OCR GCSE GATEWAY PHYSICS A · J249

PHYSICS



MARK SCHEME

WS1.3 ANALYSIS AND EVALUATION

SCORE	PERCENTAGE
/269	%

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Question			Answer/Indicative content	Marks	Guidance
1	a		any two from: diesel cars: • have better / low(er) fuel consumption / ORA (1) • have less carbon emissions / ORA (1) more seats / larger cars: • gives more carbon emissions / ORA (1) • gives worse / high(er) fuel consumption / ORA (1) better / low(er) fuel consumption • gives low(er) carbon emissions / ORA (1)	2	For **WORSE / HIGH(ER)** fuel consumption allow reference to low(er) values in the table For **BETTER / LOW(ER)** fuel consumption allow reference to high(er) values in the table
	b		car **D** (1) it has the best fuel consumption / is the most efficient (1)	2	If D is **not** selected then zero marks for the whole question. Look for answers that use the information rather than just quote it For **BETTER / LOWER** fuel consumption allow reference to high(er) values in the table
	c		any two from: so people can make the right decisions / ORA / AW (1) reliable information / unbiased / avoids cheating on tests (1)	2	**Ignore** 'accurate' as it is in the stem of the question Also read the stem to avoid repetition in answers. Eg. so you can make an informed choice (1) Eg. Car salesmen may tell lies etc. Eg. Need to be confident in the information Do not award marks for vague answers: Eg. Customers will not be happy
			Total	6	

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Question			Answer/Indicative content	Marks	Guidance
2			C ✓	1 (AO1.2)	Examiner's Comments Just over half of all candidates got this correct. The most common wrong answer here was D; candidates need to realise that 'elastic behaviour' for a spring is intended to refer to the straight-line section of the graph.
			Total	1	
3			B ✓	1 (AO2.1)	Examiner's Comments This proved to be the easiest question in Section A, with about 85% of all candidates getting it right. The commonest wrong answer was D.
			Total	1	
4			C ✓	1 (AO2.1)	
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
5			Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. **Level 3 (5–6 marks)** Detailed description and comparison of the motion of all four students in terms of distance and time relating speed to distance run **AND** Calculates the speed of all four students. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Description and comparison of the motion of three students of distance and time **OR** Calculates the speed of at least three students. *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** Brief description of the motion of at least three students. **OR** Calculates the speed of at least one student. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*	6 (AO2 × 1.1) (AO2 × 2.2) (AO1 × 3.1a) (AO1 × 3.2b)	**AO1.1 Demonstrate knowledge and understanding of the correct formulae** • speed = distance ÷ time • v = s ÷ t • evidence of calculation **AO2.2 Apply knowledge and understanding of the motion of the four students** • Race B is a longer distance than race A • Race B and C are the same distance • Students B & C take different amounts of time • Student D takes the longest time • Race D is the longest distance • Race A is the shortest distance • Student A speed = 15÷6 = 8.3m/s • Student B speed = 100÷15 = 6.7m/s • Student C speed = 100÷14 = 7.1m/s • Student D speed = 200÷31 = 6.5m/s **AO3.1a & AO3.2b Analyse information to interpret and draw conclusions about the motion of the four students** • Race B is twice the length of race A, but time is more than twice that of race A • C is faster than B as the time is shorter (for the same distance) • As race length increases, average speed decreases Examiner's Comments  There were many excellent answers, with the mean speeds of all four runners calculated with comments about how they had run different races (apart from B and C). Many candidates helped themselves by annotating the calculated speeds next to

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Question	Answer/Indicative content	Marks	Guidance
			the table). The most able candidates discussed the effect of running a longer race on the mean speed of the runner (see Exemplar 7 below). Less able candidates compared the times of each runner but did not calculate speeds (see Exemplar 5 below). **OCR support** About one in ten candidate did not attempt to answer this question. Level of Response (LoR) questions are designed to open up the potential answers so that candidates at all levels of ability have an opportunity to show their scientific understanding. Every candidate should be encouraged to answer LoR questions as even a weak but relevant answer will be credited. The 'How to answer 6 mark LoR questions' resource can be used to help candidates prepare for this style of question http://www.ocr.org.uk/Images/374902-how-to-answer-6-mark-lor-activity.doc Exemplar 5 Use the information in the table to **describe** and **compare** the motion of the four students. Use the data in your answer. The less motion the student had compleated the race quicker as to student A the race distance is 50m then did the race in 6s about student D the race resistance was 200 and did the race in 8ls however student B and C race resistance was the same 100m and student B did the race in 15s and C did the race in 14s. [6] A Level 1 candidate response. They describe the data in the table with no attempt to process data and calculate the speed of each runner. The information is relevant to the question but there is no real attempt to compare the motion of the four students.

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Question	Answer/Indicative content	Marks	Guidance
			Exemplar 6

Use the information in the table to **describe** and **compare** the motion of the four students.

Use the data in your answer.

