Cambridge Assessment International Education

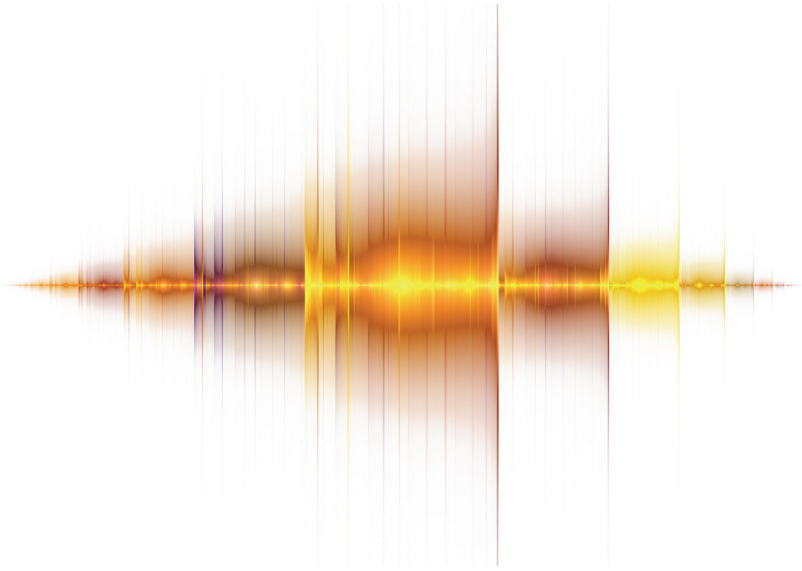
Example Candidate Responses

Paper 4

Cambridge IGCSE®

Physics 0625

For examination from 2016



Version 2.0

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Contents

Introduction

The main aim of this booklet is to exemplify standards for those teaching IGCSE Physics (0625), 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 to exemplify a range of answers. Each response is accompanied by a brief commentary explaining the strengths and weaknesses of the answers.

For each question, response is annotated with clear explanation of where and why marks were awarded or omitted. This, in turn, 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 will have to do to improve their marks. At the end there is a list of common mistakes candidates made in their answers for each question.

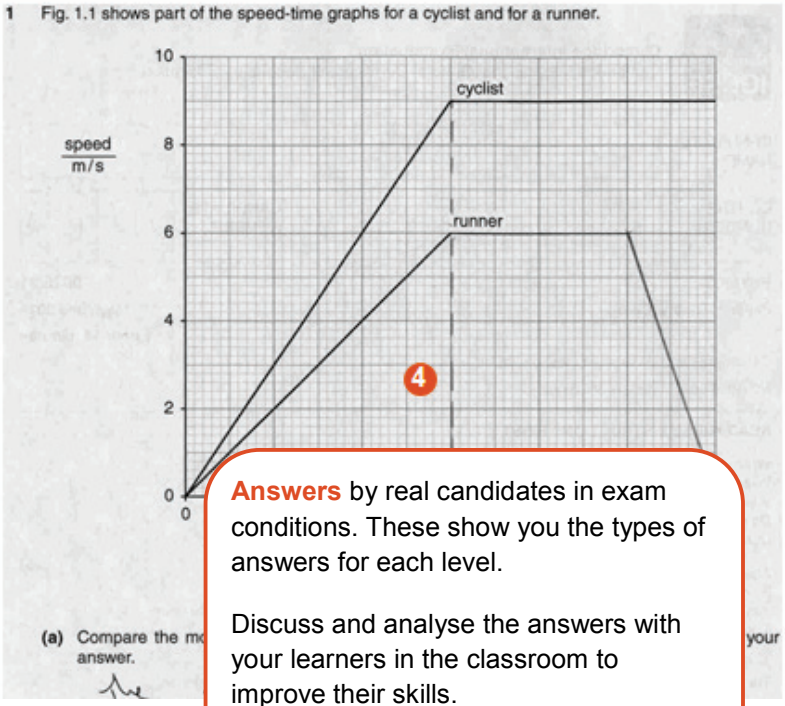
This document provides illustrative examples of candidate work. These help teachers to assess the standard required to achieve marks, beyond the guidance of the mark scheme. Some question types where the answer is clear from the mark scheme, such as short answers and multiple choice, have therefore been omitted.

The questions, mark schemes and pre-release material used here are available from the School Support Hub. These files are:

Question Paper 31, June 2016	
Question paper	0620_s16_qp_31.pdf
Mark scheme	0620_s16_ms_31.pdf
Question Paper 42, March 2016	
Question paper	0620_m16_qp_42.pdf
Mark scheme	0620_m16_ms_42.pdf
Question Paper 61, June 2016	
Question paper	0620_s16_qp_61.pdf
Mark scheme	0620_s16_ms_61.pdf

Other past papers, Examiner Reports and other teacher support materials are available on the School Support Hub at www.cambridgeinternational.org/support

How to use this booklet

Example Candidate Response – middle	Examiner comments
1 Fig. 1.1 shows part of the speed-time graphs for a cyclist and for a runner.  (a) Compare the mo … your answer.	1 This response indicates that the cyclist is gaining speed but does not give details of the motion of the runner. A mark is scored for identifying correctly the faster speed of the cyclist. Mark awarded for (a) = 1 out of 3

Examiner annotations: Each response is annotated with clear explanation of where and why marks were awarded or omitted. In this way it is possible for you to understand what candidates have done to gain their marks.

Answers 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.

How the candidate could have improved the answer

(a) To achieve full marks candidate should have …

(c) The candidate should have calculated the are… 81m having to gain full marks.

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

Common mistakes candidates made in this question

(b) A common misconception was that the cycli…

(c) A common incorrect value was 108m. Candid… the maximum speed by the total time. They did n…

Common mistakes a list of common mistakes candidates made in their answers for each question.

Assessment at a glance

All candidates take must enter for three papers.

Core candidates take:	
Paper 1	45 minutes
Multiple Choice	30%
40 marks	
40 four-choice multiple-choice questions	
Questions will be based on the Core subject content	
Assessing grades C–G	
Externally assessed	
and:	
Paper 3	1 hour 15 minutes
Theory	50%
80 marks	
Short-answer and structured questions	
Questions will be based on the Core subject content	
Assessing grades C–G	
Externally assessed	
All candidates take either:	
Paper 5	1 hour 15 minutes
Practical Test	20%
40 marks	
Questions will be based on the experimental skills in Section 4	
Assessing grades A*–G	
Externally assessed	

Extended candidates take:	
Paper 2	45 minutes
Multiple Choice	30%
40 marks	
40 four-choice multiple-choice questions	
Questions will be based on the Extended subject content (Core and Supplement)	
Assessing grades A*–G	
Externally assessed	
and:	
Paper 4	1 hour 15 minutes
Theory	50%
80 marks	
Short-answer and structured questions	
Questions will be based on the Extended subject content (Core and Supplement)	
Assessing grades A*–G	
Externally assessed	
or:	
Paper 6	1 hour
Alternative to Practical	20%
40 marks	
Questions will be based on the experimental skills in Section 4	
Assessing grades A*–G	
Externally assessed	

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Paper 4 – Theory (Extended)

Question 1

Example Candidate Response – high	Examiner comments

1 A driving instructor gives a student a sudden order to stop the car in the shortest possible time.

Fig. 1.1 shows the speed-time graph of the motion of the car from the moment the order is given.

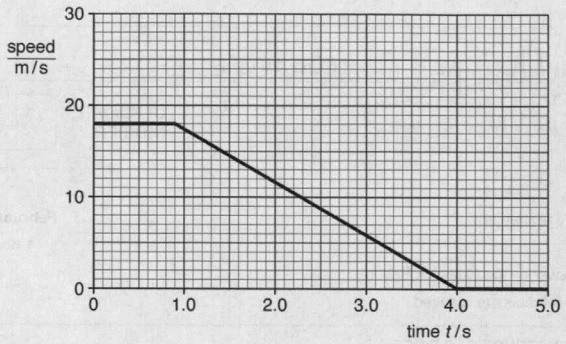


Fig. 1.1

(a) The order to stop is given at time $t = 0$ s.

(i) State the speed of the car at $t = 0$ s.

speed = 18 m/s [1]

(ii) Suggest why the car continues to travel at this speed for 0.9 s.

It takes some time before the car decelerates after the breaks are ~~pressed~~ pushed due to the hydraulic system. [1]

(b) Calculate

(i) the deceleration of the car between $t = 0.9$ s and $t = 4.0$ s,

deceleration = Gradient

Gradient = $\frac{y_2 - y_1}{x_2 - x_1}$

$= \frac{0 - 18}{4 - 0.9}$

$= \frac{-18}{3.1} = -5.81 \text{ m/s}^2$

deceleration = 5.81 m/s² [2]

(ii) the total distance travelled by the car from $t = 0$ s.

d = A under graph

$= \frac{1}{2}(a+b)h$

$= \frac{1}{2}(0.9 + 4)\,18$

$= 44.1$ m

distance = 44.1 m [3]

(c) Describe and explain a danger to a driver of not wearing a safety belt during a sudden stop.

The sudden deacrease in motion of the car will cause the diver to be thrusted out of his seat and hit the front glass of the car if he is not wearing a seat belt. [2]

[Total: 9]

1 The graph was read correctly and the correct speed stated.

2 The continuity of the initial speed was wrongly attributed to the hydraulic system of the car rather than to the reaction time of the driver.

Mark awarded for (a) = 1 out of 2

3 The formula was stated and the deceleration correctly calculated.

4 The distance required was recognised as being given by the area under the graph. The formula for the area of a trapezium was quoted, correct substitutions were made and the answer calculated correctly.

Mark awarded for (b) = 5 out of 5

5 The danger to the driver (hitting the windscreen) was described, but the suggestion that this was due to the driver being thrust forward, rather than continuing at the pre-braking speed of the car, was wrong.

Mark awarded for (c) = 1 out of 2

Total mark awarded = 7 out of 9

How the candidate could have improved the answer

(a) (ii) Reference should have been made to the reaction time of the driver rather than to a mechanical feature of the braking system.

(c) An explanation in terms of the driver continuing to move forwards with the previous speed of the car was needed to gain full credit.

Example Candidate Response – middle

1 A driving instructor gives a student a sudden order to stop the car in the shortest possible time.

Fig. 1.1 shows the speed-time graph of the motion of the car from the moment the order is given.

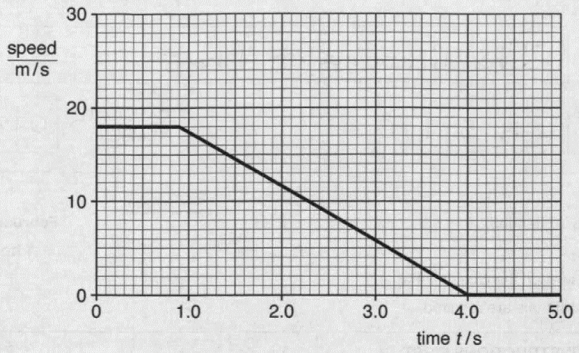


Fig. 1.1

(a) The order to stop is given at time $t = 0$ s.

(i) State the speed of the car at $t = 0$ s.

speed = 18m/s 1 [1]

(ii) Suggest why the car continues to travel at this speed for 0.9 s.

Due to a sudden break, the car travelled for more 0.9 seconds because the brakes stopped speed was accelerating 2 [1]

(b) Calculate

(i) the deceleration of the car between $t = 0.9$ s and $t = 4.0$ s,

gradient = deceleration

$\frac{y_2 - y_1}{x_2 - x_1} = x$

$\frac{0 - 18}{4 - 0.9} = x$

$\frac{-18}{3.1} = x$

$-5.806 = x$

$-5.81 = x$

deceleration = −5.81 m/s² 3 [2]

(ii) the total distance travelled by the car from $t = 0$ s.

distance = A under graph.

$\therefore \frac{1}{2} \times (a+b) \times h = A$

$\frac{1}{2} \times (1+4) \times 18 = A$

$45 = A$

distance = 45m 4 [3]

(c) Describe and explain a danger to a driver of not wearing a safety belt during a sudden stop.

