidate substituted correctly into the correct equation, but a fully correct response also requires the unit Ns or kg m/s.
- **(a)(ii)** The candidate knew the correct equation and how to apply it, but a correct answer requires correct mathematical evaluation.
- **(b)** The reference to work done in the question, made clear that it was to be part of the explanation of the energy change. A correct response must address the question asked.

## Common mistakes candidates made in this question

- In the first two parts, a common mistake was to supply an incorrect unit for impulse; kg / m / s was often used and the conversion of 0.52 g to kg was sometimes ignored or used incorrectly.
- In the final part, many candidates referred to work done in an entirely separate comment rather than using it as part of the explanation. An initial definition of work done was not what the question asked for. There were also candidates who introduced forms of energy other than those that related to the decelerating trolley and did so either instead of the correct forms or in addition to them.

# Question 3

| Example Candidate Response – high | Examiner comments |
|---|---|
| | |

3 (a) Explain, in terms of molecules, why liquids are very difficult to compress.

Liquids cannot be compressed due to having very small spaces between the molecules. They also have strong intermolecular forces that repel it. [2] **1**

(b) Fig. 3.1 shows a device that uses liquid pressure to lift heavy boxes.

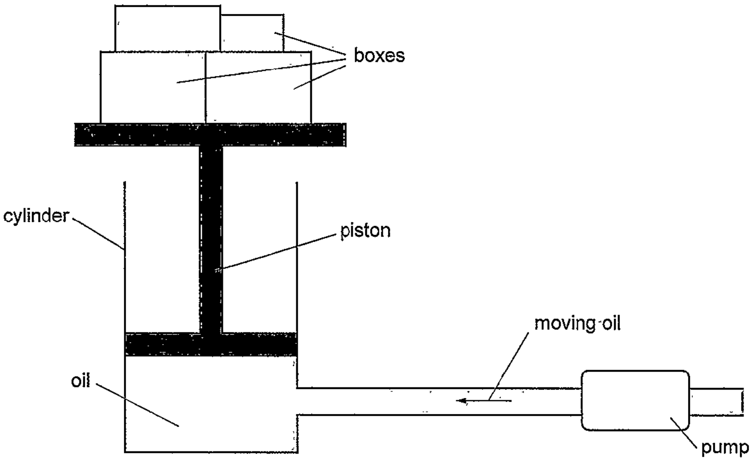



**Fig. 3.1**

The boxes are lifted by pumping oil into the cylinder.

The force upwards on the piston due to the oil, and the force downwards on the piston due to the air above the piston, combine to produce a constant force of 8800 N. $P_1 + P_2 = 8800$

The pressure of the air is $1.0 \times 10^5$ Pa and the cross-sectional area of the bottom surface of the piston is $0.016\,m^2$. $P_2 = 1.0 \times 10^5$

(i) Calculate the pressure of the oil at the bottom surface of the piston.

8800

$P = \frac{f}{a}$

$P = \frac{8800}{0.016}$

$P = 550\ 000$

pressure = 550 000 Pa [3] **2**

(ii) As the boxes are lifted, the depth of the oil increases.

Explain why the pump must exert an increasing pressure on the oil as the depth of the oil increases.

As the depth increases so does the pressure due to having to lift the oil as well and the gravitation potential energy increases [2] **3**

(iii) Suggest **one** reason why the force of 8800 N in **(b)** cannot lift boxes of weight 8800 N.

It cannot lift it due to having to lift the piston and other oil as well. **4** [1]

[Total: 8]

**Examiner comments**

**1** The answer here is well expressed and deserving of full credit. Both parts of the answer are given; the small molecular separation and the large size of the intermolecular force are both referred to. The candidate is also clear that it is the size of the repulsive force that is important when the resistance to compression of liquids is considered.
Mark for (a) = 2 out of 2

**2** The candidate correctly calculates the increase in pressure due to the force given in the question but omits to add on the pressure of the atmosphere.
Mark for (b)(i) = 2 out of 3

**3** The candidate identifies the increase in the pressure at the bottom of the oil although it is only referred to as the pressure of the oil. It is made clear that this is a consequence of increasing depth. Secondly, the candidate identifies the need to lift the oil as the depth increases and that an increased pressure is needed to do this.
Mark for (b)(ii) = 2 out of 2

**4** The candidate identifies that it is not just the boxes that need to be lifted and that the piston itself needs to be lifted.
Mark for (b)(iii) = 1 out of 1

**Total mark awarded = 7 out of 8**

## How the candidate could have improved their answer

- **(a)** It was not clear what the final word ‘it’ was referring to. This did not contradict any correct point already made, however.
- **(b)(i)** The candidate’s answer was the increase of pressure. The correct final answer requires atmospheric pressure to be added.
- **(b)(ii)** Had the terms pressure at the bottom of the oil and to lift the additional oil been used, the answer would have been improved.

## Example Candidate Response – middle

3 (a) Explain, in terms of molecules, why liquids are very difficult to compress.

Liquids have molecules which have little or no space between one another, and can slide over each other, hence is diggicult to compress. (1) [2]

(b) Fig. 3.1 shows a device that uses liquid pressure to lift heavy boxes.

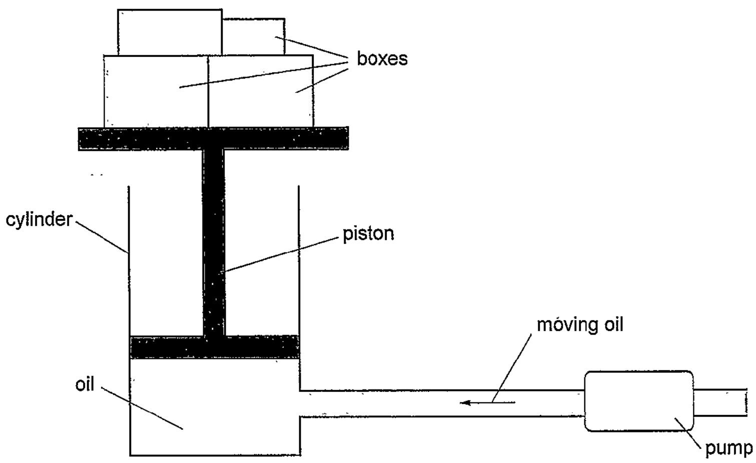



**Fig. 3.1**

The boxes are lifted by pumping oil into the cylinder.

The force upwards on the piston due to the oil, and the force downwards on the piston due to the air above the piston, combine to produce a constant force of 8800 N.

The pressure of the air is $1.0 \times 10^5$ Pa and the cross-sectional area of the bottom surface of the piston is $0.016\,m^2$.

(i) Calculate the pressure of the oil at the bottom surface of the piston.

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

$$= \frac{8800}{0.016}$$

$$= 5.5 \times 10^5\ \text{Pa} - 1.0 \times 10^5\ \text{Pa}$$

$$= 4.5 \times 10^5\ \text{Pa}$$

pressure = $4.5 \times 10^5$ Pa (2) [3]

(ii) As the boxes are lifted, the depth of the oil increases.

Explain why the pump must exert an increasing pressure on the oil as the depth of the oil increases.

P = ρgh, so for a greater depth (h) more pressure is needed. More pressure is also needed to oppose the atmospheric pressure and the air resistance. (3) [2]

(iii) Suggest **one** reason why the force of 8800 N in **(b)** cannot lift boxes of weight 8800 N.

The forces will balance out and there will be no resultant force. (4) [1]

[Total: 8]

## Examiner comments

(1) The closeness of the molecules, is referred to, but no mention is made of the intermolecular force of repulsion between the molecules.
Mark for (a) = 1 out of 2

(2) The candidate calculates the pressure due to the depth of the oil and realises that the pressure of the atmosphere affects the answer required. The pressure of the atmosphere, however, is subtracted from the pressure due to the oil, rather than added on.
Mark for (b)(i) = 2 out of 3

(3) The increase in the pressure due to the increasing depth of the oil is mentioned and this is the first mark. The candidate realises that an increasing pressure from the pump is needed to overcome something and had this been linked to the increased pressure already referred to, the answer would have been acceptable. The increasing pressure from the pump is, however, related to the atmospheric pressure and the air resistance. Neither of these is increasing and so the explanation is not valid.
Mark for (b)(ii) = 1 out of 2

(4) In the final section, the candidate recognises that the two forces given in the text are equal in size and balanced. The credit is awarded when it is made clear that these forces produce no resultant.
Mark for (b)(iii) = 1 out of 1

**Total mark awarded = 5 out of 8**

## How the candidate could have improved their answer

- **(a)** A complete answer would have added that the repulsive forces are very large.
- **(b)(i)** The atmospheric pressure should have been added not subtracted.
- **(b)(ii)** Mention should have been made that the upward force needs to be kept constant.

| Example Candidate Response – low | Examiner comments |
|---|---|
| **3 (a)** Explain, in terms of molecules, why liquids are very difficult to compress.<br>Because the ~~pe~~ molecules in a liquid are further apart unlike a solid, **1** making it harder to bring them together. [2] | **1** The comment is essentially correct, but it is not the explanation required. It suggests that liquids are relatively easy to compress when compared with solids. The candidate does not answer the question asked.<br>Mark for (a) = 0 out of 2 |

**(b)** Fig. 3.1 shows a device that uses liquid pressure to lift heavy boxes.

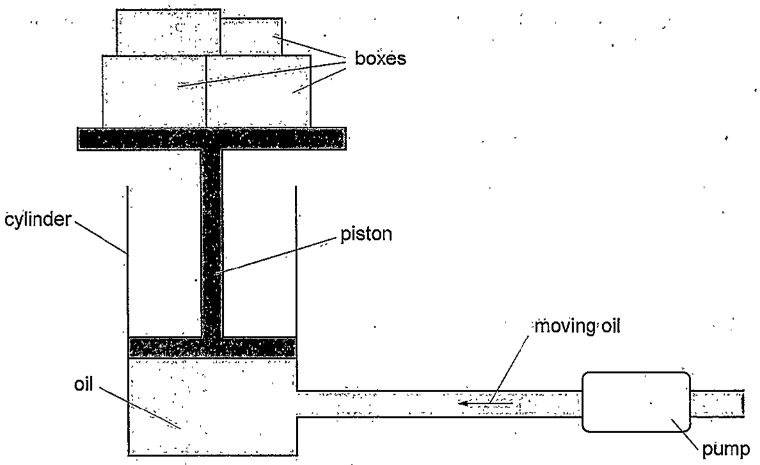



Fig. 3.1

The boxes are lifted by pumping oil into the cylinder.