Student A raced 50 m in 6s which means they were racing at roughly 8.3̇m/s in this shows that their motion of this student is very fast. Students B and C ran 100m. However, student B ran 100m in 15 seconds while student C ran 100m in 14 seconds This shows that student B was a slower motion than student C. Student D races 200m in 31 seconds, which is around 6.5m/s. This shows that the motion of student A is faster than the motion of student D. [6]

L2

A Level 2 candidate response. They have calculated and compared the speeds of A and D, but only compared the relative motions of B and C. There is a structured line of reasoning and the reporting of data is linked by sentences that offer some interpretation of the facts.

Exemplar 7

Student	Race distance (m)	Time (s)	Speed = distance / time
A	50	6	8.3 m/s
B	100	15	6.6 m/s
C	100	14	7.14 m/s 7.1
D	200	31	6.45 m/s 6.5

Use the information in the table to **describe** and **compare** the motion of the four students.

Use the data in your answer.

From looking at the table Student A covered the smallest distance of 50m in the smallest time of 6s but at the greatest speed of 8.3m/s. Students B and C both covered 100m during the race but Student C was one second quicker than student B (15 - 14 = 1s). Therefore student C had a greater speed distance of 7.1m/s compared to Student B at 6.6m/s. Even though student D covered the largest overall distance of 200m they moved at the smallest speed of 6.5m/s. This could be due to the fact student D took the overall largest amount of time of 31s. [6]

L3

A Level 3 candidate response. They first calculated the speed of each student and then annotated the data table. This allowed them to be more focused and precise in their response. They have offered some explanation of the relative motions of the students. This answer is logical and all the content is relevant. The word counts for all

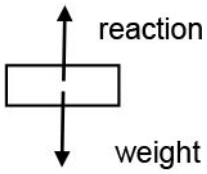
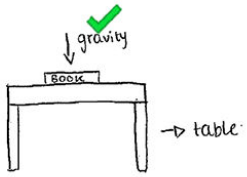
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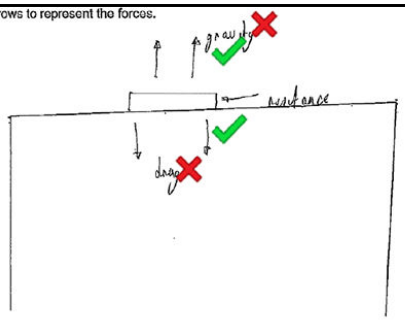
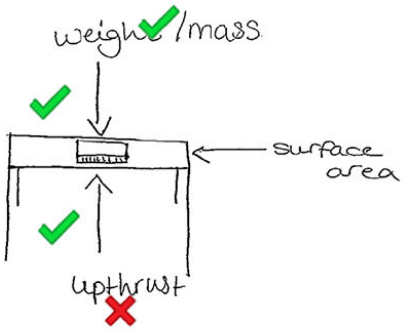
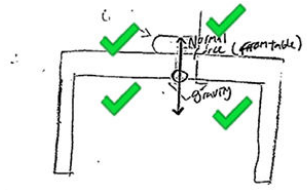
Question			Answer/Indicative content	Marks	Guidance
					three exemplars are similar and demonstrating that a well thought out answer is better than a very long answer.
			Total	6	

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Question			Answer/Indicative content	Marks	Guidance
6	a		Two arrows drawn of equal length ✓ One up and one down ✓ The downwards arrow labelled weight/gravity ✓ The upwards arrow labelled contact/reaction force ✓	4 (AO4 × 2.1)	e.g.  Examiner's Comments The best answers were offered by candidates who drew diagrammatic side view of a book on a table with opposing vertical forces shown by arrows pointing outwards from the centre of the book (see exemplar 11 below). Many candidates had drawn vertical arrows of equal length with the downward force labelled 'gravity' (see exemplars 8 and 9), the use of the correct force ''weight' was rare (see exemplars 10 and 11). Fewer candidates labelled the counter-force 'reaction' or 'contact force'. The position of the arrows emanating from a point/box representing the centre of mass of the book was not an enforced marking point. Exemplar 8 Use arrows to represent the forces.  [4] Exemplar 9

Question	Answer/Indicative content	Marks	Guidance
			Use arrows to represent the forces.  [4] Exemplar 10  [4] Exemplar 11  [4]