The sudden stop caused the drivers body to lean forward. If no belt is worn, drivers can crash is forehead on the steering. 5

[2]

[Total: 9]

Examiner comments

1 The graph was read correctly and the correct speed was stated.

2 The answer given, suggesting that the car travelled for more than 0.9 s and stopped accelerating, bore no relation to the required response.

Mark awarded for (a) = 1 out of 2

3 The formula was stated and the deceleration correctly calculated.

4 The distance required was recognised as being given by the area under the graph. However, the substitution of 1 rather than 0.9 in the trapezium formula resulted in the wrong numerical answer.

Mark awarded for (b) = 3 out of 5

5 The danger to the driver (hitting the windscreen) was described correctly. The explanation, that the driver's body would lean forward, was vague and unacceptable.

Mark awarded for (c) = 1 out of 2

Total mark awarded = 5 out of 9

How the candidate could have improved the answer

(a) (ii) The driver's time to react should have been referred to.

(b) (ii) Correct numbers needed to be substituted into the correct formula that the candidate wrote down.

(c) The cause of the danger to the driver was also required.

Example Candidate Response – low

1 A driving instructor gives a student a sudden order to stop the car in the shortest possible time.

Fig. 1.1 shows the speed-time graph of the motion of the car from the moment the order is given.

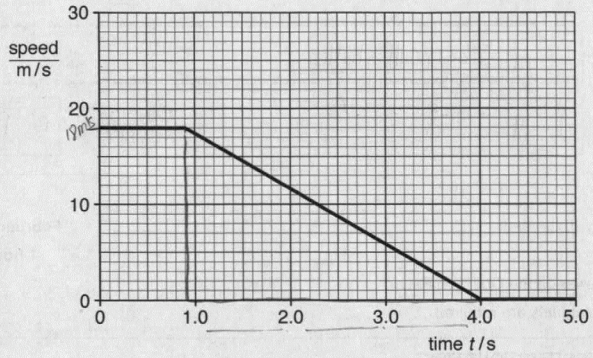


Fig. 1.1

(a) The order to stop is given at time $t = 0$ s.

(i) State the speed of the car at $t = 0$ s.

speed = 18m/s (1) [1]

(ii) Suggest why the car continues to travel at this speed for 0.9 s.

The car travels at the constant speed. (2)

[1]

(b) Calculate

(i) the deceleration of the car between $t = 0.9$ s and $t = 4.0$ s,

deceleration = $\frac{(v-u)}{t} = \frac{20}{-3.1}$

$= \frac{20-0}{0.9-4.0}$ $= -6.45$

deceleration = −6.45. (3) [2]

(ii) the total distance travelled by the car from $t = 0$ s.

① $18 \times 0.9 = 16.2$.

② $18 \times 3.1 = 55.8$

$16.2 + 55.8 = 72$.

distance = 72 m (4) [3]

(c) Describe and explain a danger to a driver of not wearing a safety belt during a sudden stop.

The driver may injour himself because he is not wearing a safetybelt. When the car suddenly stop, the driver may get a jerk or the body may come forward very rapidly and hit the stering. As the break is Pressed hardly so the car has to stop immediately. (5) [2]

[Total: 9]

Examiner comments

(1) The graph was read correctly and the correct speed stated.

(2) The statement that the car travels at constant speed, suggested failure to grasp the requirements of the question.

Mark awarded for (a) = 1 out of 2

(3) The formula quoted for calculating the deceleration was rewarded. The subsequent substitution into the formula was wrong.

(4) The candidate's work involved the calculation of the area of two rectangles rather than a rectangle and a triangle. This produced a wrong numerical answer. With no statement that the area under the graph was needed, no compensation marks were possible.

Mark awarded for (b) = 1 out of 5

(5) The danger to the driver was described correctly. The explanation failed to make any reference to the driver continuing to move forward with the speed of the car.

Mark awarded for (c) = 1 out of 2

Total mark awarded = 3 out of 9

How the candidate could have improved the answer

(a) (ii) A reason for the delay in applying the brakes was needed.

(b) (i) Correct numbers needed to be substituted into the formula that the candidate wrote down.

(b) (ii) Numbers obtained from the graph were written down, but it needed to be clear from these that the area under the graph was being deduced.

(c) The cause of the danger to the driver was also required.

Common mistakes candidates made in this question

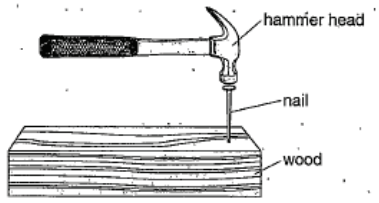
(a) (i) Failure to recognise the significance of the reaction time the driver was a common feature.

(b) (i) Many candidates failed to quote an acceptable formula. Others succeeded in this aspect, but then substituted wrong data from the graph.

(b) (ii) The relevance of finding the area under the graph was usually known, but incorrect substitutions or wrong arithmetic frequency followed.

(c) Having correctly describing the danger to the driver, many answers suggested that the driver experienced a force from the seat causing forward motion, rather than continuing to move forwards with previous speed of the car.

Question 2

Example Candidate Response – high	Examiner comments
2 Fig. 2.1 shows a hammer being used to drive a nail into a piece of wood.  Fig. 2.1 The mass of the hammer head is 0.15 kg. The speed of the hammer head when it hits the nail is 8.0 m/s. The time for which the hammer head is in contact with the nail is 0.0015 s. The hammer head stops after hitting the nail. (a) Calculate the change in momentum of the hammer head. momentum = v x m 8m/s x 0.15 change in momentum = 1.2 Kgm/s [2] (b) State the impulse given to the nail. 1.2 / 0.0015 = 800 800 x 0.0015 Force = Mom Ns / Time. Force x Time. impulse = 1.2 Ns [1] (c) Calculate the average force between the hammer and the nail. F = change in momentum / time. 1.2 Kg m/s / 0.0015 s average force = 800N. [2] [Total: 5]	1 The formula for momentum change was correctly stated, as were the numbers substituted and the ensuing calculation. Mark awarded for (a) = 2 out of 2 2 The candidate correctly stated the impulse. Mark awarded for (b) = 1 out of 1 3 The formula written as force = change in momentum / time was correctly stated as were the numbers substituted ensuring the correct response. Mark awarded for (c) = 2 out of 2 **Total mark awarded = 5 out of 5**

How the candidate could have improved the answer

Candidate was awarded full marks.

Example Candidate Response – middle

2 Fig. 2.1 shows a hammer being used to drive a nail into a piece of wood.

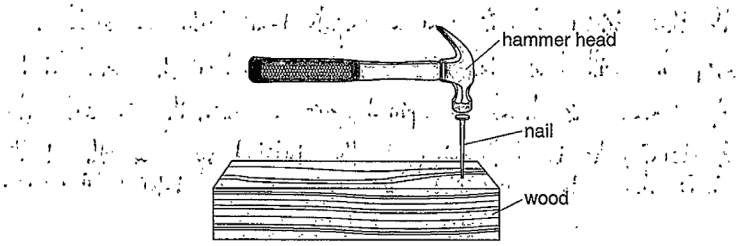


Fig. 2.1

The mass of the hammer head is 0.15 kg.
The speed of the hammer head when it hits the nail is 8.0 m/s.
The time for which the hammer head is in contact with the nail is 0.0015 s.

The hammer head stops after hitting the nail.

(a) Calculate the change in momentum of the hammer head.

mass x velocity − mass x velocity
0.15 x 8 0.15 x 0
1·2 kg m/s 0 kg m/s
1·2 − 0 = 1·2 kg m/s

change in momentum = 1.2 kg m/s [2]

(b) State the impulse given to the nail.

impulse = 1.2 Ns [1]

(c) Calculate the average force between the hammer and the nail.

average force = $\frac{2 \times \text{mass} \times \text{speed}}{\text{time}}$ = $\frac{2.4}{0.0015}$
= 1600 N
= $\frac{2 \times 0.15 \times 8}{0.0015}$

average force = 1600 N [2]

[Total: 5]

Examiner comments

1 The formula for momentum change was correctly stated, as were the numbers substituted and the ensuing calculation.

Mark awarded for (a) = 2 out of 2

2 The candidate correctly stated the impulse as being equal to the momentum change in **(a)**, albeit with the alternative acceptable unit.

Mark awarded for (b) = 1 out of 1

3 In this calculation, the formula $2mv/t$ was used rather than the correct mv/t.

Mark awarded for (c) = 0 out of 2

Total mark awarded = 3 out of 5

How the candidate could have improved the answer

(c) The formula *mv/t*, written as symbols or words, should have been used. The candidate used 2 x mass x speed / time. (Use of the word 'speed' rather than the correct word 'velocity' was condoned in this answer.)

Example Candidate Response – low	Examiner comments

2 Fig. 2.1 shows a hammer being used to drive a nail into a piece of wood.

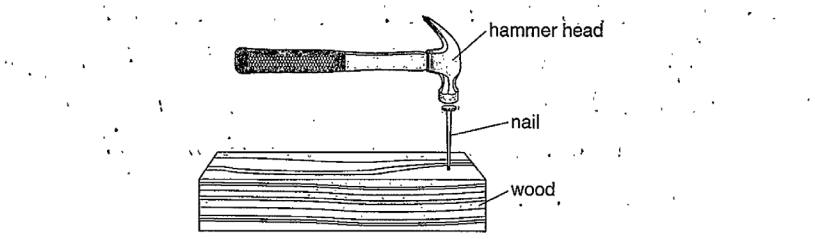


Fig. 2.1

The mass of the hammer head is 0.15 kg.
The speed of the hammer head when it hits the nail is 8.0 m/s.
The time for which the hammer head is in contact with the nail is 0.0015 s.

The hammer head stops after hitting the nail.

(a) Calculate the change in momentum of the hammer head.

Momentum = Mass x Velocity.
= 0·15 x 8·0
= 1·2

change in momentum = 1·2 [2]

(b) State the impulse given to the nail.

impulse = 0·0018. [1]

(c) Calculate the average force between the hammer and the nail.

Force = Mass x acceleration.

average force = ... [2]

[Total: 5]

1 The correct numerical value was calculated using the acceptable formula mass x velocity. Omission of the unit resulted in a 1 mark penalty.

Mark awarded for (a) = 1 out of 2

2 For no apparent reason, the impulse was stated as 0.0018 s.

Mark awarded for (b) = 0 out of 1

3 The formula written as force = mass x acceleration was rewarded. No substitutions into this formula followed.

Mark awarded for (c) = 1 out of 2

Total mark awarded = 2 out of 5

How the candidate could have improved the answer

(a) For both marks the candidate was required to write the correct unit with the numerical value that was calculated.

(b) The requirement was to recall that impulse = change of momentum and thus to repeat the answer to (a).

(c) The answer began correctly with F = mass x acceleration. No further work was shown. Data from the question should then have been used to evaluate the acceleration.

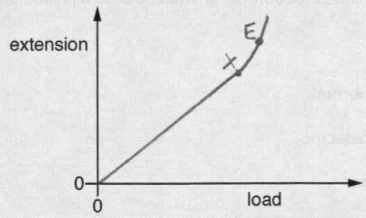
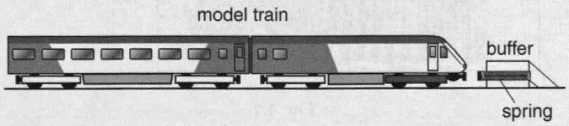
Common mistakes candidates made in this question

(a) The common error was to quote a wrong unit, e.g. kg / ms instead of kg m/s, or to omit a unit.

(b) Errors were made by candidates who failed to recall that change of momentum, (the answer to (a)), is equal to impulse.

(c) Failure to make progress after quoting $F = ma$ or $F = m(v - u)/t$ was a frequent mistake.