The force upwards on the piston due to the oil, and the force downwards on the piston due to the air above the piston, combine to produce a constant force of 8800 N.

The pressure of the air is $1.0 \times 10^5$ Pa and the cross-sectional area of the bottom surface of the piston is $0.016\,m^2$.

| Example Candidate Response – low | Examiner comments |
|---|---|
| **(i)** Calculate the pressure of the oil at the bottom surface of the piston.<br>$P = \frac{F}{a}$ $P = \frac{8800}{0.016} = 550\,000$<br>pressure = 550 000 Pa **2** [3] | **2** The candidate calculates the pressure due to the force of 8800 N but makes no reference to the atmospheric pressure; it should have been added on to the result obtained.<br>Mark for (b)(i) = 2 out of 3 |
| **(ii)** As the boxes are lifted, the depth of the oil increases.<br>Explain why the pump must exert an increasing pressure on the oil as the depth of the oil increases.<br>The pressure exerted ~~is~~ directly proportionate **3** to the ~~height~~ depth of the oil, so for depth to increase, more pressure is needed to push up the boxes. [2] | **3** There are two pressure increases of significance in part (b)(ii): the increased pressure due to the depth of the oil and the increased pressure of the pump which is needed to overcome the first increase. This candidate does not really distinguish between them. It is the pressure due to the increased depth that is increasing first of all, and the pressure exerted by the pump is increased to overcome this.<br>Mark for (b)(ii) = 1 out of 2 |
| **(iii)** Suggest **one** reason why the force of 8800 N in **(b)** cannot lift boxes of weight 8800 N.<br>Because more force is needed to push **4** through the pressure of the piston. [1]<br>[Total: 8] | **4** In the last part, the expression 'the pressure of the piston' is not clearly referring to the fact that the piston also needs to be lifted.<br>Mark for (b)(iii) = 0 out of 1<br><br>**Total mark awarded = 3 out of 8** |

## How the candidate could have improved their answer

- **(a)** Reference should be made to the close spacing between molecules and the very large repulsive forces.
- **(b)(i)** Atmospheric pressure should have been added to the calculated pressure.
- **(b)(ii)** It should have been stated that the upwards force is constant.
- **(b)(iii)** Mention should have been made that the upwards force balances the weight.

## Common mistakes candidates made in this question

- **(a)** In the first section, many candidates referred to one of the parts of the full explanation, but only rarely were both parts supplied. Here were answers that referred to the attractive force between the molecules which are not important in explaining the difficulty in compressing a liquid.
- **(b)(i)** Any reference to the atmospheric pressure was often omitted and when it was not ignored it was very frequently subtracted from the pressure caused by the force, rather than added on.
- **(b)(ii)** It was quite common for the increasing depth of the oil to be offered as an explanation for an increasing pressure in the oil. This argument should have been extended and used to explain that the pump now needed to exert an increasing pressure to overcome this.

# Question 4

## Example Candidate Response – high

4 An aluminium saucepan with a plastic handle contains cold water.

Fig. 4.1 shows the saucepan on a hotplate.

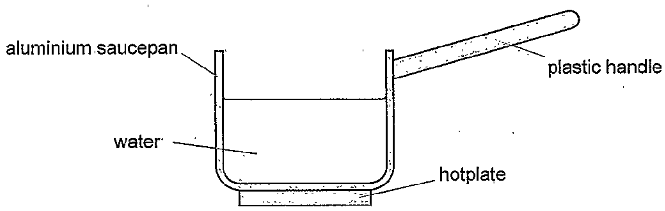



**Fig. 4.1**

(a) State why the pan is made from aluminium but the handle is made from plastic.

Aluminium is a good conductor of heat while plastic is a good insulator, so whoever holds the pan handle doesn't get burnt / injured. **1** [1]

(b) The hotplate is switched on and, as the temperature of the water increases, the internal energy of the water increases.

(i) State, in terms of molecules, what is meant by *an increase in internal energy*.

An increase in kinetic energy of molecules as well as an increase in potential energy i.e. Molecules move faster. **2** [1]

(ii) Explain, in terms of the atomic lattice and electrons, how thermal energy is transferred through the aluminium.

In the atomic lattice, neighbouring atoms vibrate due to thermal energy and pass on vibrations, as well as transferring heat and electrons collide with atoms as electrons are mobile which transfers thermal energy to atoms so they ~~aster~~ faster. **3** [3]

(iii) Eventually, the water reaches boiling point. Thermal energy from the hotplate is still being transferred to the water.

Explain, in terms of molecules, the effect of this thermal energy on the water.

This thermal energy is used to break intermolecular bonds between water molecules so they can change state from liquid to glass. **4**

[3]

(iv) The mass of the water decreases by 0.11 kg in 300 s. The specific latent heat of vaporisation of water is $2.3 \times 10^6$ J/kg.

Calculate the rate at which the water gains thermal energy.

$Q = mc\Delta T$

$Q = ml$

$= 0.11 \times 2.3 \times 10^6$

$= \frac{253000 \text{ J}}{300 \text{ s}}$

$= 843.3$ J/s

$\approx 840$ J/s

rate of gain of energy = 840 J/s **5** [3]

[Total: 11]

## Examiner comments

**1** The candidate offers a complete explanation in terms of the relative thermal conductivities of the two materials. That the term conductivity is applied in both electrical and thermal situations, the candidate might have referred to the plastic being a good thermal insulator.
Mark for (a) = 1 out of 1

**2** The candidate correctly refers to both the increase in the molecular kinetic energy and the increase in the potential energy.
Mark for (b)(i) = 1 out of 1

**3** There are several comments that can be made in the third part and the candidate makes three of them.
Mark for (b)(ii) = 3 out of 3

**4** The candidate makes one point very clearly: the bonds between the liquid molecules are broken. The escape of the molecules from the liquid is referred to more obliquely and the credit is awarded by giving the candidate the benefit of the doubt. Then they suggest that it is the molecules that are changing state (rather than the liquid as a whole) and in this context, 'glass' was very likely to have been intended to be 'gas'.
Mark for (b)(iii) = 2 out of 3

**5** In the final section, the candidate obtains the correct answer, correctly rounded to 2 significant figures and shows correct working.
Mark for (b)(iv) = 3 out of 3

**Total mark awarded = 10 out of 11**

## How the candidate could have improved their answer

- **(b)(i)** A reference to the molecular potential energy would have been more explicit but this followed on from molecular kinetic energy and it is fair to assume that the description 'molecular' is carried on.
- **(b)(ii)** The wording was not completely clear, and the third line suggested that passing on the vibrations was an activity separate from transferring heat rather than the mechanism for it. This does not constitute a contradiction, however.
- **(b)(iii)** A complete answer would have added that molecules gain potential energy.
- **(b)(iv)** The presence of the irrelevant equation $Q = mc\Delta T$ was unexplained, but it was not used at all, and the final answer has not been influenced by it. It is an irrelevant distraction so it would have been better not to write it down.

| Example Candidate Response – middle | Examiner comments |
|---|---|

4 An aluminium saucepan with a plastic handle contains cold water.

Fig. 4.1 shows the saucepan on a hotplate.

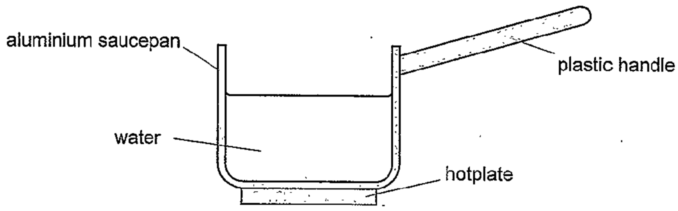



**Fig. 4.1**

(a) State why the pan is made from aluminium but the handle is made from plastic.

The aluminium will conduct heat and therefore heat up the water. The handle is made from plastic to prevent the pan from burning a person's hand when it is picked up. [1] ①

(b) The hotplate is switched on and, as the temperature of the water increases, the internal energy of the water increases.

(i) State, in terms of molecules, what is meant by *an increase in internal energy*.

An increase in the kinetic energy of the molecules of the water. [1] ②

(ii) Explain, in terms of the atomic lattice and electrons, how thermal energy is transferred through the aluminium.

The free mobile electrons allow the aluminium to conduct heat from the hotplace. The lattice structure ~~of the atom~~ allows heat to be transferred by conduction through the atoms of the aluminium. [3] ③

(iii) Eventually, the water reaches boiling point. Thermal energy from the hotplate is still being transferred to the water.

Explain, in terms of molecules, the effect of this thermal energy on the water.

At this point, the heat is no longer being used to increase temperature. The temperature remains constant and instead the thermal energy is being used to break the bonds ~~between~~ between the ~~atoi~~ molecules of the water, turning it into a gas. [3] ④

0625/41/M/J/21

**Examiner comments**

① The candidate does not answer in terms of the thermal properties of aluminium and plastic, but explains, in terms of the way in which a saucepan is used, why it is appropriate to use these materials. This implies that the thermal properties are known.
Mark for (a) = 1 out of 1

② Although, in (b)(i), an increase in internal energy is the result of an increase in both the kinetic energy of the molecules and in their potential energy, only one of these is required for the mark and this candidate supplies an answer in terms of the molecular kinetic energy.
Mark for (b)(i) = 1 out of 1

③ There are several possible points to make in (b)(ii), and this candidate refers to the role played by the moving electrons. The transfer of energy through the aluminium by lattice vibrations is named ('conduction') rather than explained.
Mark for (b)(ii) = 1 out of 3

④ In the answer to part (b)(iii), a correct reference is made to the breaking of molecular bonds. The reference to the temperature's remaining constant is correct, but it is not an answer to what has been asked to have been intended to be 'gas'.
Mark for (b)(iii) = 1 out of 3

| Example Candidate Response – middle, continued | Examiner comments |
| --- | --- |
| **(iv)** The mass of the water decreases by 0.11 kg in 300 s. The specific latent heat of vaporisation of water is $2.3 \times 10^6$ J/kg.<br><br>Calculate the rate at which the water gains thermal energy.<br><br>$Q = ml$<br>$Q = 0.11 \times (2.3 \times 10^6)$<br>$Q = 253\,000$<br><br>rate of gain of energy = 843.3 J/s **5** [3]<br><br>[Total: 11]<br><br>300 s — 253 000 J<br>1 s — x<br>300x = 253 000<br>$x = \frac{253\,000}{300}$<br>x = 843.3 J/s | **5** The calculation is performed correctly, and the final answer is given acceptable units, the answer, correctly rounded to 2 significant figures and shows correct working.<br>Mark for (b)(iv) = 3 out of 3<br><br>**Total mark awarded = 7 out of 11** |

## How the candidate could have improved their answer

- **(b)(ii)** The mention of free electrons was a correct statement, but there should also have been further statements about atoms passing on energy.
- **(b)(iii)** Mention should have been made about molecules escaping from the liquid and molecules gaining potential energy.
- **(b)(iv)** The answer was expressed to 4 significant figures which cannot be justified as the number supplied by the question are to a lesser precision. This does not lead to any lost credit.