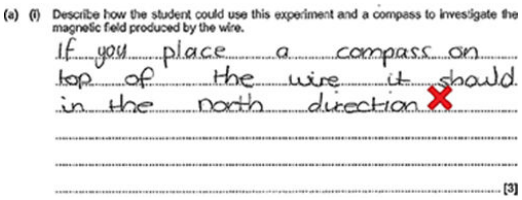
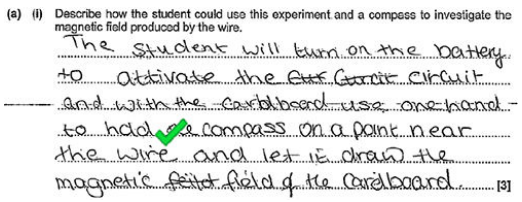
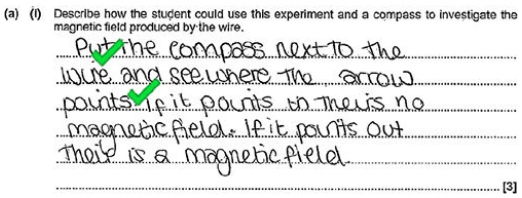
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Question			Answer/Indicative content	Marks	Guidance
	b		**Any two from:** (glider) accelerates during the push ✓ (then has) constant/steady/uniform speed/velocity ✓ (because) there are no other/horizontal/external (unbalanced) forces acting on it / AW ✓ there is (slight) deceleration due to air resistance ✓	2 (AO2 × 1.2)	Examiner's Comments Many candidates did not seem to know what an air-track glider was and as a result there answers showed limited understanding of the practical activity. Other candidates had seen an air-track glider and discussed the (relatively) unhindered movement of the glider and the action of air resistance. The most able candidates gained credit for discussing the motion of the glider during the initial push given by the teacher.
			Total	6	
7		i	(filament) bulb / lamp ✓	1 (AO3.2a)	Examiner's Comments More able candidates were able to recognise the response of a filament lamp.
		ii	gradient / slope (of graph) changes (as potential difference / voltage changes) ✓ idea of increasing resistance (with more p.d.) / ORA ✓ idea of increasing temperature / AW ✓	3 (AO3.1a) (AO1.2) (AO2.2)	**ALLOW** 'graph / line / slope levels off' ✓ } Resistance increases with greater temperature ✓✓ Examiner's Comments This overlap question was challenging for most candidates. Most stated 'as p.d. increases, current increases' which does not address the fact that the *V/I* ratio is increasing, due to the graph curving downwards, so *R* must be increasing also.
			Total	4	

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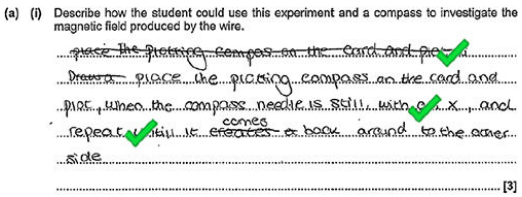
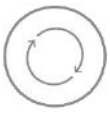
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Question			Answer/Indicative content	Marks	Guidance
8		i	Any three from: place the compass onto the card or near to the wire (and turn on the current) ✓ plot / observe the direction of the compass / needle ✓ repeat idea of tip-to-tail / plotting onto the card ✓ repeat at different distances from the centre ✓	3 (AO3 × 1.2)	<u>Examiner's Comments</u> Q23 is an overlap question with J249/03. Identifying the command word 'describe' was key to candidates successfully answering this question. Those that did were able to apply their experience of practical activities supporting P4.1 and wrote down what they could do with a plotting compass in this experiment. Exemplar 14  (a) (i) Describe how the student could use this experiment and a compass to investigate the magnetic field produced by the wire. If you place a compass on top of the wire it should in the north direction ✗ [3] This candidate has not understood the question and is answering a different one about predicting how the compass will behave. Exemplar 15  (a) (i) Describe how the student could use this experiment and a compass to investigate the magnetic field produced by the wire. The student will turn on the battery to activate the circuit and with the cardboard use one hand to hold ✓ a compass on a point near the wire and let it draw the magnetic field of the cardboard. [3] The candidate has not thought out what they were going to say, so they have only made one relevant point before running out of space. Exemplar 16  (a) (i) Describe how the student could use this experiment and a compass to investigate the magnetic field produced by the wire. Put the compass next to the wire ✓ and see where the arrow points ✓ if it points to the is no magnetic field. If it points out there is a magnetic field. [3]

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Question			Answer/Indicative content	Marks	Guidance
					If the candidate had written their answer as bullet points it would have helped them to identify that after the first two clear descriptions they were no longer describing how to investigate a magnetic field. Exemplar 17  (a) (i) Describe how the student could use this experiment and a compass to investigate the magnetic field produced by the wire. ~~place the plotting compass on the card and put~~ Draw, place the plotting compass on the card and put, when the compass needle is still, with a x, and repeat until it comes back around to the other side [3] This candidate's response is a good example of the effective use of short clear instructions when describing experimental procedures . It is much easier to follow this type of scientific writing rather than continuous descriptive prose in longer sentences.  **AfL** Give the students the instructions for a practical activity as a single descriptive paragraph and ask them to summarise the instructions a fixed number of short bullet points. Alternatively ask them to write down the procedure after they have completed the activity, but keeping to a word limit.
		ii	one or more circles around wire ✓ clockwise arrow(s) ✓	2 (AO2 × 2.2)	**DO NOT ALLOW** a spiral BUT **ALLOW** if clockwise direction shown by an arrow on the spiral then ✓ Examiner's Comments Some good answers were drawn by candidates. However, the annotated field direction on the drawings were not always correct. The question explicitly asks for the shape of the field around **this** wire. A common misconception was to draw the field around a bar magnet.