Question 3

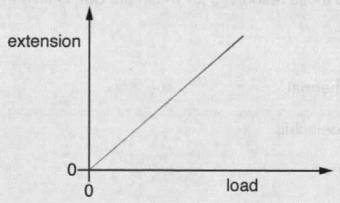
Example Candidate Response – high	Examiner comments
3 (a) (i) On Fig. 3.1, draw a graph of extension against load for a spring which obeys Hooke's law. [1]  1 Fig. 3.1 (ii) State the word used to describe the energy stored in a spring that has been stretched or compressed. Strain ~~elastic potential~~ energy or elastic potential energy 2 [1]	1 The drawing showed a straight line through the origin that became a curve at its upper end. The end of the straight line section was labelled X with a further label Y on the curve. With an appropriate key for point X, e.g. limit of proportionality, a mark would have been possible. 2 The candidate wrote 'strain energy or elastic potential energy'. Either of these alternatives is acceptable. Mark awarded for (a) = 1 out of 2
(b) Fig. 3.2 shows a model train, travelling at speed v, approaching a buffer.  Fig. 3.2 The train, of mass 2.5 kg, is stopped by compressing a spring in the buffer. After the train has stopped, the energy stored in the spring is 0.48 J. Calculate the initial speed v of the train. $KE = \frac{1}{2} \times m \times v^2$ $0.48 = \frac{1}{2} \times 2.5 \times v^2$ $v^2 = 0.384$ $v = \sqrt{0.384}$ $v = 0.62$ m/s $v =$ 0.62 m/s 3 [4] [Total: 6]	3 For a successful calculation, candidates needed to assume that all the energy stored in the spring transfers to the train as kinetic energy. The candidate made this assumption and successfully carried out the calculation of the speed of the train. Mark awarded for (b) = 4 out of 4 **Total mark awarded = 5 out of 6**

How the candidate could have improved the answer

(a) (i) The candidate's graph should have terminated at point X. Alternatively, the point X could have been identified as the limit of proportionality, inferring that Hooke's was applicable up to this point.

Example Candidate Response – middle

3 (a) (i) On Fig. 3.1, draw a graph of extension against load for a spring which obeys Hooke's law. [1]



1

Fig. 3.1

(ii) State the word used to describe the energy stored in a spring that has been stretched or compressed.

Static energy 2 [1]

(b) Fig. 3.2 shows a model train, travelling at speed *v*, approaching a buffer.

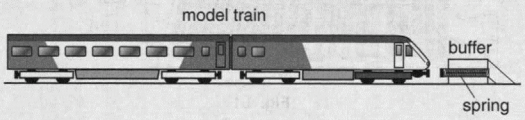


Fig. 3.2

The train, of mass 2.5 kg, is stopped by compressing a spring in the buffer. After the train has stopped, the energy stored in the spring is 0.48 J.

Calculate the initial speed *v* of the train.

Mass: m = 2.5 kg Energy Stored in Spring: 0.48 J

Potential energy: Kinetic energy

$0.48 = \frac{1}{2} mv^2$

$0.48 = \frac{1}{2} \times 0.48 \times v^2$

$0.96 = 0.48 \times v^2$

$\frac{0.96}{0.48} = v^2$

$v^2 = 2$

$v = \sqrt{2}$

3

$v = 1.4$ m/s [4]

$v = 1.4$ m/s

[Total: 6]

Examiner comments

1 The straight-line graph drawn through the origin fulfilled the requirement for the mark.

2 'Static' energy was not an acceptable statement of the type of energy stored in a spring.

Mark awarded for (a) = 1 out of 2

3 The 2 marks awarded were for the use of $1/2mv^2$ and for equating this to the energy stored in the spring. An incorrect substitution of the value of *m* meant that no further marks could be allowed.

Mark awarded for (b) = 2 out of 4

Total mark awarded = 3 out of 6

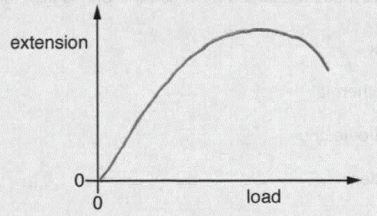
How the candidate could have improved the answer

(a) (ii) The type of energy should have been identified as 'strain' or 'elastic' rather 'static'.

(b) The correct formula was stated. The mass of the train should have been substituted for the mass in that formula rather than the energy stored in the spring.

Example Candidate Response – low	Examiner comments

3 (a) (i) On Fig. 3.1, draw a graph of extension against load for a spring which obeys Hooke's law. [1]



1

Fig. 3.1

(ii) State the word used to describe the energy stored in a spring that has been stretched or compressed.

Elastic energy 2 [1]

(b) Fig. 3.2 shows a model train, travelling at speed *v*, approaching a buffer.

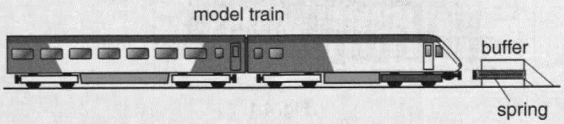


Fig. 3.2

The train, of mass 2.5 kg, is stopped by compressing a spring in the buffer. After the train has stopped, the energy stored in the spring is 0.48 J.

Calculate the initial speed *v* of the train.

$= \frac{1}{2} mv^2$

$= \frac{1}{2} 2.5 \times 0.48^2$

$= 0.288$

$v =$ 0.288 3 [4]

[Total: 6]

1 A curved graph drawn from the origin was unacceptable.

2 The reference to elastic energy gained the mark.

Mark awarded for (a) = 1 out of 2

3 $1/2mv^2$ was seen and rewarded with a mark. No correct work followed.

Mark awarded for (b) = 1 out 4

Total mark awarded = 2 out of 6

How the candidate could have improved the answer

(a) (i) The graph required was a straight line starting at the origin, not a curve.

(b) The candidate wrote down the correct formula for kinetic energy, but failed to equate this with the given quantity of energy stored in the spring.

Common mistakes candidates made in this question

(a) (i) Failure to draw a straight line starting at the origin.

(a) (ii) Wrong identification of the type of energy stored in a spring.

(b) After a correct statement of the formula for kinetic energy, failing to equate this to the given quantity of energy stored in the spring, or, having done this correctly, making mistakes with the ensuing calculation.

Question 4

Example Candidate Response – High

4 **(a)** The source of solar energy is the Sun.

Tick the box next to those resources for which the Sun is also the source of energy.

- [✓] coal
- [ ] geothermal
- [✓] hydroelectric
- [ ] nuclear
- [✓] wind

[2]

(b) Fig. 4.1 shows a solar water-heating panel on the roof of a house.

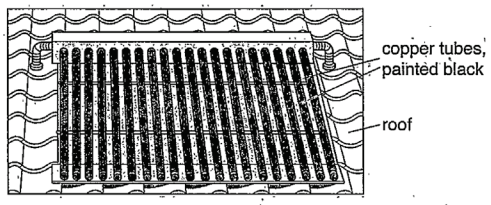


Fig. 4.1

Cold water flows into the copper tubes, which are heated by solar radiation. Hot water flows out of the tubes and is stored in a tank.

(i) Explain why the tubes are made of copper and are painted black.

The tubes are made of copper because copper is a good conductor of heat, so it will be heated easily. It is painted black because black objects are good absorbers of heat.

[2]

(ii) In 5.0 s, 0.019 kg of water flows through the tubes. The temperature of the water increases from 20 °C to 72 °C. The specific heat capacity of water is 4200 J/(kg °C).

Calculate the thermal energy gained by the water in 5.0 s.

energy = $mc\Delta T$

energy = $0.019 \times 4200 \times (72 - 20)$

$= 79.8 \times 52$

$= 4149.6$ J

thermal energy = 4149.6 J [3]

(iii) The efficiency of the solar panel is 70%.

Calculate the power of the solar radiation incident on the panel.

70% → 4149.6

100% → $\frac{4149.6}{70} \times 100 = 5928$

power = 5928 W [2]

[Total: 9]

Examiner comments

1 The 3 correct boxes, coal, hydroelectric and wind, were ticked.

Mark awarded for (a) = 2 out of 2

2 A correct explanation for the use of copper tubes was given. The explanation for the tubes being painted black required a reference to their good absorption of radiation or infra-red, not simply 'heat' as suggested by the candidate.

3 The thermal energy was correctly calculated, correct substitutions having been made into the recalled formula.

4 Having written an acceptable definition of efficiency, the candidate calculated the energy incident on the panel in the stated time rather than the power.

Mark warded for (b) = 5 out of 7

Total mark awarded = 7 out of 9

How the candidate could have improved the answer

(b) (i) The second part required 'tubes painted black because black is a good absorber of radiation', not simply 'heat'.

(b) (iii) In order to calculate the power input, the thermal energy calculated in (b) (ii) needed to be divided by 5 before the subsequent calculation. The candidate's answer was the energy input.

Example Candidate Response – middle

4 (a) The source of solar energy is the Sun.

Tick the box next to those resources for which the Sun is also the source of energy.

- ☐ coal
- ☐ geothermal
- ☑ hydroelectric
- ☐ nuclear
- ☑ wind

1

[2]

(b) Fig. 4.1 shows a solar water-heating panel on the roof of a house.

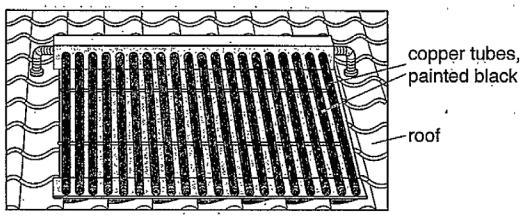


Fig. 4.1

Cold water flows into the copper tubes, which are heated by solar radiation. Hot water flows out of the tubes and is stored in a tank.

(i) Explain why the tubes are made of copper and are painted black.

Copper tubes conduct heat and can easily pass heat to the water flowing.
Black painted tube

2

[2]

(ii) In 5.0 s, 0.019 kg of water flows through the tubes. The temperature of the water increases from 20 °C to 72 °C. The specific heat capacity of water is 4200 J/(kg °C).

Calculate the thermal energy gained by the water in 5.0 s.

$H = mc\Delta t$

$H = 0.019 \times 4200 \times 52 = 4149.6 \times 5 = 20748$

thermal energy = 20748 J

3

[3]

(iii) The efficiency of the solar panel is 70%.

Calculate the power of the solar radiation incident on the panel.

$\frac{4149.6 \times 100}{1 \times 70} = 5928$

power = 5928 W/s

4

[2]

[Total: 9]

Examiner comments

1 The hydroelectric and wind boxes only were ticked, the candidate presumably not realising that coal is derived from wood, for which the growth requires sunlight.

Mark awarded for (a) = 1 out of 2

2 The candidate wrote that copper conducts heat, as do all metals, rather than that copper is a good conductor of heat.
No explanation as to why the tubes are painted black was offered.

3 The correct formula was used, correct substitutions were made, and the thermal energy correctly calculated. This thermal energy was then inexplicably multiplied by the time of heating, resulting in the loss of a mark.

4 Having made correct substitution into an energy formula (not written down), the energy incident on the panel was calculated, rather than the power.

Mark awarded for (b) = 3 out of 7

Total mark awarded = 4 out of 9

How the candidate could have improved the answer

(a) A tick was also required in the box for ‘coal’.

(b) (i) An explanation for the tubes being painted black was also required. None was offered.

(b) (ii) The candidate should not have multiplied the value of the energy that had been correctly calculated, by the time of heating.

(b) (iii) In order to calculate the power input, the thermal energy calculated in (b) (ii) needed to be divided by 5 before the subsequent calculation. The candidate’s answer was the energy input.

Example Candidate Response – low

4 (a) The source of solar energy is the Sun.

Tick the box next to those resources for which the Sun is also the source of energy.

- ☐ coal
- ☑ geothermal
- ☐ hydroelectric
- ☑ nuclear
- ☐ wind

1

[2]

(b) Fig. 4.1 shows a solar water-heating panel on the roof of a house.

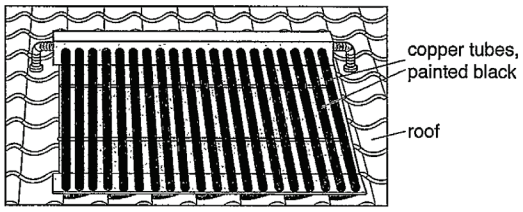


Fig. 4.1

Cold water flows into the copper tubes, which are heated by solar radiation. Hot water flows out of the tubes and is stored in a tank.