## Example Candidate Response – low

**4** An aluminium saucepan with a plastic handle contains cold water.

Fig. 4.1 shows the saucepan on a hotplate.

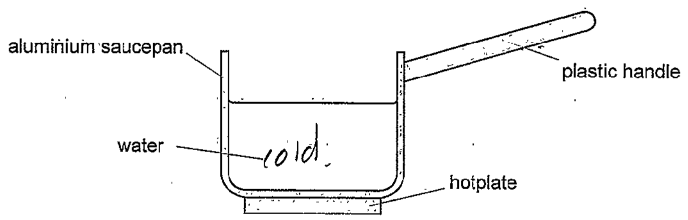



**Fig. 4.1**

**(a)** State why the pan is made from aluminium but the handle is made from plastic.

Because aluminium is a good conductor of heat and plastic is not preventing burning (1) [1]

**(b)** The hotplate is switched on and, as the temperature of the water increases, the internal energy of the water increases.

**(i)** State, in terms of molecules, what is meant by *an increase in internal energy*.

This means the energy in the molecules (2) that enable the molecules to move around i.e. kinetic energy [1]

**(ii)** Explain, in terms of the atomic lattice and electrons, how thermal energy is transferred through the aluminium.

Aluminium contains free electrons that carry the energy from the hotter end to cooler end and in this process they bump into (3) the tightly packed atoms hence conducting heat [3]

**(iii)** Eventually, the water reaches boiling point. Thermal energy from the hotplate is still being transferred to the water.

Explain, in terms of molecules, the effect of this thermal energy on the water.

The thermal energy is transfered to the molecules of the water making them gain kinetic energy hence the molecules move faster (4) [3]

## Examiner comments

(1) The essential comparison of the thermal properties of aluminium and plastic is made.
Mark for (a) = 1 out of 1

(2) The candidate does not refer to an increase in the molecular kinetic energy, but suggests that it is related to the molecular kinetic energy.
Mark for (b)(i) = 0 out of 1

(3) The answer to (b)(ii) is lacking in clarity. That the electrons are moving is implied by their carrying energy but it is not clear that the electrons collide with distant atoms or particles.
Mark for (b)(ii) = 1 out of 3

(4) The answer to (b)(iii), makes one point which is not correct. The water molecules do not gain kinetic energy.
Mark for (b)(iii) = 0 out of 3

## Example Candidate Response – low, continued

**(iv)** The mass of the water decreases by 0.11 kg in 300 s. The specific latent heat of vaporisation of water is $2.3 \times 10^6$ J/kg.

Calculate the rate at which the water gains thermal energy.

$Q = (2.3 \times 10^6) \times 0.11$

$Q = 253000$

253000

rate of gain of energy = .................................................. [3]

[Total: 11]

$Q = lm$

$L = \frac{Q}{M}$

Q / L M

$Q = MC\Delta T$

Q / C M θ

$T = \frac{Q}{CM}$

253000

5

## Examiner comments

5 In the final part, the candidate states one of the appropriate equations, in addition to one that is not needed. It is the correct one that is used, and the candidate correctly substitutes the relevant numbers and calculates a correct numerical value for the thermal energy transferred by heating. No reference is made to the rate of transfer of thermal energy and no calculation is performed for this last stage.

Mark for (b)(iv) = 2 out of 3

**Total mark awarded = 4 out of 11**

## How the candidate could have improved their answer

- **(a)** This answer was brief and the omission of a comma after ‘not’ could cause confusion.
- **(b)(i)** Mention should have been made of an increase of kinetic or potential energy of the molecules.
- **(b)(ii)** Mention needed to be made about **how** energy is transferred.
- **(b)(iii)** Mention should have been made of bonds being broken, and molecules gaining potential energy as they escape the liquid.
- **(b)(iv)** The candidate should have divided the energy required by the time.

## Common mistakes candidates made in this question

- **(a)** An occasional candidate only stated the thermal property of one of the materials.
- **(b)(i)** It was important to make clear that the increase in either kinetic or potential energy was at a molecular level, but some candidates seemed to be suggesting, incorrectly, that the kinetic or potential energy of the water as a whole was increasing.
- **(b)(ii)** These answers were not always clear and several candidates gave explanations that involved the passing on of energy by the transfer of vibration from electron to electron.
- **(b)(iii)** Very few candidates mentioned the increase in potential energy of the molecules that escape but an erroneous increase in the kinetic energy of these molecules was a common error.
- **(b)(iv)** The equation $Q = mc\Delta T$ was often written down although it was not always used. There were, however, those who used it and substituted a time of 300 (s) for $\Delta T$; this, of course, generated an answer far greater than the correct answer.

# Question 5

## Example Candidate Response – high

5 Fig. 5.1 shows the structure of a liquid-in-glass thermometer.

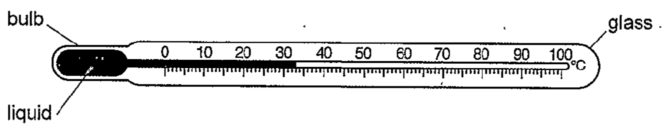



**Fig. 5.1**

The bulb of the thermometer is placed into a beaker of warm water. As the liquid expands, it moves along the tube.

**(a)** Explain, in terms of molecules, why a liquid expands when heated.

The liquid molecules gain kinetic energy and move faster with more collisions and move away from each other so their volume increases when heated and they expand as overcome intermolecular forces of attraction [2]

**(b)** Explain, in terms of molecules, why a liquid expands more than a solid when heated.

liquids have weaker intermolecular forces of attraction than solids so they require less energy to overcome these forces than solids and expand more when given same amount of heat [2]

**(c)** A second thermometer has a larger bulb that contains more of the same liquid than the thermometer shown in Fig. 5.1. It has a different scale. In every other way, it is identical.

**(i)** Explain how the sensitivity of the second thermometer compares with the sensitivity of the thermometer in Fig. 5.1.

It has greater sensitivity as it has more liquid in bulb which expands more than the thermometer in Fig. 5.1 so it shows more increase in length for every increase in 1°C [2]

**(ii)** Explain how the range of the second thermometer compares with the range of the thermometer in Fig. 5.1.

it has lower range as it shows more sensitivity and length of bore is same so it cannot measure a temperature as high as 100°C as it doesnt have enough length [1]

**(d) (i)** State **one** everyday problem that is a result of thermal expansion.

it is difficult to open bottles with metal caps when they come out of fridge, cold [1]

**(ii)** Suggest and explain **one** way of solving this problem.

by putting warm water over cap which makes the cap expand so there will be less friction between cap and bottle and easier to open [2]

[Total: 10]

## Examiner comments

1 The candidate is awarded full credit; the molecules move faster and move apart.
Mark for (a) = 2 out of 2

2 The first point concerning the weaker intermolecular forces in the liquid is clearly made. The term 'overcome' is usually used to refer to what happens when molecules escape into a vapour whereas here, the bonds are not broken, and vaporisation is not what is being asked about. The final sentence, however, is correct and clear.
Mark for (b) = 2 out of 2

3 The answer is correct, and the explanation is correct. The candidate even defines sensitivity as a part of the explanation.
Mark for (c)(i) = 2 out of 2

4 There is only one mark in (c)(ii) for both the answer and the explanation so the answer is sufficient. The candidate adds extra detail, however.
Mark for (c)(ii) = 1 out of 1

5 The answer to (d)(i) is a problem associated with thermal contraction but since this is the same phenomenon, the clear reference to the problem being due to a low temperature is enough.
Mark for (d)(i) = 1 out of 1

6 The explanation given is detailed and accurate.
Mark for (d)(ii) = 2 out of 2

**Total mark awarded = 10 out of 10**

## How the candidate could have improved their answer

**(d)(ii)** To be sure of being awarded full credit, a candidate might have offered a problem associated with thermal expansion rather than hoping that thermal contraction would be seen as a negative expansion.

## Example Candidate Response – middle

**5** Fig. 5.1 shows the structure of a liquid-in-glass thermometer.

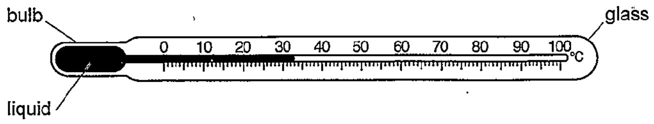



**Fig. 5.1**

The bulb of the thermometer is placed into a beaker of warm water. As the liquid expands, it moves along the tube.

**(a)** Explain, in terms of molecules, why a liquid expands when heated.

Molecules gain energy and start moving faster and in random directions this causes them to grow further apart, thus expanding the liquid. (1) [2]

**(b)** Explain, in terms of molecules, why a liquid expands more than a solid when heated.

The attraction forces between it's molecules are weaker than the solid's & the molecules need less energy to break or weaken the bonds whereas a solid would need more energy to weaken it's attraction forces and spread apart. (2) [2]

**(c)** A second thermometer has a larger bulb that contains more of the same liquid than the thermometer shown in Fig. 5.1. It has a different scale. In every other way, it is identical.

**(i)** Explain how the sensitivity of the second thermometer compares with the sensitivity of the thermometer in Fig. 5.1.