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Question			Answer/Indicative content	Marks	Guidance
			Total	5	
9			B ✓	1 (AO1.1)	Examiner's Comments Only about a third of candidates gave the correct answer 'B'. A common incorrect response was 'A' although the other distractors were also seen on occasions.
			Total	1	
10			D ✓	1 (AO2.1)	Examiner's Comments About 40% of candidates gave the correct answer D. A common incorrect response (the differences in speeds rather than velocities with direction) was 'A'.
			Total	1	
11			B ✓	1 (AO2.1)	Examiner's Comments This was and intentionally challenging question AO2 question and about a quarter of candidates gave the correct answer B. A common incorrect response was 'D'.
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
12		i	Any three from: place the compass onto the card or near to the wire (and turn on the current) ✓ plot / observe the direction of the compass / needle ✓ repeat idea of tip-to-tail / plotting onto the card ✓ repeat at different distances from the centre ✓	3 (AO3 × 1.2)	Examiner's Comments Some candidate did not attempt to describe the experiment here. Most got the idea of placing the compass on the card or near the wire. Rather fewer described the plotting or observing using the compass. Fewer still suggested the idea of repeating at different distances or places. About a quarter of candidates gained all 3 marks here and about a quarter did not gain credit.
		ii	one or more circles around wire ✓ clockwise arrow(s) ✓	2 (AO2 × 2.2)	DO NOT ALLOW a spiral BUT ALLOW if clockwise direction shown by an arrow on the spiral Examiner's Comments This was well answered with about half of the candidates drawing a circular field [1] with arrows showing a clockwise direction [1]. Some candidates drew a circular field [1] but either got the direction wrong or did not indicate a direction at all. Some labelled it with both clockwise and anticlockwise arrows so the direction mark could not be given.
			Total	5	

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Question			Answer/Indicative content	Marks	Guidance
13		i	(filament) bulb / lamp ✓	1 (AO3.2a)	Examiner's Comments Most gave the correct answer as a filament lamp. Lamp or bulb was acceptable also.
		ii	gradient / slope (of graph) changes (as potential difference / voltage changes) ✓ idea of increasing resistance (with more p.d.) / ORA ✓ idea of increasing temperature / AW ✓	3 (AO3.1a) (AO1.2) (AO2.2)	ALLOW 'graph / line / slope levels off' / non-linear Resistance increases with greater temperature ✓✓ Examiner's Comments Many of the answers here did not refer to the graph so these did not secure the first marking point about the slope or the gradient changing. Other marks were available for increasing resistance (often given) and increasing temperature (less often seen). The answered covered the whole range here with only about 10% gaining all three. About a third of candidates gained 1 mark only, usually for the idea of increasing resistance.
			Total	4	

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Question			Answer/Indicative content	Marks	Guidance
14			Rod **attracts** water ✓ • Opposite charges attract ✓ • water has both + and – charges / idea of polarisation / AW ✓	3 (AO3 × 1.2)	**IGNORE** positive electrons / movement of protons / ions for this answer. **ALLOW** Water bends or moves towards rod **OR** for candidates that have misinterpreted the diagram as repulsion of water then **ALLOW** Rod **repels** water / water bends or moves away from rod ✓ • Like charges repel ✓ • water has both + and – charges / idea of polarisation / AW ✓ Examiner's Comments The diagram was interpreted differently by candidates. Some thought it attracted (ideal scenario) and others thought it repelled. However marks were made available for both lines of thought as both interpretations were valid from the diagram. It gave a full range of marks and discriminated well with about 10% gaining full marks by including the idea of polarisation. The ideas of repulsion of water and opposite charges repelling were credited 2 marks.
			Total	3	

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Question			Answer/Indicative content	Marks	Guidance
15	a	i	as the length of the wire increases the resistance increases / proportional relationship / ORA ✓ **BUT** idea of **directly** proportional ✓ ✓	2 (AO2 × 3.2b)	**IGNORE** positive correlation Numerical answers must **USE** values rather than merely quoting values Eg. (approximately) doubling the length, doubles the resistance / ORA ✓ ✓ Eg. Increases by 7 to 8Ω per 25cm / 0.3Ω (allow 0.28 to 0.32) per cm ✓✓ <u>Examiner's Comments</u> Most answers indicated the correct relationship between the length of the wire and its resistance for 1 mark. It was common in answers for values to be merely quoted rather than used. For example, better answers (from about a fifth of candidates) that stated 'doubling the length doubles the resistance' were credited both marks.
		ii	mean for 25cm (is recorded to 3 decimal places) **and** it should be recorded to one decimal place ✓ mean for 50cm is incorrect **and** it should be 16.2Ω ✓	2 (AO2 × 3.3a)	Error **and** a solution required for each marking point. **ALLOW** answer in terms of sig. figs: Eg. mean for 25cm is recorded to 4 sig. figs. – it should be recorded to 2 sig. figs. <u>Examiner's Comments</u> About third of answers identified clearly the mean for 25cm was recorded to three decimal places and it should only be one. Also shown in about a fifth of answers was the mean at 50cm should be 16.2.
		iii	75cm attempt 3 or 18.7 (is an anomaly) ✓ it has not been included in the **mean** ✓	2 (AO2 × 3.2a)	<u>Examiner's Comments</u> There was an erratum included for this question. Virtually all candidates edited their question to include this. There was no evidence at all that any candidates were disadvantaged by this and 80% gained full marks.