(i) Explain why the tubes are made of copper and are painted black.

Copper is a good conductor of heat and colour black is a good absorber of heat.

2

[2]

(ii) In 5.0 s, 0.019 kg of water flows through the tubes. The temperature of the water increases from 20 °C to 72 °C. The specific heat capacity of water is 4200 J/(kg °C).

Calculate the thermal energy gained by the water in 5.0 s.

$Q = m \times \Delta\theta \times c$

$Q = 0.019 \times 52 \times 4200\ J/kg°C$

$= 4149.6\ J \times 5 = 20748\ J$

thermal energy = ~~4149.6 J~~ 20748 J 3 [3]

(iii) The efficiency of the solar panel is 70%.

Calculate the power of the solar radiation incident on the panel.

$\frac{x}{4149.6} \times 100 = 70 = 2904.72\ J$

power = 2904.72 J 4 [2]

[Total: 9]

Examiner comments

1 It is possible that the candidate had misread the question. The 2 boxes ticked were those not associated with energy derived from the Sun.

Mark awarded for (a) = 0 out of 2

2 A correct explanation for the use of copper tubes was given. As with many answers to this question about the reason for using tubes painted black, the candidate referred to their good absorption of heat, not thermal energy or infra-red, as required.

3 The correct formula was used, correct substitutions were made, and the thermal energy correctly calculated. This thermal energy was then multiplied by the time of heating, resulting in a mark deduction.

4 A formula defining energy was not written down. The use of data did not suggest that a correct formula had been recalled.

Mark awarded for (b) = 3 out of 7

Total mark awarded = 4 out of 9

How the candidate could have improved the answer

(a) The candidate left unticked the 3 boxes that should have been ticked, instead ticking the other 2 wrong boxes. It is possible that the question had been misinterpreted.

(b) (i) The second part required 'tubes painted black because black is a good absorber of radiation', not simply 'heat'.

(b) (ii) The candidate should not have multiplied the value of the correctly calculated energy by the time of heating.

(b) (iii) The formula relating efficiency to energy input and output, or power input and output, should have been written down, which if correct would have gained a mark.

Common mistakes candidates made in this question

(a) Possible misreading of the question may have led to some of the wrong responses. In general, awareness that the Sun is not the origin of nuclear and geothermal energy is not a well-known idea.

(b) (i) Many answers referred to the good absorption of heat radiation by a black-painted surface rather than the correct good absorption of radiation.

(b) (ii) It was not uncommon for answers to show a correct value for the thermal energy gained subsequently multiplied by the time.

(b) (iii) Failure to write down a formula before attempting to use the numbers deprived many of a possible mark. Many answers failed to address the power aspect, working entirely with energy instead.

Question 5

Example Candidate Response – high

5 (a) A student carries out an experiment to find the relationship between the pressure p and the volume V of a fixed mass of gas. The table contains four of her sets of measurements.

p/kPa	250	500	750	1000
V/cm^3	30.0	15.2	9.8	7.6

(i) Use the data in the table to suggest the relationship between the pressure and the volume in this experiment. Explain how you reach your conclusion.

as the gas pressure decreases increases the volume increases decreases. Therefore therefore pressure is inversly proportional to volume

1 [2]

(ii) State the property of the gas, apart from the mass, that remains constant during the experiment.

temperature 2 [1]

(b) A lake is 5.0 m deep. The density of the water is 1000 kg/m^3.

(i) Calculate the pressure at the bottom of the lake due to this depth of water.

$P = \rho g h$

$P = 1000 \times 10 \times 5 = 50000$

pressure = 50000 Pa 3 [2]

(ii) A bubble of gas escapes from the mud at the bottom of the lake and rises to the surface.

Place one tick in each row of the table to indicate what happens to the volume, the mass and the density of the gas in the bubble. Assume that no gas or water vapour enters or leaves the bubble.

	increases	stays the same	decreases
volume of bubble	✓		
mass of gas in bubble		✓	
density of gas in bubble	✓		

4 [2]

[Total: 7]

Examiner comments

1 The statement that pressure and volume are inversely proportional to each other was correct and probably based on recall of Boyle's law. However, the explanation that this is simply because as the volume decreases the pressure increases is insufficient to explain the inverse relationship.

2 The temperature was correctly identified as being the quantity that stays constant, this being a conditional factor in the statement of Boyle's law.

Mark awarded for (a) = 2 out of 3

3 The formula $P = h\rho g$ was stated was used to obtain the correct pressure.

4 The boxes for 'volume increases' and 'mass stays the same' were ticked as required. Correctly using the recall of density = mass/volume would have directed the candidate to tick 'density decreases' rather than increases.

Mark awarded for (b) = 3 out of 4

Total mark awarded = 5 out of 7

How the candidate could have improved the answer

(a) (i) A complete answer required a reference as to how the data confirmed the relationship between the pressure and volume. The answer only stated the relationship.

(b) (ii) The answer should have shown that the density of the gas decreases.

Example Candidate Response – middle

5 (a) A student carries out an experiment to find the relationship between the pressure p and the volume V of a fixed mass of gas. The table contains four of her sets of measurements.

p/kPa	250	500	750	1000
V/cm^3	30.0	15.2	9.8	7.6

(i) Use the data in the table to suggest the relationship between the pressure and the volume in this experiment. Explain how you reach your conclusion.

Pressure is inversely proportional to volume.
This is because the when the volume decreases
the pressure increases. 1

.....[2]

(ii) State the property of the gas, apart from the mass, that remains constant during the experiment.

Energy 2 .....[1]

(b) A lake is 5.0 m deep. The density of the water is 1000 kg/m^3.

(i) Calculate the pressure at the bottom of the lake due to this depth of water.

$p = \rho g h$
$= 1000 \times 10 \times 5$
$= 50{,}000$

pressure = 50,000 Pa 3 .....[2]

(ii) A bubble of gas escapes from the mud at the bottom of the lake and rises to the surface.

Place one tick in each row of the table to indicate what happens to the volume, the mass and the density of the gas in the bubble. Assume that no gas or water vapour enters or leaves the bubble.

	increases	stays the same	decreases
volume of bubble	✓		
mass of gas in bubble			✓
density of gas in bubble			✓

4 [2]

[Total: 7]

1 The correct statement that pressure and volume are inversely proportional to each other was probably based on recall of an aspect of Boyle's law. The explanation that this is because as the volume decreases the pressure increases is insufficient to explain this relationship.

2 'Energy' was chosen as being the quantity that stays constant rather than the correct 'temperature'. It appears that the candidate's recall of Boyle's law was incomplete.

Mark awarded for (a) = 1 out of 3

3 The formula P = hρg was stated was used to obtain the correct pressure.

4 To have ticked the boxes volume increases (correct), mass decreases (wrong) and density decreases (correct), suggests that the candidate did not consider the validity of the formula density = mass/volume in the approach to these responses.

Mark awarded for (b) = 3 out of 4

Total mark awarded = 4 out of 7

How the candidate could have improved the answer

(a) (i) A complete answer required a reference as to how the data confirmed the relationship between the pressure and volume. The answer only stated the relationship.

(a) (ii) Temperature should have been stated as the property of the gas that remained constant, not energy.

(b) (ii) The answer should have shown that the mass of the gas stays the same.

Example Candidate Response – low

5 (a) A student carries out an experiment to find the relationship between the pressure p and the volume V of a fixed mass of gas. The table contains four of her sets of measurements.

p/kPa	250	500	750	1000
V/cm^3	30.0	15.2	9.8	7.6

(i) Use the data in the table to suggest the relationship between the pressure and the volume in this experiment. Explain how you reach your conclusion.

Pressure is Inversely proportion to Volume
As Pressure increases then Volume also decreases. 1

.....[2]

(ii) State the property of the gas, apart from the mass, that remains constant during the experiment.

~~Weight~~ Density 2 .....[1]

(b) A lake is 5.0 m deep. The density of the water is 1000 kg/m^3.

(i) Calculate the pressure at the bottom of the lake due to this depth of water.

pressure = 5 × 1000

5000
pressure = ~~0.005~~ 3 .....[2]

(ii) A bubble of gas escapes from the mud at the bottom of the lake and rises to the surface.

Place one tick in each row of the table to indicate what happens to the volume, the mass and the density of the gas in the bubble. Assume that no gas or water vapour enters or leaves the bubble.

	increases	stays the same	decreases
volume of bubble		✓	
mass of gas in bubble			✓
density of gas in bubble			✓

4 [2]

[Total: 7]

Density = mass / volume

Examiner comments

1 The relationship between pressure and volume was correctly stated. From the explanation given it is apparent that there is a general belief that an inversely proportional relationship is confirmed if one quantity increases and the other one decreases.

2 To answer this correctly, there needs to be a thorough knowledge of a complete statement of Boyle's law and the relationship between density, mass and volume. The statement that density stays constant suggests a lack of this knowledge.

Mark awarded for (a) = 1 out of 3

3 The depth of the lake and density of the water were multiplied together. No recall of $P = hpg$ was apparent.

4 The candidate ticked the boxes for volume stays the same and mass decreases, both wrong. Although density = mass/volume had been written down, the box for density decreases was ticked correctly, although it did not follow from the previous wrong ticks, gaining a mark.

Mark awarded for (b) = 1 out of 4

Total mark awarded = 2 out of 7

How the candidate could have improved the answer

(a) (i) A complete answer required a reference as to how the data confirmed the relationship between pressure and volume. The answer only stated the relationship.

(a) (ii) Temperature should have been stated as the property of the gas that remained constant, not mass.

(b) (i) Candidates should always state a relevant formula, which if correct, gains a mark. In this case no formula was stated and the use of numbers in the calculation was totally incorrect.

(b) (ii) The answer should have shown that the volume of the gas increases and the mass of the gas stays the same.

Common mistakes candidates made in this question

(a) (i) The requirement to use the data in the table was infrequently complied with. Candidates could either state that the products of *P* and *V* were all about 7500 or show that if pressure doubles the volume halves, or vice versa.

(a) (ii) Many instances of candidates stating the wrong property as constant were seen.

(b) (i) Most mistakes that were made were due to failure to recall the required formula.

(b) (ii) One, or less frequently two, wrongly placed ticks were in seen in a significant number of answers. It was particularly disappointing to see a response suggesting that the mass of the bubble changes.

Question 6

Example Candidate Response – high

6 (a) Fig. 6.1 represents the waveform of a sound wave. The wave is travelling at constant speed.

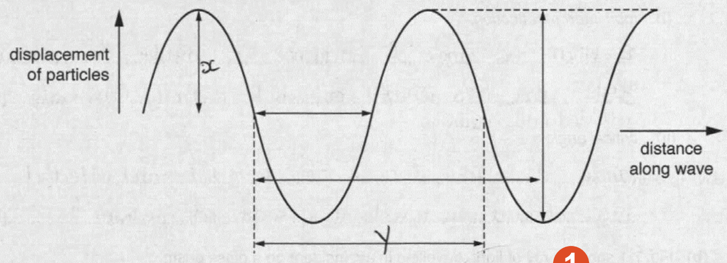


Fig. 6.1

(i) On Fig. 6.1,

1. label with the letter X the marked distance corresponding to the amplitude of the wave, [1]

2. label with the letter Y the marked distance corresponding to the wavelength of the wave. [1]

(ii) State what happens to the amplitude and the wavelength of the wave if

1. the loudness of the sound is increased at constant pitch,

amplitude ....increases..........

wavelength ....increases.......... [1]

2. the pitch of the sound is increased at constant loudness.

amplitude ....decreases..........

wavelength ....decreases.......... **2** [1]

(b) A ship uses pulses of sound to measure the depth of the sea beneath the ship. A sound pulse is transmitted into the sea and the echo from the sea-bed is received after 54 ms. The speed of sound in seawater is 1500 m/s.

0.054 s

Calculate the depth of the sea beneath the ship.