It is more sensitive as the bulb is larger and has a larger surface area to detect the heat and more liquid to detect it. (3) [2]

**(ii)** Explain how the range of the second thermometer compares with the range of the thermometer in Fig. 5.1.

Since it has a different scale the range would (4) differ accordingly, as it has more liquid there should be more space to expand in meaning it has a greater range. [1]

**(d) (i)** State **one** everyday problem that is a result of thermal expansion.

Overhead cables expand and become loose and carry electricity inefficiently. (5) [1]

**(ii)** Suggest and explain **one** way of solving this problem.

Making the cables tighter during summer and hot seasons/periods. (6) [2]

[Total: 10]

## Examiner comments

(1) This is a correct response.
Mark for (a) = 2 out of 2

(2) This candidate mentions the weaker molecular forces in the liquid state. This candidate also refers to breaking the bonds which is not strictly relevant when discussing the expansion of the liquid. The final sentence correctly states that less energy is needed in the liquid to move the molecules apart.
Mark for (b) = 2 out of 2

(3) The candidate correctly deduces that the second thermometer has a greater sensitivity, but an explanation in terms of the surface area of the bulb is not correct.
Mark for (c)(i) = 1 out of 2

(4) At the very end of the answer, the candidate does give a direct answer concerning the range; it is however, incorrect.
Mark for (c)(ii) = 0 out of 1

(5) The answer correctly states that the power cables become loose. This term is vague, but probably means that they are hanging rather more loosely than they should, which is a problem that can arise with overhead cables.
Mark for (d)(i) = 1 out of 1

(6) No mechanism by which the tightness can be restored is suggested no explanation is given.
Mark for (d)(ii) = 0 out of 2

**Total mark awarded = 6 out of 10**

## How the candidate could have improved their answer

- **(a)** Although the reference to an increased molecular speed is enough for the first mark, the candidate might have also mentioned that the increase in speed is a result of the increase in the kinetic energy that accompanies the increase in temperature.
- **(c)(i)** This explanation suggests that the candidate suspects that sensitivity is related to the speed with which the final reading is reached.
- **(c)(ii)** The range becomes smaller, and a valid reason is required.
- **(d)(ii)** The candidate has not supplied a viable solution with explanation.

## Example Candidate Response – low

5 Fig. 5.1 shows the structure of a liquid-in-glass thermometer.

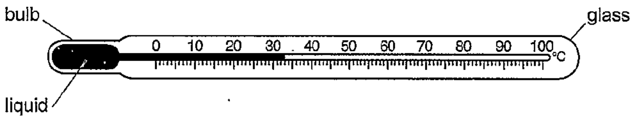



**Fig. 5.1**

The bulb of the thermometer is placed into a beaker of warm water. As the liquid expands, it moves along the tube.

**(a)** Explain, in terms of molecules, why a liquid expands when heated.

- Molecules gain kinetic energy when heated
- Molecules start to move in random motion, hitting each other

[2] (1)

**(b)** Explain, in terms of molecules, why a liquid expands more than a solid when heated.

- Solids are in a fixed position
- When heated, solids ~~do no~~ molecules do not start to move around in random motion ~~liq~~ like liquids

[2] (2)

**(c)** A second thermometer has a larger bulb that contains more of the same liquid than the thermometer shown in Fig. 5.1. It has a different scale. In every other way, it is identical.

**(i)** Explain how the sensitivity of the second thermometer compares with the sensitivity of the thermometer in Fig. 5.1.

- ~~Sensitivity~~ The second thermometer ~~is~~ ~~mo~~ has more sensitivity than the thermometer in Fig 5.1
-

[2] (3)

**(ii)** Explain how the range of the second thermometer compares with the range of the thermometer in Fig. 5.1.

- The second thermometer ~~is~~ has a larger range than the thermometer in Fig 5.1

[1] (4)

**(d) (i)** State **one** everyday problem that is a result of thermal expansion.

Breaking of bimetal strip on an iron

[1]

**(ii)** Suggest and explain **one** way of solving this problem.

- Replacing the Bi-metal strip in an iron regularly, making
- ~~Not~~ sure not to leave the iron ~~for~~ on for too long.

(5) [2]

[Total: 10]

## Examiner comments

(1) The first marking point is made directly and clearly and no reference to the molecules moving apart is made at all.
Mark for (a) = 1 out of 2

(2) The difference between the rates of expansion of liquids and solids is due to the relative magnitudes of the intermolecular forces that act. This answer makes no reference to these forces.
Mark for (b) = 0 out of 2

(3) The answer is a very clear and correct comment on the sensitivity of the second thermometer, but there is no explanation as to why the sensitivity is greater in the second case.
Mark for (c)(i) = 1 out of 2

(4) This statement is also clear and direct, but it is incorrect.
Mark for (c)(ii) = 0 out of 1

(5) The answers in (d)(i) and (d)(ii) suggest that the point of the question has been missed. A bimetallic strip uses thermal expansion to function and so thermal expansion in this context, does not, of itself, constitute a problem.
Mark for (d)(i) = 0 out of 1

Mark for (d)(ii) = 0 out of 2

**Total mark awarded = 2 out of 10**

## How the candidate could have improved their answer

- **(a)** The candidate should state that the molecules move further apart.
- **(b)** It should have been stated that the forces between molecules are weaker, so less energy is required to separate them.
- **(c)(i)** The answer should have given a reason.
- **(c)(ii)** An explanation of some sort was required, and so had the statement been correct, the mark would not have been different, and there is no explanation here.

## Common mistakes candidates made in this question

- **(a)** The second mark was less frequently awarded than was the first mark. The simple comment that the separation of the molecules increases was only rarely made, and no credit was awarded for the comment that the molecules themselves expand.
- **(b)** Some candidates attempted to answer this part of the question in terms of the average separation of the molecules in solids and liquids and made no mention of the strength of the intermolecular forces. Very few candidates related the sizes of the forces to the energy needed to separate the molecules by a given distance.
- **(c)(i)** The term ‘sensitivity’ was interpreted to refer to the time taken for the thermometer to register the final temperature and there were many answers based on this. In particular, answers that referred to a greater surface area of the bulb were often used to explain a greater sensitivity for the second thermometer, whereas answers that referred to the greater mass of liquid in the larger bulb were commonly used to suggest a smaller sensitivity.
- **(c)(ii)** Many incorrect interpretations of the term ‘range’ were offered, and few candidates were awarded any credit for the answers here.
- **(d)** The most commonly selected problem was the behaviour of railways tracks when exposed to high temperatures. The emphasis here was on the solution to the problem however, and merely to state that railway tracks expanded on hot days was not enough for any credit in **(d)(i)**. The problem is the buckling which could have been described in many ways. Candidates who chose the example of railway tracks often proposed a correct solution but not all of the explanations were sufficient.

# Question 6

## Example Candidate Response – high

6 Fig. 6.1 is a full-scale diagram that represents a sound wave travelling in air.

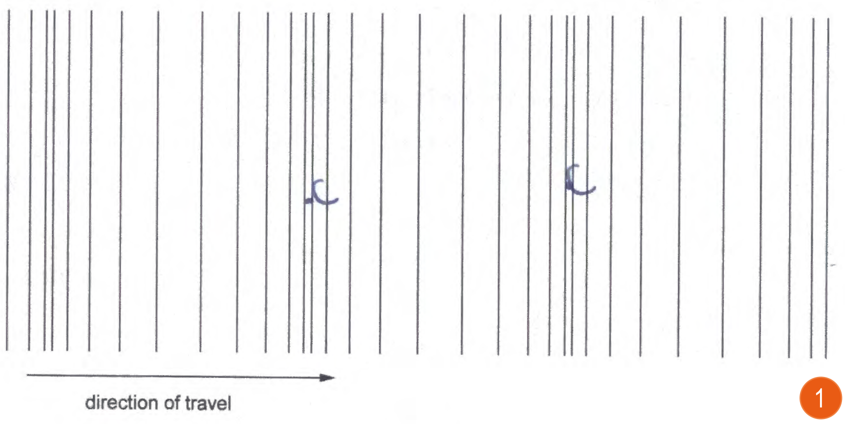



Fig. 6.1

(a) On Fig. 6.1, mark **two** points, each at the centre of a different compression. Label both of the points C. [1]

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

Measure the diagram and determine the frequency of the sound.

$\lambda = 5.2\text{cm}$
$= 0.052\text{m}$

$s = \lambda \times f$

$330 = 0.052 \times f$

$f = 6346.1538$

2

frequency = 6350 Hz [3]

## Examiner comments

1 The two Cs asked for in (a) are placed in appropriate positions.
Mark for (a) = 1 out of 1

2 The candidate clearly identifies 5.2 cm as the wavelength and coverts it to 0.052 m. The final answer, which has been given the correct unit, is right in the middle of the acceptable range.
Mark for (b) = 3 out of 3

## Example Candidate Response – high, continued

**(c)** The wave reaches a barrier. Fig. 6.2 shows the wave passing through a gap in the barrier.

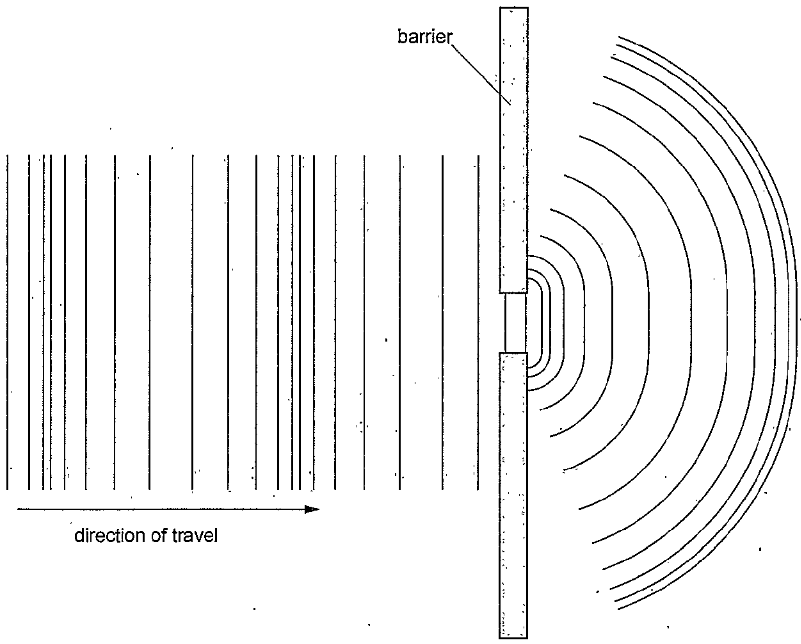



**Fig. 6.2**

The frequency of the wave is increased to a value many times greater than the value obtained in **(b)**.

Describe and explain **two ways** in which a diagram representing the wave with the greater frequency differs from Fig. 6.2.