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Question			Answer/Indicative content	Marks	Guidance
		iv	**straight** line **through the origin** scores ✓✓ **straight** line / linear relationship / proportional and not through origin scores ✓	2 (AO2 × 3.1a)	**ALLOW** answers shown on a diagram **ALLOW** directly proportional ✓ ✓ **DO NOT ALLOW** a curved line through origin **IGNORE** positive correlation (in written comments) Examiner's Comments Some sketched a straight line graph through the origin for 2 marks here. Some described it as a straight line through the origin [2] or it was directly proportional [2]. Others described the shape as a straight line or proportional [1] but did not mention the origin.
	b	i	**Any two from:** (extra resistance due to) connecting leads too long / too thin ✓ (extra) resistance of the croc clips / connections ✓ croc clip is not at 0cm / the end of the ruler / length of resistance wire **longer** than intended / AW ✓ Heating effect of wires ✓	2 (AO2 × 3.1b)	**DO NOT ALLOW** idea of less resistance Eg. Crocodile clips rusted / poor conductor / bad or loose connections **IGNORE** crocodile clips in wrong place unless qualified correctly. Eg. croc clips too far apart **ALLOW** Parallax error on meter (if it is analogue) / meter not calibrated (so resistance higher) Examiner's Comments Answers her were often vague here and examiners were seeking to award marks for clearly described errors. About a third gained one mark for either the idea of the crocodile clip not being at zero or the meter not being zeroed or calibrated.

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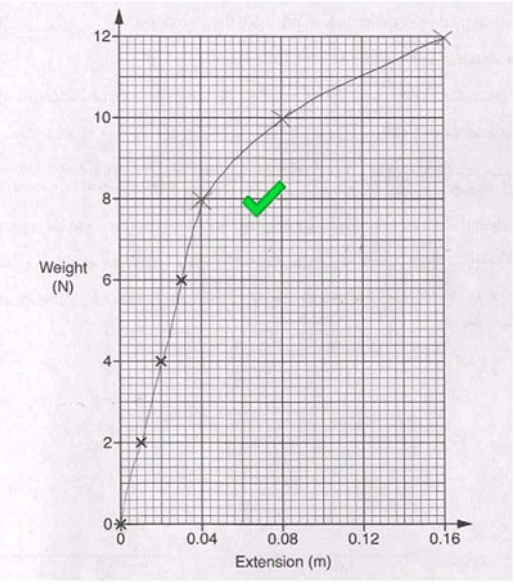
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Question			Answer/Indicative content	Marks	Guidance
		ii	**Any one from:** make the connecting wires as short as possible ✓ keep croc clips clean / solder connections ✓ place croc clip exactly at the end of the ruler / at 0cm / AW✓	1 (AO3.3b)	Solution needs to be consistent with an error identified in part i. OR a new specified error **ALLOW**: use **thicker** connecting wires **ALLOW** let wire(s) cool between readings / Securely fix croc clip / calibrate meter / avoid parallax error Examiner's Comments About a quarter gained one mark here for taking an error from part (i) and providing a solution.
			Total	11	

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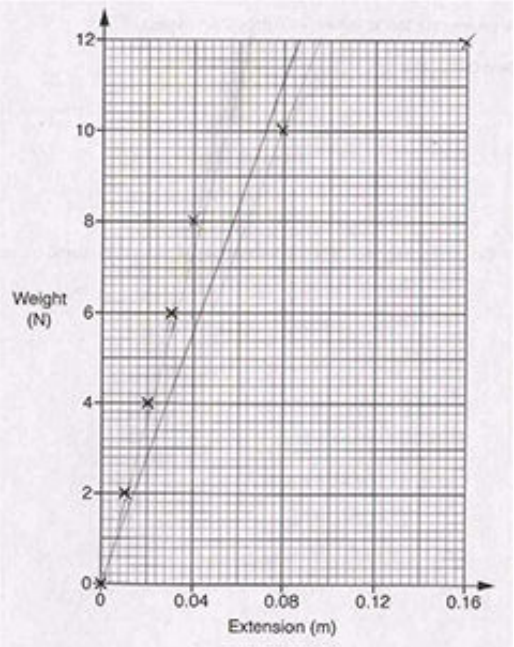
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Question			Answer/Indicative content	Marks	Guidance
16	a	i	All three points correctly plotted ✓✓ OR two points correctly plotted ✓	2 (AO 2 × 2.2)	Points should be + / – ½ square or less (by eye) Examiner's Comments All the points were usually plotted correctly.
		ii	straight line up to 0.04, 8 and curved line consistent with points plotted past this point ✓	1 (AO 3.1a)	ALLOW ecf from part ai for misplotted points ALLOW straight part of graph drawn without ruler. DO NOT ALLOW dot-to-dot for curve Single line should be thin (less than ½ square thick) and continuous to gain the mark. Examiner's Comments Just over half of answers gained the one mark here. Common mistakes were double lines, lines too thick (larger than half a square) and straight line of best fit with no curve. Exemplar 1  This gets full marks for both parts as the answer shows accurate plotting for part i of