1 s = 1000 ms

S=f×λ

$S = \frac{2d}{t}$ $d = 40.5$

$1500 \times 0.054 = 2d$

$\frac{81}{2} = d$

depth = ...40.5 m.......... **3** [3]

[Total: 7]

Examiner comments

1 The candidate is clearly aware of the required definitions.
1. The amplitude was correctly labelled.
2. The wavelength was correctly labelled.

2 There is evidence of some confusion in the answers here. Neither mark could be awarded.
1. The amplitude and wavelength were both described as increasing. The former only was correct.
2. The amplitude and wavelength were both described as decreasing. The latter only was correct.

Mark awarded for (a) = 2 out of 4

3 Substitutions were made into the correct formula. With correct manipulation of the numbers, the depth of water was accurately calculated.

Mark awarded for (b) = 3 out of 3

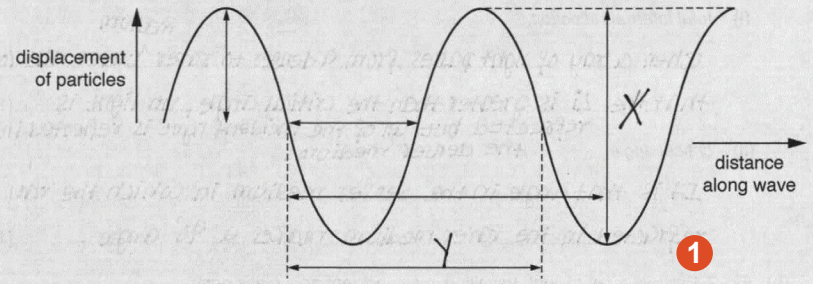
Total mark awarded = 5 out of 7

How the candidate could have improved the answer

(a) (ii) The candidate needed to have learnt thoroughly the links between amplitude and loudness, and between pitch, frequency and wavelength.

Example Candidate Response – middle

6 (a) Fig. 6.1 represents the waveform of a sound wave. The wave is travelling at constant speed.



1

Fig. 6.1

(i) On Fig. 6.1,

1. label with the letter X the marked distance corresponding to the amplitude of the wave, [1]
2. label with the letter Y the marked distance corresponding to the wavelength of the wave. [1]

(ii) State what happens to the amplitude and the wavelength of the wave if

1. the loudness of the sound is increased at constant pitch,

amplitude ..... becomes larger .....

wavelength ..... becomes shorter .....

[1]

2. the pitch of the sound is increased at constant loudness.

amplitude ..... stays the same .....

wavelength ..... becomes shorter .....

2

[1]

(b) A ship uses pulses of sound to measure the depth of the sea beneath the ship. A sound pulse is transmitted into the sea and the echo from the sea-bed is received after 54 ms. The speed of sound in seawater is 1500 m/s.

Calculate the depth of the sea beneath the ship.

$v = \frac{2d}{t}$

$\Rightarrow 1500 = \frac{2 \times d}{54}$

$\Rightarrow 81{,}000 = 2d$

$\Rightarrow 40{,}500 = d$

depth = ... 40,500 m ..... [3]

3

[Total: 7]

Examiner comments

1 The candidate's recall of the definition of amplitude was unsound.
1. The labelling of the amplitude was incorrect.
2. The labelling of the wavelength was correct.

2 The candidate was aware of the connection between loudness and amplitude. The knowledge of relationship between pitch and wavelength is less certain.
1. The amplitude was correctly described as larger. The wavelength was incorrectly described as shorter.
2. The amplitude was correctly described as the same. The wavelength was correctly described as shorter.

Mark awarded for (a) = 2 out of 4

3 The formula was stated correctly. 54 milliseconds was not converted to seconds before substitution, so there was a power of 10 error in the depth, resulting in a 1 mark penalty.

Mark awarded for (b) = 2 out of 3

Total mark awarded = 4 out of 7

How the candidate could have improved the answer

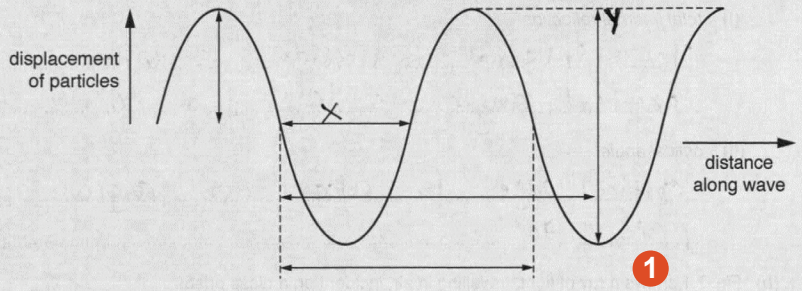
(a) (i) The candidate needed to have learnt and recalled the definition of amplitude as the maximum displacement.

(a) (ii) Recall of the link between amplitude and loudness was shown, but a mistake was made in recalling the link between pitch and wavelength.

(b) More care in reading the question may have avoided the mistake of using 54 s in the calculation instead of 54 *ms*.

Example Candidate Response – low

6 (a) Fig. 6.1 represents the waveform of a sound wave. The wave is travelling at constant speed.



1

Fig. 6.1

(i) On Fig. 6.1,

1. label with the letter X the marked distance corresponding to the amplitude of the wave, [1]
2. label with the letter Y the marked distance corresponding to the wavelength of the wave. [1]

(ii) State what happens to the amplitude and the wavelength of the wave if

1. the loudness of the sound is increased at constant pitch,

amplitude ..... Stays the Same .....

wavelength ..... increase .....

[1]

2. the pitch of the sound is increased at constant loudness.

amplitude ..... decrease .....

wavelength ..... increase .....

2

[1]

(b) A ship uses pulses of sound to measure the depth of the sea beneath the ship. A sound pulse is transmitted into the sea and the echo from the sea-bed is received after 54 ms. The speed of sound in seawater is 1500 m/s.

Calculate the depth of the sea beneath the ship.

$S = \frac{D}{t}$

$= 1500 = \frac{D}{0.93}$

$\frac{54}{60} = 0.93333\ S$

$D = 1500 \times 90.93$

$= \frac{1395\,m}{2}$

$= D = 697.5\,m$

depth = 697.5 m

3

[3]

[Total: 7]

Examiner comments

1 The candidate showed no appreciation of the definition of amplitude.
1. The labelling of the amplitude was incorrect.
2. The labelling of the wavelength was correct.

2 Knowledge of the relationships between loudness and amplitude, and between wavelength and pitch was not in evidence.
1. The amplitude was incorrectly described as staying the same. The wavelength was incorrectly described as increased.
2. The amplitude was incorrectly described as decreased. The wavelength was incorrectly described as increased.

Mark awarded for (a) = 2 out of 4

3 The mark awarded was for stating speed s = *d*/*t*.
The conversion of 54 milliseconds to seconds was made by dividing 54 by 60. Inevitably the calculation of the depth was wrong.

Mark awarded for (b) = 1 out of 3

Total mark awarded = 4 out of 7

How the candidate could have improved the answer

(a) (i) The candidate needed to have learnt and recalled the definition of amplitude as the maximum displacement.

(a) (ii) The relationships between loudness and amplitude, and between pitch, frequency and wavelength need to have been learnt thoroughly.

6 (b) The method of conversion of milliseconds to seconds must be learnt. The formula relating the time for an echo to return to a source of sound, the speed of the sound, and the distance from a reflecting surface needed to be recalled.

Common mistakes candidates made in this question

(a) (i) Mistakes due to lack of or poor recall of the definitions of amplitude, and less frequently, wavelength.

(a) (ii) Mistakes due to lack of knowledge of the relationships between loudness and amplitude, and between pitch, frequency and wavelength.

(b) Failure to the conversion of milliseconds to seconds. Using v = d/t without noting the fact that d is twice the distance from the source of sound to the reflecting surface.

Question 7

Example Candidate Response – high

7 (a) Explain what is meant by

(i) *total internal reflection,*

All of the light is reflected inside the glass prism/block without any (continue below) refraction of light [1]

1

(ii) *critical angle.*

The angle at which the refracted ray is perpendicular to the normal and (continue below) parallel to the surface of the block [1]

2

(b) Fig. 7.1 shows a ray of light, travelling in air, incident on a glass prism.

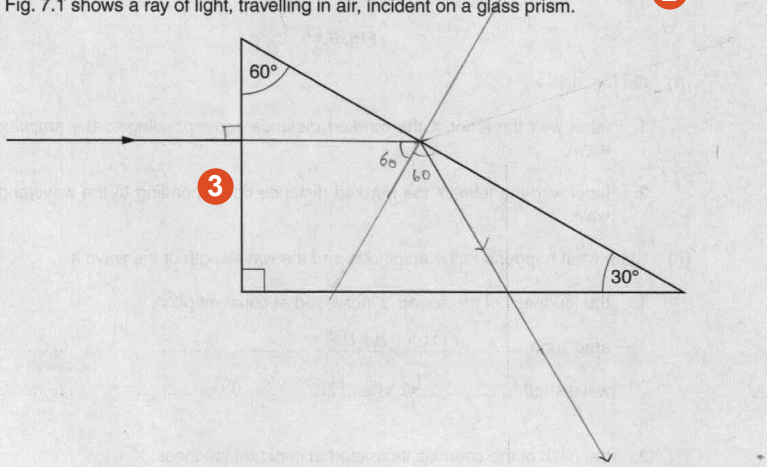


Fig. 7.1

(i) The speed of light in air is 3.0×10^8 m/s. Its speed in the glass is 2.0×10^8 m/s.

Calculate the refractive index of the glass.

refractive index = $\frac{\text{speed of light in air}}{\text{speed of light in object}}$

$= \frac{3 \times 10^8}{2 \times 10^8} = 1.5$

refractive index = 1.5 [2]

4

(ii) Show that the critical angle for the glass-air boundary is 42°.

Refractive index = $\frac{1}{\sin C}$

$1.5 = \frac{1}{\sin C}$

$\sin C = \frac{1}{1.5}$

$C = \sin^{-1}\left(\frac{1}{1.5}\right)$

$= 41.8$

$= 42^\circ$

5 [1]

(iii) On Fig. 7.1, draw carefully, without calculation, the continuation of the ray through the prism and into the air. [3]

[Total: 8]

Examiner comments

1 Reference to a glass prism is accepted as a more dense medium, so the detail given was correct.

2 The candidate needed to say that the angle of incidence, not just the angle, at which the refracted ray is perpendicular to the normal.

Mark awarded for (a) = 1 out of 2

3 The ray diagram fails to show the refraction of the ray away from the normal at the lower face of the prism.

4 The formula stated the substitutions and the calculation are correct.

5 The formula stated the substitutions and the calculation are correct.

Mark awarded for (b) = 5 out of 6

Total mark awarded = 6 out of 8

How the candidate could have improved the answer

(a) (ii) The angle referred to must be the angle of incidence.

(b) (iii) The ray emerging from the lower face needed to be shown bending away from the normal.

Example Candidate Response – middle

7 (a) Explain what is meant by

(i) *total internal reflection,*

~~when angle~~ Angle of incident more than critical angle. 1

.....[1]

(ii) *critical angle.*

~~Refraction~~ Angle of refraction equal to 90°. 2

.....[1]

(b) Fig. 7.1 shows a ray of light, travelling in air, incident on a glass prism.

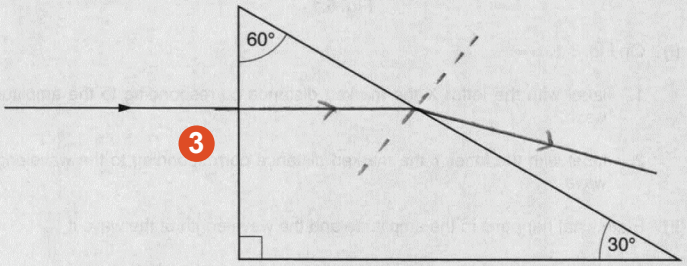


Fig. 7.1

(i) The speed of light in air is 3.0×10^8 m/s. Its speed in the glass is 2.0×10^8 m/s.

Calculate the refractive index of the glass.