1. * ~~there are more waves passing per second~~ the wavelength is smaller, lines closer together

2. the waves are closer together, compressions and rarefactions are closer together, more lines ~~therefore wave length decreases~~ * because there are more waves passing per seconde [3]

[Total: 7]

2

## Examiner comments

3 The candidate correctly makes two of the three points required. Mark for (c) = 2 out of 3

**Total mark awarded = 6 out of 7**

## How the candidate could have improved their answer

- **(b)** The candidate quoted the equation needed in the form $s = f\lambda$; the syllabus and conventional usage has $v = f\lambda$. The symbol $s$ was often used in this context for other quantities and although no credit has been forfeited here, it is usually best to use standard symbols.
- **(c)** A complete answer stated that a wave with a greater frequency would undergo less extensive diffraction, and this candidate made no mention of diffraction. The comments that this candidate made about the lines being closer together and the waves being closer together were not credited; it was only when the candidate stated that the compressions and rarefactions were closer that it was a clear and correct statement.

## Example Candidate Response – middle

**6** Fig. 6.1 is a full-scale diagram that represents a sound wave travelling in air.

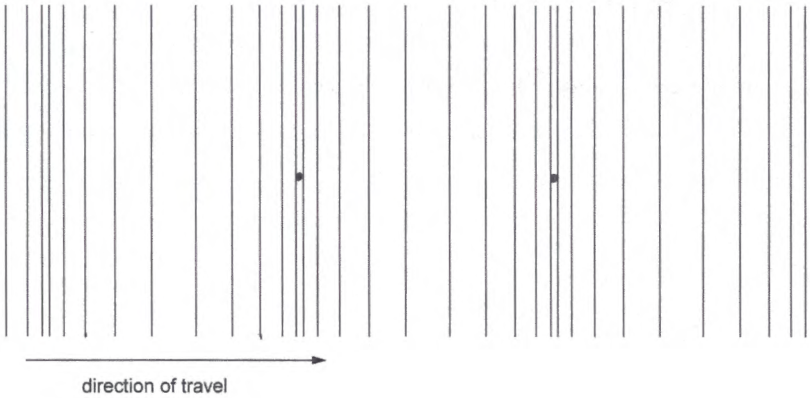



**Fig. 6.1**

1

**(a)** On Fig. 6.1, mark **two** points, each at the centre of a different compression. Label both of the points C. [1]

**(b)** The speed of sound in air is 330 m/s.

Measure the diagram and determine the frequency of the sound.

3.6 cm = 0.036 m

2

$V = F\lambda$

$F = \frac{V}{\lambda} = \frac{330\ m/s}{0.036\ m} = 9166.7\ Hz$

frequency = 9166.7 Hz [3]

## Examiner comments

1 The candidate marks two points on the diagram but does not label them despite being asked to do so. Since these are the only marks on the diagram and they are in correct positions, they must be correct.
Mark for (a) = 1 out of 1

2 The candidate supplies a relevant equation using conventional symbols. The candidate does not state what the distance 3.6 cm refers to but does use it as the wavelength. This is not within the acceptable range and, consequently, neither is the final answer within the acceptable range.
Mark for (b) = 1 out of 3

| Example Candidate Response – middle, continued | Examiner comments |
|---|---|
| **(c)** The wave reaches a barrier. Fig. 6.2 shows the wave passing through a gap in the barrier. | |

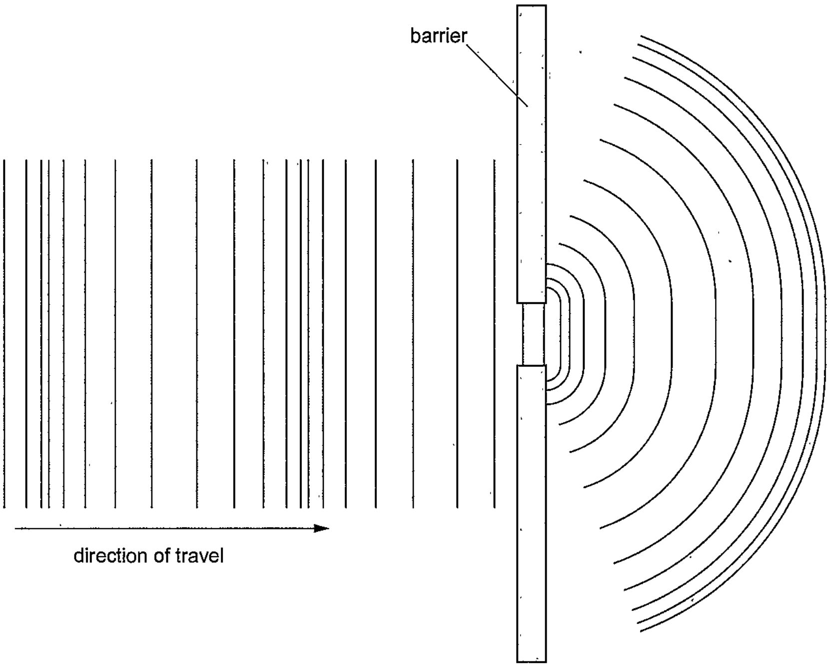



**Fig. 6.2**

The frequency of the wave is increased to a value many times greater than the value obtained in **(b)**.

Describe and explain **two** ways in which a diagram representing the wave with the greater frequency differs from Fig. 6.2.

1. There would be less diffraction as the wave length will decrease (3)

2. ........................................

[3]

[Total: 7]

**Examiner comments**

(3) The answer in 1 provides two valid statements but is incomplete. Mark for (c) = 2 out of 3

**Total mark awarded = 4 out of 7**

## How the candidate could have improved their answer

- **(a)** The labels 'c' should have been added.
- **(b)** The candidate was unaware of the distance on such a diagram that corresponds to wavelength and marking the two compressions initially was not sufficient. The correct equation was used and correctly rearranged, but a full correct answer requires the substitution of the correct values.
- **(c)** A remark concerning the decrease in the separation of the compressions or rarefactions was also required for a full correct answer.

## Example Candidate Response – low

**6** Fig. 6.1 is a full-scale diagram that represents a sound wave travelling in air.

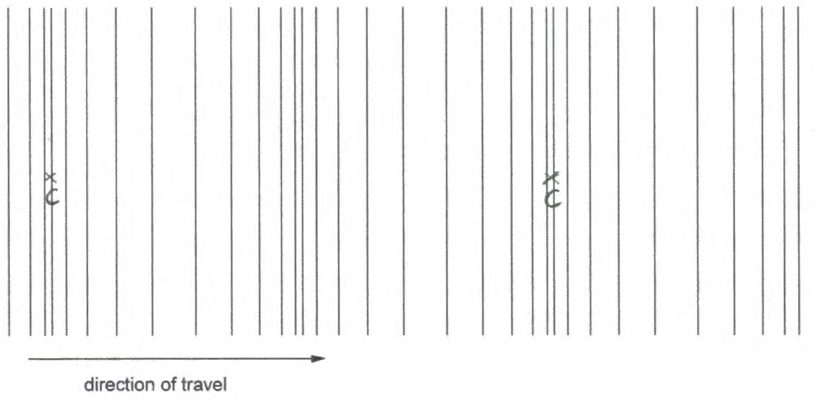



**Fig. 6.1**

1

**(a)** On Fig. 6.1, mark **two** points, each at the centre of a different compression. Label both of the points C. [1]

**(b)** The speed of sound in air is 330 m/s.

Measure the diagram and determine the frequency of the sound.

Wavelength = 0.08 m

$v = f\lambda$

$f = \frac{v}{\lambda} = \frac{330}{0.08} = 4125\,\text{Hz}$

2

frequency = 4125 Hz [3]

## Examiner comments

1 On the diagram in (a), two appropriate points have been marked and labelled Full credit has been earned.
Mark for (a)(i) = 1 out of 1

2 This answer includes a relevant and correct equation given in the usual notation. The candidate is clear that the wavelength is 0.08 m, but this is not correct even to the precision suggested by the 1 significant figure of the value offered.
Mark for (b) = 1 out of 3

## Example Candidate Response – low, continued

(c) The wave reaches a barrier. Fig. 6.2 shows the wave passing through a gap in the barrier.

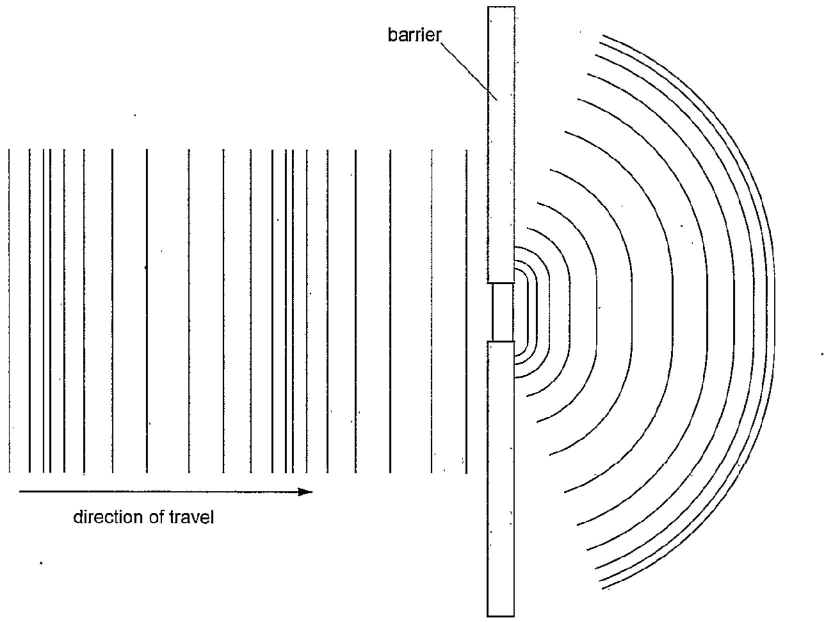



**Fig. 6.2**

The frequency of the wave is increased to a value many times greater than the value obtained in **(b)**.

Describe and explain **two** ways in which a diagram representing the wave with the greater frequency differs from Fig. 6.2.

*1. The amplitude of the wave increases

2. The number of waves increases than the waves in Fig. 6.2.

[3]

[Total: 7]

3

## Examiner comments

3 The candidate offers two differences in (c). The first is not correct as the change in frequency need not affect the amplitude of the wave and there is no reason for suspecting that the amplitude would increase. The second answer is similarly imprecise. There is only one wave shown in such a diagram and so what the candidate intends by the number of waves is not at all clear. It is not obvious that it refers to the number of wavelengths of the wave that fit into the diagram or to the number of compression to compression lengths that it contains.