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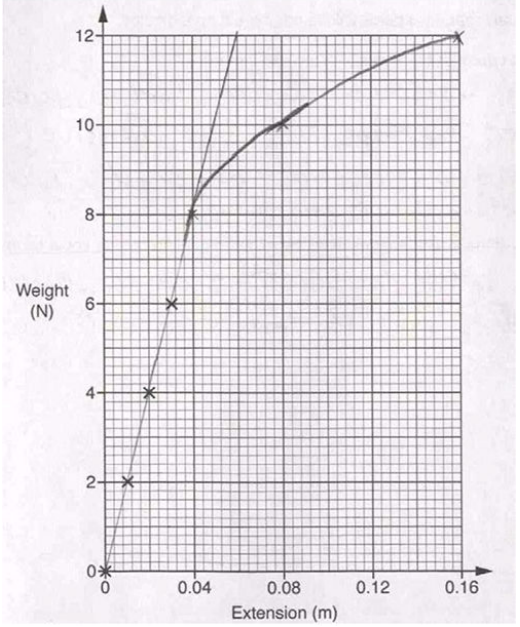
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Question	Answer/Indicative content	Marks	Guidance
			the question and produces a straight line graph in part ii that becomes curved after 8N. Although the line does slightly miss the point at 8N, the line and curve are reasonable. Exemplar 2  This was a common error with points plotted accurately but a straight line drawn so this was credited 0 marks. Exemplar 3

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Question			Answer/Indicative content	Marks	Guidance
					 This shows two lines, one curved and one straight. The marker cannot give credit as they are unsure which one to mark. In any case the curved line would have been too thick to award the mark as it is thicker than half a square.
		iii	Initially the **extension** increases steadily / linearly / uniformly / (directly) proportionally / elastically / AW ✓ (then the) wire reaches its **elastic limit** ✓ the extension increases plastically / by more for each (2N) weight added (past this point) / AW ✓	3 (AO 3.1a) (AO 1.2) (AO 3.1a)	**ALLOW** gradient is steady up to 8N **ALLOW** initially obeys Hooke's law **IGNORE** limit of proportionality (as this is an AO3 answer for an AO1 question) **ALLOW** Hooke's law not obeyed after 8N <u>Examiner's Comments</u> This gave a good range of marks with most describing the first stage as extension is linear or proportional. Some clearly referred to elastic limit [1 mark] although vague answers such as 'limit of proportionality' was frequently seen [0 mark]. Some were successful in describing the extension after the limit is reached.

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Question			Answer/Indicative content	Marks	Guidance
	b		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 200 (N/m) award 3 marks k = F ÷ x ✓ k = 6 ÷ 0.03 ✓ (or equivalent correct expression from 0 to 6N) k = 200 (N/m) ✓	3 (AO 1.2) (AO 2.1) (AO 2.1)	**IGNORE** F=kx Substitution into correctly rearranged formula ✓✓ Examiner's Comments This calculation, like many on the paper was answered well. Here about third quarters of answers gained all three marks. For unsuccessful calculations however, 1 mark was given for the correct rearrangement of the formula k = F ÷ x.
	c		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.16 (J) award 2 marks E = 0.5 × 200 × 0.04^2 ✓ E = 0.16 (J) ✓	2 (AO 1.2) (AO 2.1)	**ALLOW** ecf from part b **ALLOW** area under graph method: 0.5 × 8 × 0.04 ✓ **BUT** area under graph method used to calculate 0.16 scores ✓✓ Examiner's Comments Most candidates incorrectly used 'work done = force × distance' giving the answer 0.32 (J). Better answers used E = 0.5 × 200 × 0.4^2 to successfully get 0.16 (J) and gained full marks.
			Total	11	

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Question			Answer/Indicative content	Marks	Guidance
17		i	initial speed is zero **and** • either acceleration due to gravity = 10 • or g = 10 ✓ use a = (v-u) ÷ t to find the final speed / v ✓ use $v^2 - u^2 = 2as$ to find s ✓	3 (AO 3 × 1.1)	IGNORE the idea of echoes and speed of sound ALLOW answers using g = 9.8 or 9.81 ALLOW v = u + at ✓ ALLOW credit for higher level answers: Eg. three marks for answer in terms of $s = ut + ½at^2$ <u>Examiner's Comments</u> This was an intentionally challenging question where less than 10% did not score at all. Most of these wrote about g = 10 and the initial velocity was 0 and gained 1 mark. Very few successfully continued further.
		ii	FIRST CHECK THE ANSWER ON ANSWER LINE **If answer = 22 (m/s) award 2 marks** 10 = v (- 0) / 2.2 OR uses idea that stone gains 10m/s each second ✓ V = 22 (m/s) ✓	2 (AO 2 × 2.1)	ALLOW 21.56 or 21.58 or 21.6 (if g=9.8 or 9.81) ✓✓ <u>Examiner's Comments</u> Again this challenging calculation saw about $1/5^{th}$ gaining both marks with 22 (m/s). A few correctly used g = 9.8 or 9.81 and still scored full marks. Many used speed = distance ÷ time and did not score.
			Total	5	
18			C ✓	1 (AO1.2)	
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
19			B ✓	1 (AO2.2)	Examiner's Comments Candidates found this question challenging and many candidates selected distractor A as their answer. Key Misconception Candidates knew that the ray should enter and leave the block in the same direction (options A and B). However, the ray is also refracted as it enters the glass block and this is independent of the angle of incidence. Therefore option B is the only correct answer.
			Total	1	
20			B ✓	1 (AO1.2)	Examiner's Comments This question required candidates to use their knowledge of half-life to interpret the graph. The majority of candidates were able to work out the half-life of the source using the graph.
			Total	1	
21			D ✓	1 (AO1.2)	
			Total	1	