$n = \frac{3 \times 10^8}{2 \times 10^8}$

$= 1.5$

refractive index = 1.5 4 .....[2]

(ii) Show that the critical angle for the glass-air boundary is 42°.

$\sin c = \frac{1}{1.5}$

$c = 41.8$

$c = 42°$. 5

[1]

(iii) On Fig. 7.1, draw carefully, without calculation, the continuation of the ray through the prism and into the air. [3]

[Total: 8]

Examiner comments

1 The answer omits the point that the angle of incidence is in a more dense medium or e.g. glass.

2 The critical angle is an angle of incidence and this aspect is not addressed in the answer.

Mark awarded for (a) = 0 out of 2

3 The only possible credit is for showing that the ray undergoes no change of direction at the vertical face of the prism. The ray is shown as passing out of the prism at the sloping face, not undergoing total internal reflection.

4 The formula is not stated, but the data is used to calculate the correct value of the refractive index.

5 As in **(i)**, no formula is stated, but a correct calculation is carried out.

Mark awarded for (b) = 4 out of 6

Total mark awarded = 4 out of 8

How the candidate could have improved the answer

(a) (i) The response needed to refer to reflection in a more dense material and state that there is no refracted ray.

(a) (ii) The response needed to state that the critical angle is an angle of incidence and also that it is the angle for which the refracted ray travels along the boundary, or the angle above which total internal reflection occurs.

(b) (iii) The completed diagram needed to show total internal reflection at the sloping face of the prism followed by bending away from the normal.at the lower face.

Example Candidate Response – low

7 (a) Explain what is meant by

(i) *total internal reflection,*

When the incident ray from a denser medium reflects back into the medium itself. [1]

(ii) *critical angle.*

When the incident ray travels exactly below the surface of the medium [1]

(b) Fig. 7.1 shows a ray of light, travelling in air, incident on a glass prism.

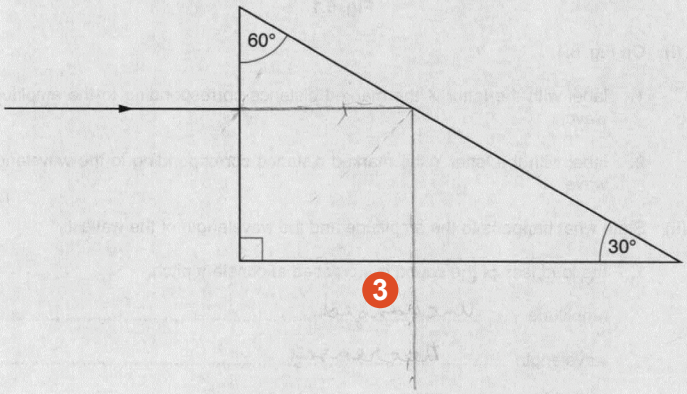


Fig. 7.1

(i) The speed of light in air is 3.0×10^8 m/s. Its speed in the glass is 2.0×10^8 m/s.

Calculate the refractive index of the glass.

$n_1 \sin i = n_2 \sin r$

refractive index = $\frac{3}{2}$ [2]

(ii) Show that the critical angle for the glass-air boundary is 42°.

[1]

(iii) On Fig. 7.1, draw carefully, without calculation, the continuation of the ray through the prism and into the air. [3]

[Total: 8]

Examiner comments

1 The meaning of total internal reflection is satisfactorily explained.

2 In common with many answers to this question, there is no reference to the critical angle being an angle of incidence.

Mark rewarded for (a) = 1 out of 2

3 The ray was correctly shown as passing through the first face undeflected. Total internal reflection at the sloping face was shown but would only have been correct for a 45°, 90°, 45° prism.

4 The formula stated is not relevant to the data provided. The answer stated as 3/2, that should have been written as 1.5, does not follow from the preceding work and could simply be a recall of the value of the refractive index of glass.

5 No attempt at calculating the critical angle was made.

Mark awarded for (b) = 0 out of 6

Total mark awarded = 2 out of 8

How the candidate could have improved the answer

(a) (ii) The response needed to state that the critical angle is an angle of incidence and also that it is the angle for which the refracted ray travels along the boundary' or the angle above which total internal reflection occurs.

(b) (i) The formula needed was the one relating the refractive index of the glass to the speeds of light in air and in glass, with substitutions into this formula. The numerical answer needed to follow from this working.

(b) (ii) No response was offered.

(b) (iii) The completed diagram was required to show total internal reflection with reasonable accuracy occurring at the sloping face of the prism. This accuracy was not achieved in the answer. The ray needed to be shown bending away from the normal.at the lower face.

Common mistakes candidates made in this question

(a) (i) Failure to refer to the reflection taking place in a more dense material.

(a) (ii) Failure to state that the critical angle is an angle of incidence.

(b) (i) In the context of the data given in the question, use of the wrong formula for refractive index.

(b) (ii) Lack of recall of the relevant formula relating the critical angle to the refractive index of the denser material.

(b) (iii) Insufficient accuracy in drawing the totally reflected ray at the sloping face of the prism. Not showing the ray refracting away from the normal at the lower face of the prism.

Question 8

Example Candidate Response – high

8 (a) Fig. 8.1 shows 3 lamps and a fuse connected to a power supply.

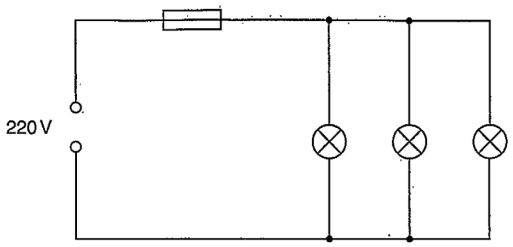


Fig. 8.1

The e.m.f. of the supply is 220 V. Each lamp is labelled 220 V, 40 W. The rating of the fuse is 2.0 A.

Calculate

(i) the current in each lamp,

Current = Power / Voltage

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

$= \frac{40}{220}$

$= 0.18$

current = 0.18A [1] [2]

(ii) the current in the fuse,

Total current in circuit: $\frac{120}{220} = 0.55A$

Fuse current = total − lamps

$= 0.55 - (3 \times 0.18)$

$= 0.55 - 0.54$

$= 0.01$

current = ~~0.01A~~ 2A [2] [1]

(iii) the total number of lamps, all in parallel, that could be connected without blowing the fuse.

Total number of lamps = $\frac{\text{current in fuse}}{\text{current of lamp}}$

$= \frac{2}{0.18} = 11.11$

number = 11 [3] [2]

(b) After a very long period of use, the wire filament of one of the lamps becomes thinner.

(i) Underline the effect of this change on the resistance of the filament.

resistance increases resistance remains the same resistance decreases [4] [1]

(ii) State and explain the effect of this change on the power of the lamp.

The power of the lamp would decrease. This is due to decrease in current. The current is decreased due to the increase in resistance. [5] [2]

[Total: 8]

Examiner comments

[1] With the correct formula and substitution, the correct current was calculated.

[2] After an inconclusive attempt at a calculation, the candidate wrote down the rating of the fuse as the total current. The current in a single lamp had to be multiplied by 3.

[3] The fuse rating was correctly divided by the value calculated in (a) (i).

Mark awarded for (a) = 4 out of 5

[4] The candidate had recalled correctly that a thinner wire has a larger resistance.

[5] The statement that the power would be reduced was rewarded. The explanation was incomplete. It was correct to write that the current would be reduced, but a reference to $P = IV$ with V having a constant value also had to be made.

Mark awarded for (b) = 2 out of 3

Total mark awarded = 6 out of 8

How the candidate could have improved the answer

(a) (ii) The answer to (i) needed to be multiplied by 3.

(b) (ii) The answer required a reference to a relevant formula; either $P = IV$ or $P = V^2/R$.

Example Candidate Response – middle

8 (a) Fig. 8.1 shows 3 lamps and a fuse connected to a power supply.

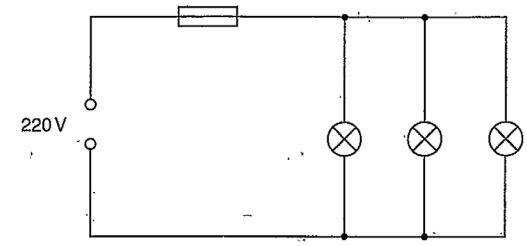


Fig. 8.1

The e.m.f. of the supply is 220 V. Each lamp is labelled 220 V, 40 W. The rating of the fuse is 2.0 A.

Calculate

(i) the current in each lamp,

$P = VI$.

$\frac{P}{V} = I$.

$\frac{40}{220} = 0.18$

current = 0.18 A [2]

(ii) the current in the fuse,

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

$I = \frac{440}{40} = 11$

current = 11 A [1]

(iii) the total number of lamps, all in parallel, that could be connected without blowing the fuse.

number = 61 [2]

(b) After a very long period of use, the wire filament of one of the lamps becomes thinner.

(i) Underline the effect of this change on the resistance of the filament.

resistance increases resistance remains the same resistance decreases [1]

(ii) State and explain the effect of this change on the power of the lamp.

$P = \frac{V^2}{R}$. This formula determines that resistance is inversely proportional to power so therefore if power is doubled than resistance is halved. [2]

[Total: 8]

Examiner comments

1 Using the correct formula and substitution, the candidate calculated the correct current.

2 The answer suggested that the candidate had no idea as to how to cope with issues concerning lamps, and by implication, resistors, in parallel. For no apparent reason, the formula $P = IV$ was quoted and spurious substitutions made.

3 A numerical answer of no relevance was written in the answer space.

Mark awarded for (a) = 2 out of 5

4 The candidate had recalled correctly that a thinner wire has a larger resistance.

5 The formula $P = V^2/R$ was quoted and power stated as being inversely proportional to resistance. Together, these aspects allowed a mark. There was no follow-up to complete an explanation.

Mark awarded for (b) = 2 out of 3

Total mark awarded = 4 out of 8

How the candidate could have improved the answer

(a) (ii) The answer to (i) needed to be multiplied by 3.

(a) (iii) The fuse value of 2 *A* should have been divided by the answer to (a) (i).

(b) (ii) A relevant formula was written down, but the candidate's use of the formula needed to be applicable to the particular details of the question.

Example Candidate Response – low

8 (a) Fig. 8.1 shows 3 lamps and a fuse connected to a power supply.

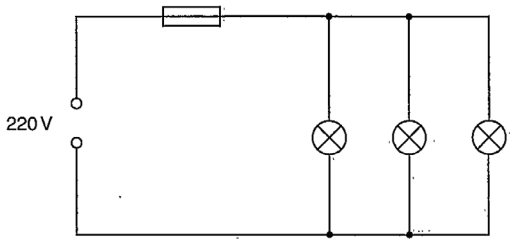


Fig. 8.1

The e.m.f. of the supply is 220V. Each lamp is labelled 220V, 40W. The rating of the fuse is 2.0A.

Calculate

(i) the current in each lamp,

$P = IV$

$40 = I220$

$\therefore \frac{220}{40} = 5.5$

current = 5.5 [2]

(ii) the current in the fuse,

220

current = 110 [1]

(iii) the total number of lamps, all in parallel, that could be connected without blowing the fuse.

2

number = 2 [2]

(b) After a very long period of use, the wire filament of one of the lamps becomes thinner.

(i) Underline the effect of this change on the resistance of the filament.

resistance increases resistance remains the same resistance decreases [1]

(ii) State and explain the effect of this change on the power of the lamp.

The resistance increases ~~and~~ so the power of the lamp will decrease.

[2]

[Total: 8]

Examiner comments

1 The stated formula was correct and gained a mark. Wrong substitutions followed.

2 No working was shown, just a wrong numerical answer with no unit.

3 Again there was no working. A wrong numerical answer was written in the answer space, but was crossed out.

Mark awarded for (a) = 1 out of 5

4 The candidate had recalled correctly that a thinner wire has a larger resistance.

5 The statement that power decreases with an increase in resistance was rewarded, but there was no subsequent explanation.

Mark awarded for (b) = 2 out of 3

Total mark awarded = 3 out of 8

How the candidate could have improved the answer

(a) (i) Correct substitutions were made into the correct formula but the arithmetic that followed should have calculated 40/220 rather than 220/40.