Mark for (c) = 0 out of 3

**Total mark awarded = 2 out of 7**

## How the candidate could have improved their answer

- **(b)** Had the candidate's answer been of the correct size, it ought still to have been given as 0.080 m; a measurement to the nearest cm is not appropriate here.
- **(c)** The candidate should have referred to a smaller wavelength, compressions closer together and less diffraction.

## Common mistakes candidates made in this question

The most common source of error was due to imprecise marking of the points asked for. A few were either too large and could not really be described as indicating a single position or were marked with little concern about precision and not at the centre of a compression.

# Question 7

## Example Candidate Response – high

7 Fig. 7.1 represents an alternating current (a.c.) generator.

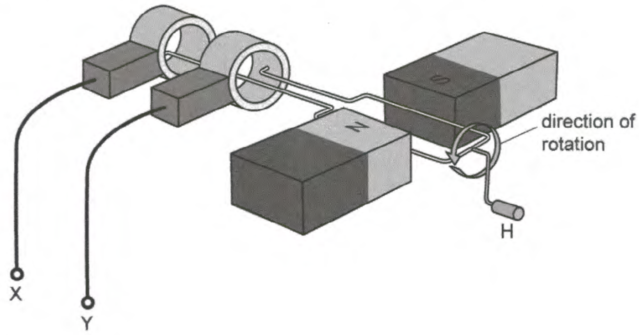



**Fig. 7.1**

(a) A student rotates the handle H, as shown in Fig. 7.1.

(i) On Fig. 7.2, sketch a graph to show how the electromotive force (e.m.f.) between terminals X and Y varies with time during **two** complete revolutions of the coil.

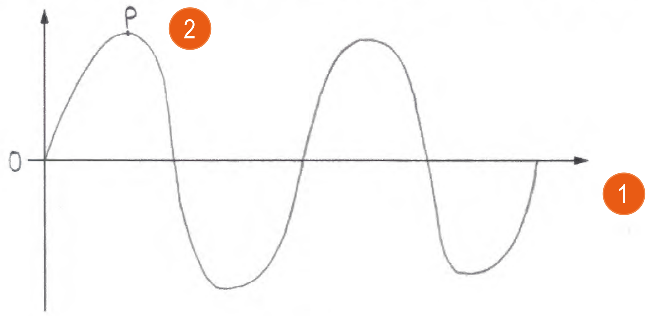



**Fig. 7.2**

[3]

(ii) On Fig. 7.2, mark and label a point P, for the e.m.f. when the coil is horizontal, as shown in Fig. 7.1. [1]

(iii) The student turns the handle more quickly.

State **two** ways in which the e.m.f. between terminals X and Y changes.

1. Greater e.m.f.

2. Gains e.m.f. faster. 3

[2]

## Examiner comments

1 This graph is clearly intended to be a sinusoidal curve and exactly two complete periods are drawn. The axes are unlabelled, and the curve shows a gentle but clear decrease in both amplitude and period as time elapses. The difference in amplitude between the second and fourth half-cycle is perhaps the most obvious change.
Mark for (a)(i) = 2 out of 3

2 The location of the letter P is correct.
Mark for (a)(ii) = 1 out of 1

3 The first point made is clearly correct; the e.m.f. induced is greater. The second mark is for stating that the frequency of the alternating e.m.f. is greater. The exact meaning of the expression used by the candidate is unclear and cannot be interpreted to mean an increased frequency.
Mark for (a)(iii) = 1 out of 2

## Example Candidate Response – high, continued

**(b)** Terminals X and Y are connected to the primary coil of a transformer.

State and explain what happens in the transformer as the student turns the handle of the a.c. generator.

There is an alternating current in the primary coil/input, causing a changing/alternating magnetic field to be created in the ~~iron core~~ primary coil, then the iron core is alternating magnetic field causes ~~causing~~ the secondary coil to induce alternating voltage [3]

4

**(c)** Explain why the power losses in transmission cables are lower when electrical energy is transmitted at higher voltages.

There is less current, so ~~lower~~ power loss by heat is less due to lower resistance. $P = I^2R$.

5

[2]

[Total: 11]

## Examiner comments

4 The candidate's answer makes all the points demanded by the mark scheme and reveals a clear understanding of the operation of a transformer.
Mark for (b) = 3 out of 3

5 The candidate's answer correctly states that there is a reduced current and that a consequence of this is less heat is lost from the cables.
Mark for (c) = 2 out of 2

**Total mark awarded = 9 out of 11**

## How the candidate could have improved their answer

- **(a)(i)** The candidate should have labelled the axes.
- **(a)(iii)** The candidate should have stated that the frequency increases.

| Example Candidate Response – middle | Examiner comments |
|---|---|

7 Fig. 7.1 represents an alternating current (a.c.) generator.

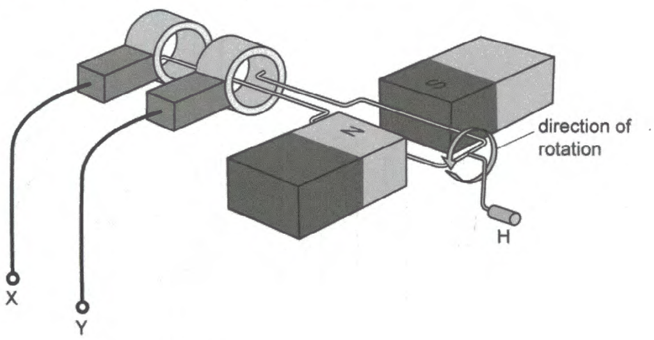



**Fig. 7.1**

**(a)** A student rotates the handle H, as shown in Fig. 7.1.

**(i)** On Fig. 7.2, sketch a graph to show how the electromotive force (e.m.f.) between terminals X and Y varies with time during **two** complete revolutions of the coil.

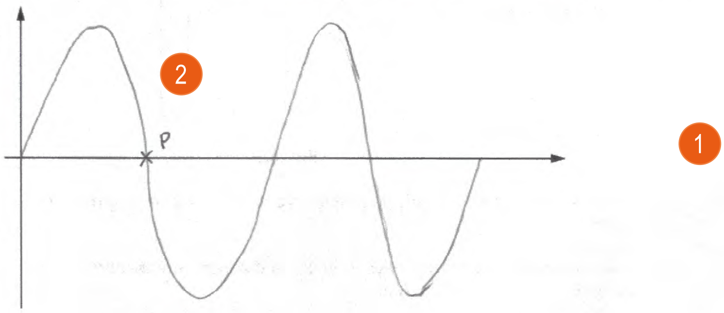



**Fig. 7.2**

[3]

**(ii)** On Fig. 7.2, mark and label a point P, for the e.m.f. when the coil is horizontal, as shown in Fig. 7.1. [1]

**(iii)** The student turns the handle more quickly.

State **two** ways in which the e.m.f. between terminals X and Y changes.

1. ~~higher~~ greater e.m.f
2. speed of variation of e.mf increases (3)

[2]

**Examiner comments**

1 The graph drawn is sinusoidal and the candidates includes exactly two cycles. The axes are unlabelled and although the amplitudes are fairly consistent, the periodic time is too variable. This is most noticeable when the second and third half-cycles are compared.
Mark for (a)(i) = 2 out of 3

2 The candidate marks point P at an incorrect position.
Mark for (a)(ii) = 0 out of 1

3 The first comment here is clearly correct and the second comment, although unusual in its wording, can only really refer to the increase in frequency, although it is not explicitly stated.
Mark for (a)(iii) = 2 out of 2

## Example Candidate Response – middle, continued

**(b)** Terminals X and Y are connected to the primary coil of a transformer.

State and explain what happens in the transformer as the student turns the handle of the a.c. generator.

The primary coil gets an alternating p.d which creates an alternating current and induces an alternating magnetic field in the coil. This alternating magnetic field is also induced through the iron core wich creates a p.d in the secondary coil and therefore a current flows. 4 [3]

**(c)** Explain why the power losses in transmission cables are lower when electrical energy is transmitted at higher voltages.

Voltage is travelling at a higher speed so the resistance is decreased. This minimises the amount of energy lost as heat. 5 [2]

[Total: 11]

## Examiner comments

4 The term 'induction' or 'induce' is twice applied to the production of a magnetic field, once in the primary coil and once in the core. The term is not used, however, to describe the electromagnetic induction that takes place in the secondary coil. The use of p.d. rather than e.m.f. is not entirely inaccurate, but questions of this sort very commonly demand the use of the term 'induction' to indicate that it is electromagnetic induction that is taking place and causing the voltage.
Mark for (b) = 2 out of 3

5 The candidate mentions reduced loss of energy but not the reduced current in the cables.
Mark for (c) = 1 out of 2

**Total mark awarded = 7 out of 11**

## How the candidate could have improved their answer

- **(a)(i)** The axes should have been labelled.
- **(a)(ii)** Point **P** should have been written at a peak or a trough.
- **(b)** The candidate should have stated that an e.m.f. is induced in the secondary coil.
- **(c)** The candidate should have stated that the reduced loss of thermal energy is because there is a smaller current.

## Example Candidate Response – low

7 Fig. 7.1 represents an alternating current (a.c.) generator.

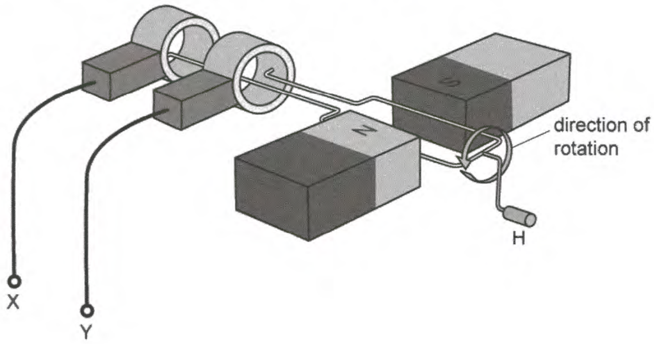



**Fig. 7.1**

**(a)** A student rotates the handle H, as shown in Fig. 7.1.

**(i)** On Fig. 7.2, sketch a graph to show how the electromotive force (e.m.f.) between terminals X and Y varies with time during **two** complete revolutions of the coil.