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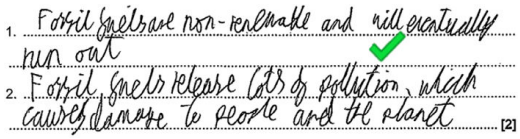
Question			Answer/Indicative content	Marks	Guidance
22			C ✓	1 (AO2.1)	Examiner's Comments  Most candidates demonstrated a good knowledge about the orbits of artificial satellites at different heights (P8.3f and P8.3g). Most other candidates correctly identified that the force of gravity would be less when the satellite is moved to a higher orbit, but also predicted that the speed would increase (distractor D).
			Total	1	

Question			Answer/Indicative content	Marks	Guidance
23	a	i	5.2 (billion tonnes oil equivalent) ✓	1 (AO3.1a)	ALLOW answers between 5.0 and 5.5 IGNORE wrong units
		ii	Oil ✓	1 (AO3.1a)	Examiner's Comments Part (a)(i) and (ii) assessed AO3 and required candidates to use estimated values from the graph. The majority of candidates were able to do this successfully.
		iii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 78 (%) award 2 marks 8.3 / 10.6 (x 100) ✓ =78 (%) ✓	2 (AO 2 × 3.1a)	ALLOW answers that round between 77(%) and 80(%) ✓✓ ALLOW 8.2 / 10.6 (x 100) OR 8.4 / 10.6 (x 100) OR 8.5 / 10.6 (x 100) OR answers that round between 0.77 and 0.80 Examiner's Comments This question required candidates to use estimated values from the graph to work out the amount of energy use due to fossil fuels and then convert their answer into a percentage of the total energy use. The question discriminated well as the lower ability candidates struggled to identify the proportion due to fossil fuel use. Many did not take into account all three of the fossil fuels which resulted in percentages that were much smaller than the expected answer. The higher ability candidates, who did identify the amount of energy use due to fossil fuels, were able to calculate the percentage correctly.

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Question			Answer/Indicative content	Marks	Guidance
	b	i	Fossil fuel may run out / is non-renewable / be in short supply / become very costly ✓ Named damage to environment: Eg (increased) greenhouse gases / global warming / sea levels rise / carbon dioxide / climate change / acid rain ✓	2 (AO3.1b) (AO3.1b)	ALLOW being used faster than being produced / finite resource ALLOW ice caps melting / droughts and storms / more polluting gases / other named polluting gases e.g. SO2 / carbon emissions IGNORE just pollution or bad for the environment / more CFCs <u>Examiner's Comments</u> This question assessed AO3 and the majority of candidates gained at least 1 mark, usually for the idea that fossil fuels are not renewable. A significant number of candidates did not gain the second mark as their responses included statements about pollution that were too vague e.g. 'harmful emissions' or 'bad for the environment'. Exemplar 2  This response was credited with 1 mark for stating that fossil fuels are renewable. The second mark was not achieved as the candidate's statement that 'fossil fuels release lots of pollution' is not specific enough. To gain the second mark, the candidate should have referred to an appropriate scientific reason, for example more CO2 or more greenhouse gases.

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Question			Answer/Indicative content	Marks	Guidance
		ii	To meet demand for electricity / not enough energy from renewable resources ✓ Less **named** damage to environment: (decreased) greenhouse gases / global warming / sea levels may fall / carbon dioxide / climate change / acid rain / ORA for coal ✓	**2** (AO1.2) (AO1.2)	**ALLOW** will not run out as fast (as coal) / to preserve fossil fuels / produces more energy (per kg than coal) **ALLOW** less polluting gases / carbon emissions / ice caps melting / droughts and storms **IGNORE** just less pollution or just better for the environment / less CFCs <u>Examiner's Comments</u> Although many candidates achieved 1 or 2 marks, a significant proportion did not gain any credit. Some candidates had the misconception that nuclear power is renewable. Others gave vague suggestions about 'damage to the environment'. Only the highest ability candidates usually gained full credit. **AfL** Candidates should be aware that in a Physics exam what they write will be assessed as a specific scientific response. Where candidates use unnamed, vague statements about 'pollution' or 'damage to the environment' these are unlikely to gain credit. For example graffiti, fly tipping and loud music are examples of pollution that are unlikely to be caused a power station.
			Total	**8**	