(a) (ii) The answer to (i) needed to be multiplied by 3.

(a) (iii) The fuse value of 2 A should have been divided by the answer to (a)(i).

(b) (ii) The answer required a reference to a relevant formula; either $P = IV$ or $P = V^2/R$.

Common mistakes candidates made in this question

(a) (i) Wrong use of the data, sometimes after correct substitution into a relevant formula.

(a) (ii) A wrong arithmetic approach, usually arising from the fact that some candidates do not appreciate that in the parallel circuit, the total current is the sum of the currents in the individual lamps.

(a) (iii) Using a recalled formula unnecessarily. This mistake arises from the point made in (a)(ii) above.
(b) (i) Failure to recall the relationship between the resistance of a wire and the area of cross-section of the wire.

(b) (ii) After stating correctly that the current in the lamp decreases, not following this with a deduction based upon using $P = IV$ or P = V^2/R.

Question 9

Example Candidate Response – high	Examiner comments

9 (a) (i) State what is meant by the *direction* of an electric field.

The direction of the force which arises from a charged particle. The direction of field lines which arise from a positive ~~par~~ charged particle. The direction of force experienced between two charged particles. [1]

(ii) Fig. 9.1 shows a pair of oppositely-charged horizontal metal plates with the top plate positive.

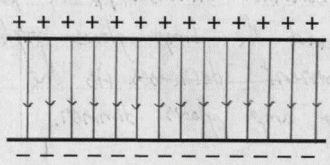


Fig. 9.1

The electric field between the plates in Fig. 9.1 is uniform.

Draw lines on Fig. 9.1 to represent this uniform field. Add arrows to these lines to show the direction of the field. [3]

(b) Fig. 9.2 shows a very small negatively-charged oil drop in the air between a pair of oppositely charged horizontal metal plates. The oil drop does not move up or down.

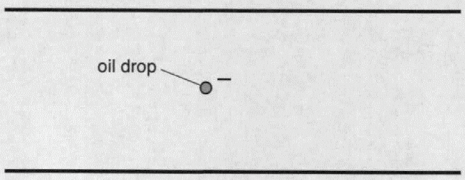


Fig. 9.2

(i) Suggest, in terms of forces, why the oil drop does not move up or down.

The net force acting on the drop is zero. The resultant ~~force~~ moment is zero. The force due to gravity is equall to the force created by the electric field. [2]

(ii) Without losing any of its charge, the oil drop begins to evaporate.

State and explain what happens to the oil drop.

The most energitic molecules ~~can~~ escape from the surface of the drop, this cools down the drop and the mass of drop decreases. [2]

[Total: 8]

1 The candidate could not recall what is meant by the direction of an electric field.

2 The field lines and the direction of the field limes were accurately drawn.

Mark awarded for (a) = 3 out of 4

3 The statement that the force due to gravity acting on the oil drop and the force created by the electric field was acceptable

4 The candidate correctly stated that the mass of the oil drop decreases due to evaporation, but made no suggestion about the consequent movement of the drop.

Mark awarded for (b) = 3 out of 4

Total mark awarded = 6 out of 8

How the candidate could have improved the answer

(a) (i) By stating that the direction of the of the field is the direction of the force acting on a positive charge.

(b) (ii) As well as stating that the mass of the drop decreases, the answer needed to include the point that the drop moves upwards.

Example Candidate Response – middle	Examiner comments

9 (a) (i) State what is meant by the *direction* of an electric field.

The flow of current from positive to negative terminals. 1 [1]

(ii) Fig. 9.1 shows a pair of oppositely-charged horizontal metal plates with the top plate positive.

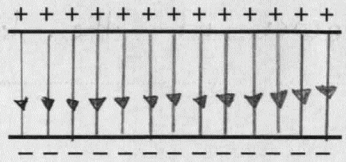


Fig. 9.1

The electric field between the plates in Fig. 9.1 is uniform. 2

Draw lines on Fig. 9.1 to represent this uniform field. Add arrows to these lines to show the direction of the field. [3]

(b) Fig. 9.2 shows a very small negatively-charged oil drop in the air between a pair of oppositely charged horizontal metal plates. The oil drop does not move up or down.

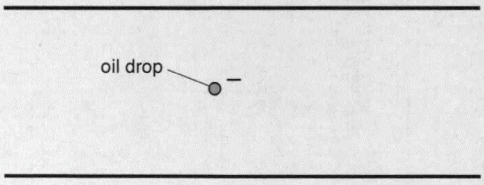


Fig. 9.2

(i) Suggest, in terms of forces, why the oil drop does not move up or down.

As it is not affected by the forces of the plates. They are not very strong. 3

(ii) Without losing any of its charge, the oil drop begins to evaporate.

State and explain what happens to the oil drop.

It moves towards the positively charged plate. 4 [2]

[Total: 8]

1 The direction of an electric field, stated as the direction of the flow of current from positive to negative terminals, was wrong.

2 The field lines and the direction of the field arrows were accurately drawn.

Mark awarded for (a) = 3 out of 4

3 The suggestion that the oil drop was not affected by forces due to the plates was entirely wrong.

4 Exceptionally for this question, the candidate's statement that the oil drop moves towards the positively charged plate was rewarded. Unfortunately, no explanation was offered.

Mark awarded for (b) = 1 out of 4

Total mark awarded = 4 out of 8

How the candidate could have improved the answer

(a) (i) By stating that the direction of the of the field is the direction of the force acting on a positive charge.

(b) (i) By stating that the upward force on the drop due to the electric field (1 mark) equals the weight of the drop or the downward force on the drop.(1 mark)

(b) (ii) The answer needed to include the point that the mass or weight of the drop decreases.

Example Candidate Response – low	Examiner comments

9 (a) (i) State what is meant by the *direction* of an electric field.

From negative to positive

[1]

(ii) Fig. 9.1 shows a pair of oppositely-charged horizontal metal plates with the top plate positive.

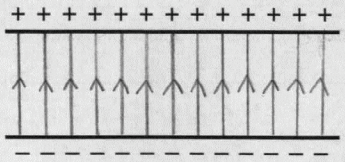


Fig. 9.1

The electric field between the plates in Fig. 9.1 is uniform.

Draw lines on Fig. 9.1 to represent this uniform field. Add arrows to these lines to show the direction of the field. [3]

(b) Fig. 9.2 shows a very small negatively-charged oil drop in the air between a pair of oppositely charged horizontal metal plates. The oil drop does not move up or down.

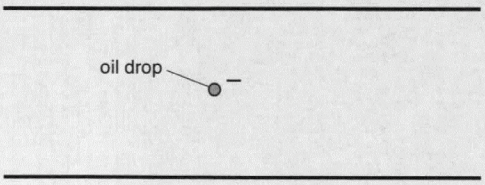


Fig. 9.2

(i) Suggest, in terms of forces, why the oil drop does not move up or down.

Because both the plates are negatively charged

[2]

(ii) Without losing any of its charge, the oil drop begins to evaporate.

State and explain what happens to the oil drop.

The size of the drop reduces because its molecules escape

[2]

[Total: 8]

1 'From negative to positive', for the suggested meaning of the direction of the electric field, was wrong.

2 The field lines between the plates were accurately drawn as parallel and equally spaces. The arrows indicating the direction of the field pointed upwards rather than downwards.

Mark awarded for (a) = 2 out of 4

3 No marks could be awarded for the statement that both plates are negatively charged.

4 The candidate stated correctly that the size of the drop reduces as a result of evaporation. However, a reduction in the mass of the drop is the issue in the context of this question. No explanation followed.

Mark awarded for (b) = 0 out of 4

Total mark awarded = 2 out of 8

How the candidate could have improved the answer

(a) (i) By stating that the direction of the of the field is the direction of the force acting on a positive charge.

(a) (ii) The field direction arrows needed to be point in in the downward direction.

(b) (i) The candidate needed to have noted that the question specified that the plates are oppositely charged.

(b) (ii) By stating that the mass or weight of the drop, not the size, decreases, and that the drop moves upwards.

Common mistakes candidates made in this question

(a) (i) Failure to recall the syllabus statement defining the direction of an electric field.

(a) (ii) Uneven spacing of field lines. Direction arrows on field line pointing in the wrong direction.

(b) (i) Making vague statements about the forces acting on the drop rather than referring to the equilibrium of the forces, i.e. the upward force on the drop due to the electric field is equal to the downward force on the drop or the weight of the drop.

(b) (ii) Not stating that the mass or weight of the drop decreases (due to evaporation), and that the drop moves upwards.

Question 10

Example Candidate Response – high	Examiner comments

10 (a) An iodine isotope $^{131}_{53}I$ decays by β-emission to an isotope of xenon (Xe).

(i) State the number of each type of particle in a neutral atom of $^{131}_{53}I$.

protons 53 neutrons 78 electrons 53 [2]

(ii) State the symbol, in nuclide notation, for the xenon nucleus.

$^{131}_{54}Xe$ [2]

(b) The background count rate of radioactivity in a laboratory is 30 counts/min.

A radioactive sample has a half-life of 50 minutes. The sample is placed at a fixed distance from a detector. The detector measures an initial count rate from the sample, including background, of 310 counts/min.

On Fig. 10.1, plot suitable points and draw a graph of the count rate from the sample, **corrected for background**, as it changes with time.

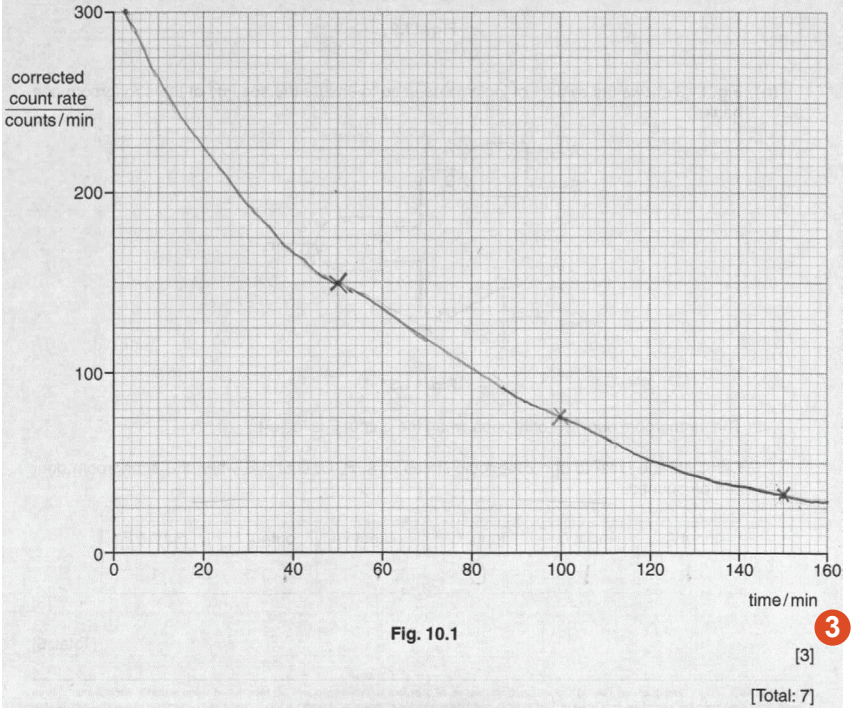


Fig. 10.1 [3]

[Total: 7]

1 The particle numbers stated were all correct.

2 The symbol for the xenon nucleus was correct.

Mark awarded for (a) = 4 out of 4

3 Points were plotted at 3 out of 4 correct times, allowing a mark. The background count rate was not subtracted from the count rates listed, so there was no further credit.

Mark awarded for (b) = 1 out of 3

Total mark awarded = 5 out of 7

How the candidate could have improved the answer

(b) The points were plotted at suitable times, but the count rates plotted did not take account of the background count rate.

Example Candidate Response – middle

10 (a) An iodine isotope $^{131}_{53}I$ decays by β-emission to an isotope of xenon (Xe).