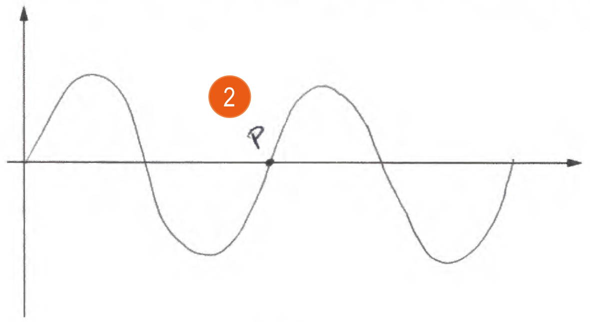



**Fig. 7.2**

1

[3]

**(ii)** On Fig. 7.2, mark and label a point P, for the e.m.f. when the coil is horizontal, as shown in Fig. 7.1. [1]

**(iii)** The student turns the handle more quickly.

State **two** ways in which the e.m.f. between terminals X and Y changes.

1. more induced emf is being produced 3
2. induced emf reachs X and Y faster

[2]

## Examiner comments

1 The candidate's curve drawn in the first part of the question, is sufficiently sinusoidal and it consists of two complete cycles. The axes are unlabelled and the differences between the third and fourth half-cycles are too great.
Mark for (a)(i) = 2 out of 3

2 The candidate does not correctly position point P.
Mark for (a)(ii) = 0 out of 1

3 The first answer is an acceptable way of referring to a larger induced e.m.f., but the meaning of the second comment is vague.
Mark for (a)(iii) = 1 out of 2

| Example Candidate Response – low, continued | Examiner comments |
|---|---|
| **(b)** Terminals X and Y are connected to the primary coil of a transformer.<br><br>State and explain what happens in the transformer as the student turns the handle of the a.c. generator.<br><br>The transformer ~~gets~~ recieves induced emf by ~~the~~ the primary coil ~~it is then~~ it then travels to iron core and reaches the secondary coil causing the circuit to have ~~em~~ current. (4) [3]<br><br>**(c)** Explain why the power losses in transmission cables are lower when electrical energy is transmitted at higher voltages.<br><br>V = IR , when the voltage is higher the power P = IV = I²R , loss is decreased because P ∝ 1/V and the current is ~~increased~~ decreased as well causing less heat loss. (5) [2]<br><br>[Total: 11] | (4) This answer does not indicate how transformer operates; it suggests that the e.m.f. from the generator is transferred to the secondary coil through the core directly and there is no mention of a magnetic field or of electromagnetic induction occurring in the transformer.<br>Mark for (b) = 0 out of 3<br><br>(5) The power referred to initially in (c) is not obviously the power wasted as heat in the cables. The final sentence, however, does explain correctly what is happening.<br>Mark for (c) = 2 out of 2<br><br>**Total mark awarded = 5 out of 11** |

## How the candidate could have improved their answer

- **(a)(i)** The axes should have been labelled.
- **(ii) P** should have been at a peak or trough.
- **(iii)** The candidate should have stated that the frequency increased.
- **(b)** The correct explanation refers to; alternating current in the primary, changing magnetic field in the secondary and e.m.f. induced in the secondary.

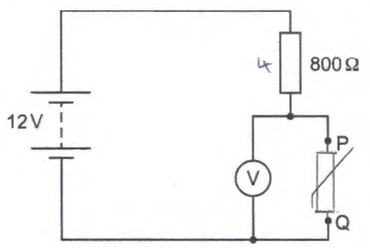
## Common mistakes candidates made in this question

- **(a)(i)** Few candidates labelled the axes, and this commonly made a difference to the final credit awarded. Although most candidates attempted a sinusoidal curve, the care with which such curves were drawn varied widely and the number of cycles was not always exactly equal to two.
- **(a)(ii)** The placing of **P** was often correct but it was incorrect to place it where the curve crossed the x-axis or for omitting this part altogether. Occasionally, the point was marked with insufficient care and was too far from a peak of the curve to be considered accurate.
- **(a)(iii)** Many candidates referred in some way to an increased e.m.f., but the increased frequency was commonly omitted. A fairly common approach was to attempt to distinguish between the e.m.f. induced at *X* and that at *Y*.
- **(b)** The omission of any reference to a magnetic field was not unusual and there were many candidates who stated that an e.m.f., or a current, passed from the primary coil to the secondary coil through the core.
- **(c)** A common misconception was the suggestion that changing the transmission voltage changed the resistance of the cables; the suggested change in resistance was sometimes consistent with a reduced current in the cables and sometimes not.

# Question 8

## Example Candidate Response – high

8 A student sets up a circuit that includes a 12 V battery, an 800 Ω resistor, a voltmeter and a thermistor. Fig. 8.1 is an incomplete circuit diagram because the symbol for the thermistor is missing.




1

**Fig. 8.1**

The thermistor is connected between terminals P and Q.

**(a)** Complete Fig. 8.1 by drawing the symbol for a thermistor between terminals P and Q. [1]

**(b)** The 12 V battery consists of eight identical cells connected in series.

Calculate the electromotive force (e.m.f.) of each cell.

2

e.m.f. = 1.5 V [1]

**(c)** The reading on the voltmeter is 8.0 V.

**(i)** Determine the resistance of the thermistor.

$R = \frac{V}{I}$ $I = \frac{V}{R}$

$I = \frac{4}{800}$

$R = \frac{8}{\frac{4}{800}} = \frac{8}{\frac{1}{200}}$

1600

3

resistance = 1600 Ω [3]

**(ii)** A few hours later, the student notices that the reading on the voltmeter is greater.

Explain what can be deduced from this observation.

The resistance of the thermistor increased due to a decrease in temperature. The voltage of the 800Ω resistor has decreased, making the voltage of the other increase [3]

4 [Total: 8]

## Examiner comments

1 The symbol added to the diagram in (a) is correct; it has been carefully drawn.
Mark for (a) = 1 out of 1

2 This candidate's correct answer gains the credit.
Mark for (b) = 1 out of 1

3 The final answer is correct, and the correct unit is included.
Mark for (c)(i) = 3 out of 3

4 This answer is far clearer. The two final deductions that deal with the resistance of the thermistor and its temperature are correct and are stated explicitly at the very beginning. The explanation is not exhaustive, but there is enough information given.
Mark for (c)(ii) = 3 out of 3

**Total mark awarded = 8 out of 8**

## How the candidate could have improved their answer

**(c)(i)** Although the final answer was correct and the correct unit was included, this was fortunate for the candidate as the working out was poorly set out and, had a single arithmetic error been made, this might have cost the candidate marks. There was little in the way of explanation and although the equation $V = IR$ was relevant, its use needed to be looked at carefully to see what the candidate had done.

## Example Candidate Response – middle

**8** A student sets up a circuit that includes a 12 V battery, an 800 Ω resistor, a voltmeter and a thermistor. Fig. 8.1 is an incomplete circuit diagram because the symbol for the thermistor is missing.

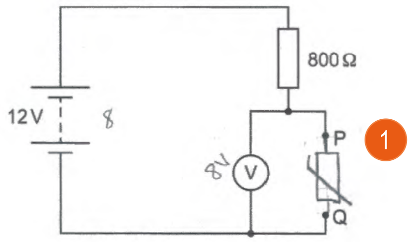



**Fig. 8.1**

The thermistor is connected between terminals P and Q.

**(a)** Complete Fig. 8.1 by drawing the symbol for a thermistor between terminals P and Q. [1]

**(b)** The 12 V battery consists of eight identical cells connected in series.

Calculate the electromotive force (e.m.f.) of each cell.

$\frac{12}{8}$

e.m.f. = 1.5 V (2) [1]

**(c)** The reading on the voltmeter is 8.0 V.

**(i)** Determine the resistance of the thermistor.

resistance = $\frac{\text{voltage}}{\text{current}}$ $\frac{12}{800}$ = 0.015 A

= $\frac{8}{0.015}$ = 533.3 Ω

resistance = 530 Ω (3) [3]

**(ii)** A few hours later, the student notices that the reading on the voltmeter is greater.

Explain what can be deduced from this observation.

The temperature has decreased because thermistors decrease their resistance with high temperatures. A higher resistance results in a higher voltage – voltage = resistance × current

voltage = resistance × current (4) [3]

[Total: 8]

## Examiner comments

(1) The thermistor symbol used on the diagram in (a) is correct.
Mark for (a) = 1 out of 1

(2) The answer is correct.
Mark for (b) = 1 out of 1

(3) The candidate is not clear about what to do here and chooses a method that does not lead to the correct answer. The relationship *V* = *IR* is used, but the voltage across the 800-ohm resistor is not 12 V and so the current and the final resistance value are incorrect. The correct equation is used, but a more careful consideration of the voltages in the circuit is needed.
Mark for (c)(i) = 1 out of 3

(4) The candidate makes a correct remark that relates to the decrease in temperature. The rest of the argument does not reveal an understanding of the operation of a potential divider.
Mark for (c)(ii) = 1 out of 3

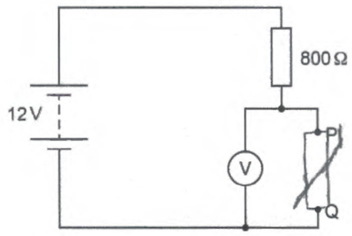
**Total mark awarded = 4 out of 8**

## How the candidate could have improved their answer

- **(c)(i)** The resistance across the 800-ohm resistor is not 12 V but 4 V and using the correct value would lead to a correct final answer.
- **(c)(ii)** The effect on the circuit of the smaller temperature must be explained.

## Example Candidate Response – low

8 A student sets up a circuit that includes a 12 V battery, an 800 Ω resistor, a voltmeter and a thermistor. Fig. 8.1 is an incomplete circuit diagram because the symbol for the thermistor is missing.




1

**Fig. 8.1**

The thermistor is connected between terminals P and Q.

**(a)** Complete Fig. 8.1 by drawing the symbol for a thermistor between terminals P and Q. [1]

**(b)** The 12 V battery consists of eight identical cells connected in series.

Calculate the electromotive force (e.m.f.) of each cell.

$\frac{12}{8} = 1.5$

2

e.m.f. = 1.5 N [1]

**(c)** The reading on the voltmeter is 8.0 V.

**(i)** Determine the resistance of the thermistor.

$R = \frac{V}{I}$ $\frac{12}{x} = 800$ $= 0.015$

$\frac{8}{0.015} = 533.3$

3

resistance = 533.3 Ω Ohms [3]

**(ii)** A few hours later, the student notices that the reading on the voltmeter is greater.

Explain what can be deduced from this observation.