(i) State the number of each type of particle in a neutral atom of $^{131}_{53}I$.

protons 53 neutrons 78 electrons 53 [2]

(ii) State the symbol, in nuclide notation, for the xenon nucleus.

$^{131}_{53}Xe$ [2]

(b) The background count rate of radioactivity in a laboratory is 30 counts/min.

A radioactive sample has a half-life of 50 minutes. The sample is placed at a fixed distance from a detector. The detector measures an initial count rate from the sample, including background, of 310 counts/min.

On Fig. 10.1, plot suitable points and draw a graph of the count rate from the sample, **corrected for background**, as it changes with time.

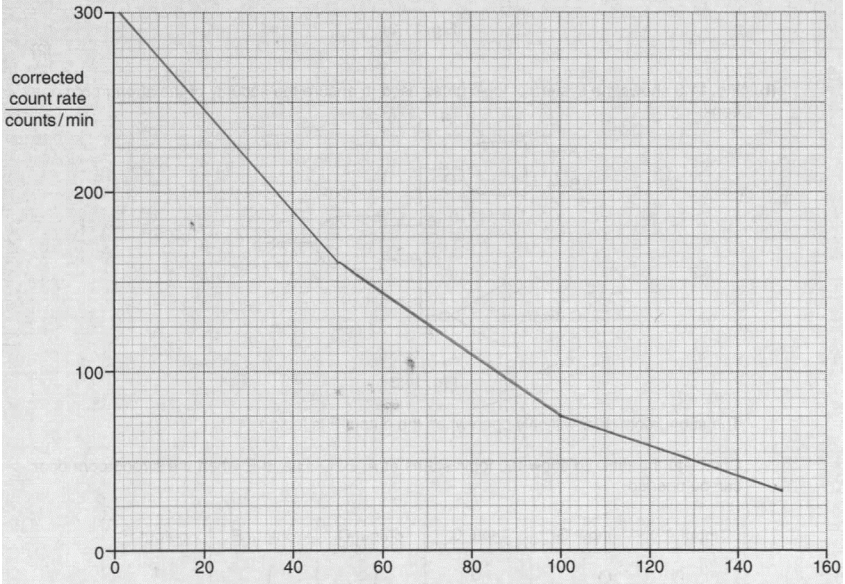


Fig. 10.1

[3]

[Total: 7]

Examiner comments

1 The particle numbers stated were all correct.

2 The subscript number, for the number of protons in the xenon nucleus, was wrong.

Mark awarded for (a) = 3 out of 4

3 Points were plotted at 3 out of 4 correct times, allowing a mark. The background count rate was not subtracted from the initial count rates listed, so the plotting of the points was wrong, as was the graph.

Mark awarded for (b) = 1 out of 3

Total mark awarded = 4 out of 7

How the candidate could have improved the answer

(a) (ii) By writing the subscript number as 54, i.e. the proton number increases by one for a β-decay.

(b) The points were plotted at suitable times, but the count rates plotted did not take account of the background count rate.

Example Candidate Response – low

10 (a) An iodine isotope $^{131}_{53}I$ decays by β-emission to an isotope of xenon (Xe).

(i) State the number of each type of particle in a neutral atom of $^{131}_{53}I$.

protons 7853 neutrons 78 electrons 52 [2]

(ii) State the symbol, in nuclide notation, for the xenon nucleus.

$^{131}_{52}Xe$ [2]

(b) The background count rate of radioactivity in a laboratory is 30 counts/min.

A radioactive sample has a half-life of 50 minutes. The sample is placed at a fixed distance from a detector. The detector measures an initial count rate from the sample, including background, of 310 counts/min.

On Fig. 10.1, plot suitable points and draw a graph of the count rate from the sample, **corrected for background**, as it changes with time.

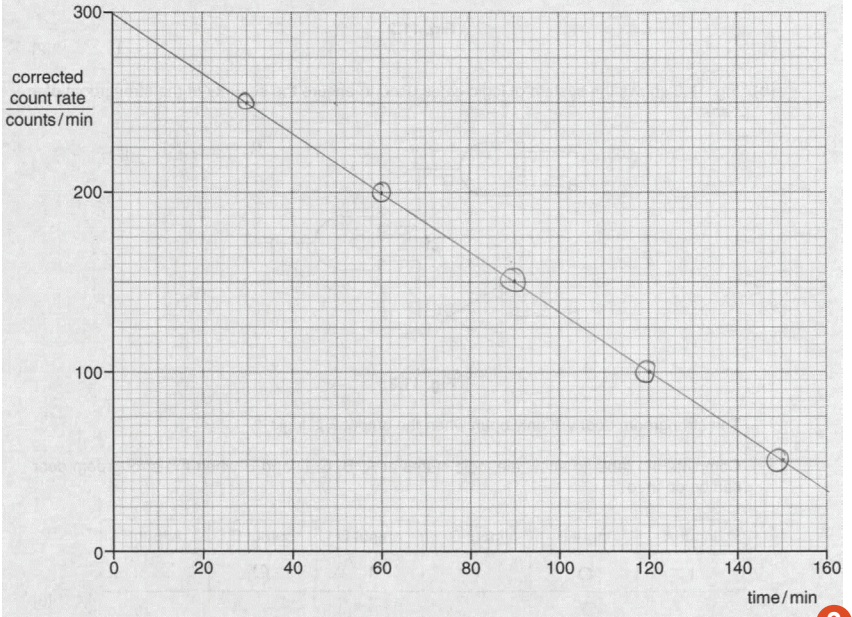


Fig. 10.1

[3]

[Total: 7]

Examiner comments

1 The electron number given in the answer was wrong. Candidates usually know that the proton number and the electron number are the same, but not in this case.

2 The subscript number, for the number of protons in the xenon nucleus, was wrong.

Mark awarded for (a) = 2 out of 4

3 The candidate clearly had no idea how to handle the given data. Points were plotted at times not suggested by the data, and such that the graph through these points lay in the straight line that was drawn.

Mark awarded for (b) = 0 out of 3

Total mark awarded = 2 out of 7

How the candidate could have improved the answer

(a) (i) The candidate should have recalled that for a neutral atom, the electron number is the same as the proton number.

(a) (ii) By writing the subscript number as 54, i.e. the proton number increases by one for a β-decay.

(b) First, by subtracting the background count rate from the initial count rate. Then dividing this corrected initial count rate successively by 2. Finally, plotting these values at 50 s intervals and drawing a curve through these points.

Common mistakes candidates made in this question

(a) (i) No particularly common mistakes, but those made tended to be random ones, mostly in either the neutron number or the electron number.

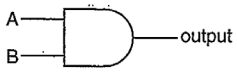
(a) (ii) Of the mistakes made, most were in the subscript, the number of protons. Fewer were in the superscript, the nucleon number.

(b) The most frequent mistake was in failing to subtract the background count rate. Some of the responses in which this aspect was correct, were followed by curves not sufficiently smooth or straight lines joining successive points.

Question 11

Example Candidate Response – high

11 (a) (i) Fig. 11.1 shows the symbol for a logic gate and its truth table.

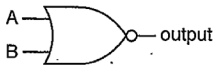


input A	input B	output
0	0	0
1	0	0
0	1	0
1	1	1

Fig. 11.1

State the name of this logic gate. AND Gate [1]

(ii) Complete the truth table for the logic gate shown in Fig. 11.2.



input A	input B	output
0	0	1
1	0	0
0	1	0
1	1	0

Fig. 11.2

[2]

(b) Fig. 11.3 shows the system of logic gates used to ensure the security of the strongroom of a bank.

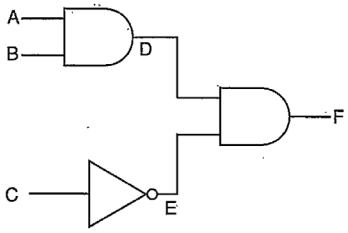


Fig. 11.3

The strongroom door will only open when the output F is logic 1.

Complete the table to show the logic states at A, B, C, D and E when the strongroom door can be opened.

input A	input B	input C	output D	output E	output F
1	1	1	1	1	1

[3]

[Total: 6]

Examiner comments

1 The logic gate was correctly identified from its symbol or its truth table, or both of these.

2 The table for the unidentified logic gate was successfully completed.

Mark awarded for (a) = 3 out of 3

3 There was an error in the entry in the C column of the table.

Mark awarded for (b) = 2 out of 3

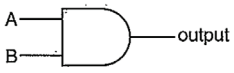
Total mark awarded = 5 out of 6

How the candidate could have improved the answer

(c) The entry in the C column should be zero.

Example Candidate Response – middle

11 (a) (i) Fig. 11.1 shows the symbol for a logic gate and its truth table.

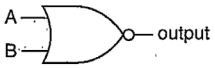


input A	input B	output
0	0	0
1	0	0
0	1	0
1	1	1

Fig. 11.1

State the name of this logic gate. AND [1]

(ii) Complete the truth table for the logic gate shown in Fig. 11.2.



input A	input B	output
0	0	0
1	0	1
0	1	1
1	1	1

Fig. 11.2

[2]

(b) Fig. 11.3 shows the system of logic gates used to ensure the security of the strongroom of a bank.

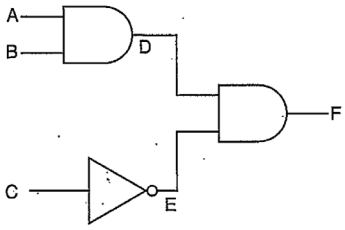


Fig. 11.3

The strongroom door will only open when the output F is logic 1.

Complete the table to show the logic states at A, B, C, D and E when the strongroom door can be opened.

input A	input B	input C	output D	output E	output F
1	1	1	1	1	1

[3]

[Total: 6]

Examiner comments

1 The logic gate was correctly identified as an AND gate.

2 The candidate either failed to recognise that the given gate as a NOR gate or could not recall the output of a NOR gate.

Mark awarded for (a) = 1 out of 3

3 There was an error in the entry in the C column of the table, the candidate having entered 1 rather than 0.

Mark awarded for (b) = 2 out of 3

Total mark awarded = 3 out of 6

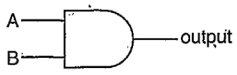
How the candidate could have improved the answer

(b) The output column numbers should be for a NOR gate, not an OR gate.

(c) The entry in the C column should be zero.

Example Candidate Response – low

11 (a) (i) Fig. 11.1 shows the symbol for a logic gate and its truth table.

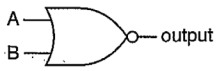


input A	input B	output
0	0	0
1	0	0
0	1	0
1	1	1

Fig. 11.1

State the name of this logic gate. ..... AND ..... [1]

(ii) Complete the truth table for the logic gate shown in Fig. 11.2.



input A	input B	output
0	0	1
1	0	1
0	1	01
1	1	0

Fig. 11.2

[2]

(b) Fig. 11.3 shows the system of logic gates used to ensure the security of the strongroom of a bank.

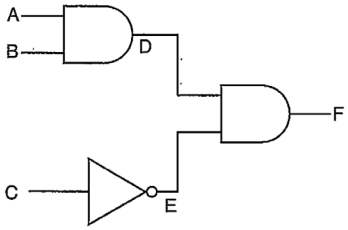


Fig. 11.3

The strongroom door will only open when the output F is logic 1.

Complete the table to show the logic states at A, B, C, D and E when the strongroom door can be opened.

input A	input B	input C	output D	output E	output F
1	81	1	0	0	1

[3]

[Total: 6]

Examiner comments

1 There was a correct identification as the gate as an AND gate

2 Two of the entries in the output column were wrong.

Mark awarded for (a) = 1 out of 3

3 The entries in the A and B columns only were correct.
The candidate clearly has poor recall of the symbols and properties of logic gates.

Mark awarded for (b) = 1 out of 3

Total mark awarded = 2 out of 6

How the candidate could have improved the answer

(b) The output column numbers should be for a NOR gate, not a NAND gate.

(c) The numbers in the C, D and E columns should be 0,1 and 1 respectively.

Common mistakes candidates made in this question

(b) Failure to identify the given gate as a NOR gate.

(c) Mistakes were fairly uncommon, but those made were most frequently made in the C column.

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