The resistance of the resistor has reduced, and therefore there is more voltage passing through the thermistor.

4

[3]

[Total: 8]

## Examiner comments

1 The symbol in (a) is not carefully drawn, but it is clear enough for the mark to be awarded.
Mark for (a) = 1 out of 1

2 Although this answer is numerically correct, the candidate supplies the unit of force rather than that of e.m.f. which is, of course, one type of voltage.
Mark for (b) = 0 out of 1

3 The candidate uses the correct equation but calculates the current incorrectly. The p.d. across the 800-ohm resistor is 4.0 V rather than 12 V.
Mark for (c)(i) = 1 out of 3

4 The final conclusion is incorrect and seems to refer to the fixed resistor. The comment about the voltage passing through the thermistor suggests that the candidate does not fully understand the difference between current and voltage, but is an attempt to reword information that has been given in the question.
Mark for (c)(ii) = 0 out of 3

**Total mark awarded = 2 out of 8**

## How the candidate could have improved their answer

- **(b)** The correct unit is V.
- **(c)(i)** The resistance across the 800-ohm resistor is not 12 V but 4 V and using the correct value would lead to a correct final answer.
- **(c)(ii)** The candidate should have explained the effects on the circuit which show that the temperature is smaller.

## Common mistakes candidates made in this question

- **(a)** The symbols drawn were very commonly correct but a variety of incorrect answers was also seen. Some candidates added an arrowhead to the diagonal line and others had an acute angle between the two straight line sections.
- **(b)** Errors included multiplying 12 V by 8 rather than performing the division or though the unit was occasionally incorrect, it was frequently simply omitted.
- **(c)(i)** The error of calculating the current by dividing 12 V by 800 Ω rather than using a p.d. of 4.0 V was common and the consequent final answer of 533 Ω was seen on many occasions.
- **(c)(ii)** There were many candidates who did not understand how to manipulate the values given in a way appropriate for a potential divider. There were also those who, having reached a conclusion about the change in the resistance of the thermistor, made an inconsistent deduction about the change in the temperature responsible.

# Question 9

## Example Candidate Response – high

9 There are three naturally occurring isotopes of hydrogen: hydrogen-1, hydrogen-2 and hydrogen-3. The nuclide notation for hydrogen-1 is $^{1}_{1}H$.

(a) Write down the symbol, using nuclide notation, for:

hydrogen-2 ........ $^{2}_{1}H$ ........

hydrogen-3 ........ $^{3}_{1}H$ ........ (1)

[1]

(b) In a fusion reactor, a nucleus of hydrogen-2 and a nucleus of hydrogen-3 undergo fusion.

(i) State what is meant by *nuclear fusion*.

The joining together of two nuclei to form another element. (2)

[2]

(ii) The fusion reaction produces a free neutron and **one** other particle.

Write down, using nuclide notation, the equation that represents this reaction.

$$^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n$$

(3) [3]

(c) Nuclear fusion in the Sun is the source of most but not all of the resources that are used to generate electrical energy on Earth.

State **two** resources for which nuclear fusion in the Sun is **not** the source.

1. Geothermal energy
2. Nuclear energy (Nuclear fission) (4)

[2]

[Total: 8]

## Examiner comments

(1) The symbols given in (a) are correct.
Mark for (a)(i) = 1 out of 1

(2) The first comment about the joining together of nuclei is correct. The second comment is imprecise and, on its own, the word ‘element’ suggests rather more than a single nucleus.
Mark for (b)(i) = 1 out of 2

(3) This equation is completely correct and clearly presented; the numbers balance and the candidate identifies that the second product is a helium nucleus.
Mark for (b)(ii) = 3 out of 3

(4) The candidate supplies two correct answers.
Mark for (c) = 2 out of 2

**Total mark awarded = 7 out of 8**

## How the candidate could have improved their answer

**(b)(i)** It was necessary to state that a larger nucleus was produced or by stating that a large amount of energy was released by the fusion of hydrogen–2 and hydrogen–3.

| Example Candidate Response – middle | Examiner comments |
|---|---|
| **9** There are three naturally occurring isotopes of hydrogen: hydrogen-1, hydrogen-2 and hydrogen-3. The nuclide notation for hydrogen-1 is $^{1}_{1}\text{H}$.<br><br>**(a)** Write down the symbol, using nuclide notation, for:<br><br>hydrogen-2 $^{2}_{1}\text{H}$<br><br>hydrogen-3. $^{3}_{1}\text{H}$ **1** [1] | **1** The nuclide symbols given are correct and the mark is awarded.<br>Mark for (a) = 1 out of 1 |
| **(b)** In a fusion reactor, a nucleus of hydrogen-2 and a nucleus of hydrogen-3 undergo fusion.<br><br>**(i)** State what is meant by *nuclear fusion*.<br><br>This is when ~~to~~ two particles bond together at higher temperatures to form a new particle and to displace sub-atomic particles e.g. Neutron ~~or~~ and proton **2** [2] | **2** The answer makes no reference to either nuclei, or to the energy released by nuclear fusion.<br>Mark for (b)(i) = 0 out of 2 |
| **(ii)** The fusion reaction produces a free neutron and **one** other particle.<br><br>Write down, using nuclide notation, the equation that represents this reaction.<br><br>$^{2}_{1}\text{H} + ^{3}_{1}\text{H} \rightarrow ^{4}_{2}\text{He}$ + Neutron **3**<br><br>[3] | **3** The candidate identifies the production of a helium nucleus which suggests that the candidate knows what nuclide notation indicates. The question does, however, ask for an equation using nuclide notation and the nuclide notation for a neutron is not included. The candidate uses only the full word as given in the text.<br>Mark for (b)(ii) = 2 out of 3 |
| **(c)** Nuclear fusion in the Sun is the source of most but not all of the resources that are used to generate electrical energy on Earth.<br><br>State **two** resources for which nuclear fusion in the Sun is **not** the source.<br><br>1. Wind energy **4**<br>2. Magnetism (A.C Generator)<br><br>[2]<br><br>[Total: 8] | **4** The two suggestions are rather different, but neither is correct. The first suggestion is an energy resource although it is one that does depend on the Sun as its ultimate source. The second suggestion is not an energy source, but a mechanism used to transfer energy from the source to a more useful form.<br>Mark for (c) = 0 out of 2<br><br>**Total mark awarded = 3 out of 8** |

## How the candidate could have improved their answer

- **(b)(i)** The term 'particle' used instead of 'nucleus' was general and was not primarily used to describe nuclei themselves. The candidate had some idea of what nuclear fusion involved but had not expressed it in a sufficiently precise manner. The second half of the answer made some reference to subatomic particles, but this was also imprecise.
- **(b)(ii)** The candidate should have used nuclide notation for the neutron $^{1}_{0}n$.
- **(c)** The correct resources were; geothermal, tidal and nuclear.

| Example Candidate Response – low | Examiner comments |
|---|---|
| 9 There are three naturally occurring isotopes of hydrogen: hydrogen-1, hydrogen-2 and hydrogen-3. The nuclide notation for hydrogen-1 is $^{1}_{1}H$.<br><br>(a) Write down the symbol, using nuclide notation, for:<br><br>hydrogen-2 ........ α ........<br><br>hydrogen-3. ........ β ........ **1** [1] | **1** The candidate does not supply answers in nuclide notation, nor indeed particles that could be considered to be isotopes of hydrogen.<br>Mark for (a) = 0 out of 1 |
| (b) In a fusion reactor, a nucleus of hydrogen-2 and a nucleus of hydrogen-3 undergo fusion.<br><br>(i) State what is meant by *nuclear fusion*.<br><br>This is when two light nuclide join together to make one large nucleus. **2** [2] | **2** The answer is sufficient.<br>Mark for (b)(i) = 2 out of 2 |
| (ii) The fusion reaction produces a free neutron and **one** other particle.<br><br>Write down, using nuclide notation, the equation that represents this reaction.<br><br>$^{4}_{2}H \rightarrow ^{-0}_{-1}N + ^{0}_{-1}e$<br><br>**3** [3] | **3** The equation does suggest that the candidate has some understanding of the term nuclide notation, but the negative signs indicate uncertainty.<br>Mark for (b)(ii)= 0 out of 3 |
| (c) Nuclear fusion in the Sun is the source of most but not all of the resources that are used to generate electrical energy on Earth.<br><br>State **two** resources for which nuclear fusion in the Sun is **not** the source.<br><br>1. ........ wind resource. ........<br>2. ........ water resource. ........ **4** [2]<br><br>[Total: 8] | **4** The candidate does supply the names of two energy resources, but both rely ultimately on the Sun for their energy and so neither is correct.<br>Mark for (c) = 0 out of 2<br><br>**Total mark awarded = 2 out of 8** |

## How the candidate could have improved their answer

- **(a)** Writing $^{2}_{1}H$ and $^{3}_{1}H$ in that order.
- **(b)(i)** The initial use of the word 'nuclide' rather than 'nucleus' was unusual in this context, although it was not incorrect. The word 'nucleus', however, would have been better as it is more general. No reference was made to the evolution of energy, but this is only one of the ways of scoring the second mark.
- **(b)(ii)** The correct nuclide equation is $^{2}_{1}H + ^{3}_{1}H \rightarrow ^{1}_{0}n + ^{4}_{2}He$.
- **(c)** The correct resources are; geothermal, tidal and nuclear.

## Common mistakes candidates made in this question

- **(a)** There were candidates who supplied notations such as: $^{2}_{2}H$ or $^{3}_{3}H$ and some candidates did not seem to know what was expected at all.
- **(b)(i)** Many answers explained 'fusion' using the word 'fuse'. This does not reveal its essential meaning and terms such as 'joining together' or 'combining' are needed in the answer. There was also a tendency to refer to the joining together of atoms, molecules, particles or even elements all of which are too vague to be creditworthy.
- **(b)(ii)** Balanced and accurate equations were not frequently given and a common error was to have $^{2}_{1}H$ and $^{3}_{1}H$ on the right-hand side as the products rather than on the left-hand side of the equation.
- **(c)** A widespread belief was that either wave energy or wind energy are not dependent on the Sun and one of these was commonly supplied by candidates who clearly knew what was being asked and whose other response was correct.

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