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Question			Answer/Indicative content	Marks	Guidance
24			**Any 3 from:** Outer ear (pinna) / auditory canal transfers sound to ear drum ✓ Ear drum vibrates ✓ Ossicles / small bones / anvil, hammer or stirrup vibrate ✓ Ossicles / small bones / anvil, hammer or stirrup amplify vibration ✓ Liquid in cochlea transmits movement (to small hairs) ✓ Small hairs / cilia vibrate ✓	**3** (AO1.1) (AO2 × 2.1)	**ALLOW** ear drum moves in and out Examiner's Comments Most candidates gained at least 1 mark for either the eardrum, ossicles or cilia vibrating. Good responses were able to mention all 3 of these vibrations. Candidates who achieved zero or 1 mark, did not use the word 'vibrate', merely listing the parts of the ear that the sound travelled through.
			Total	3	
25		i	120 (minutes) ✓	**1** (AO2.2)	Examiner's Comments Almost every candidate answered this question correctly.
		ii	Any two from: children have (more) sensitive skins ✓ children have cells / skins that are more at risk from skin cancers ✓ children lack awareness of the time they spend in the sunshine ✓ the idea that they advise a higher SPF than they (really) need just to be sure they are safe ✓	**2** (AO1.1) (AO2.1)	**IGNORE** just to reduce risk of burning **ALLOW** skin is vulnerable / more easily damaged / more affected by UV / delicate / has less melanin / AW **ALLOW** idea that damage to cells builds up over time **ALLOW** children are outside for longer / spend more time in the sun Examiner's Comments Most candidates were credited with one mark for the idea that children have more sensitive skins. Around a quarter of candidates were credited with both marks, frequently because they recognised that children spend more time in the sun.
			Total	3	

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Question			Answer/Indicative content	Marks	Guidance
26	a		Contamination occurs when radioactive **source / material** is on or in the body / object ✓ Irradiation occurs when object is exposed to radiation (from outside of the body / object) ✓	**2** (AO1.1) (AO1.1)	**ALLOW** material becomes radioactive / becomes a source of radiation Examiner's Comments Only a small number of candidates were unable to explain the difference between irradiation and contamination. A common misconception was candidates that confused the terms 'radiation' and 'radioactive source' in their explanation.
	b		Bacteria is killed / AW ✓ Slows food decay / AW ✓	**2** (AO2.2) (AO2.2)	**ALLOW** idea that food does not go mouldy / off / rot (so quickly) **IGNORE** just that food lasts longer / food does not go stale / food stays fresh Examiner's Comments  A complete explanation linking the bacteria being killed by gamma rays to the slowing down of the decay of the food was only given by higher ability candidates. Many candidates did not know that gamma rays kill bacteria. A common misconception was that gamma rays 'give energy to the food'.

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Question			Answer/Indicative content	Marks	Guidance
	c		May cause food to become radioactive ✓ May allow food (to be sold) which is old but looks fresh / AW ✓	2 (AO2.2) (AO2.2)	ALLOW food becomes contaminated / risk of cancer / they are taking in radiation ALLOW food might taste different / strange / out of date food might be eaten IGNORE food is poisonous / just unsafe Examiner's Comments The majority of candidates gained one mark for sating the concern that the food may become radioactive or cause cancer. It was rare for a second valid concern to be given by a candidate.
			Total	6	

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Question			Answer/Indicative content	Marks	Guidance
27	a		F ✓	1 (AO3.3a)	<u>Examiner's Comments</u> Almost all candidates were able to answer this correctly.
	b		E ✓ FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer = 0.6 (s) award 2 marks 5 ÷ 8 ✓ = 0.6 (s) ✓	3 (AO3.1a) (AO1.2) (AO2.2)	ALLOW 0.625 or 0.63 (s) <u>Examiner's Comments</u> Most candidates were able to identify that driver E had the quickest reaction time. Only the higher ability candidates were then able to correctly calculate the reaction time. Calculations were sometimes shown and a common error made by candidates when calculating the reaction time was to use (*thinking distance + braking distance) ÷ speed*.
	c		Any two from: A, C or D ✓ Thinking distance / reaction time is proportional to speed / AW ✓	2 (AO3.2b) (AO3.2b)	ALLOW as speed doubles, thinking distance doubles / ratio of speed:distance or distance:speed is the same / both have reaction time of 0.75 (s) <u>Examiner's Comments</u> This question required candidates to identify two drivers from A, C and D and explain why their reaction times are the same. Over half of the candidates correctly identified two of the drivers. Most of these candidates proceeded to explain why, usually by calculating the reaction time of 0.75 s. A significant number of candidates did not gain any credit. A common error candidates made was to choose drivers A and E or B and D due to their braking distances being almost the same.

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Question			Answer/Indicative content	Marks	Guidance
	d		(The **thinking** distance will) **stay the same** (The **braking** distance will) **decrease** (The **stopping** distance will) **decrease** **All three** correct ✓✓ **Two** correct ✓	2 (AO3.2b) (AO3.2b)	<u>Examiner's Comments</u> Higher ability candidates generally were credited with full marks for this question. However a third of the candidates did not provide any creditable response. . **AfL** These 'thought experiment' type questions can be used as short starter activities to help students develop the habit of thinking about science. Candidates can also be encouraged to quickly sketch out the question. This can help candidates to visualise how the forces acting on the car have changed from moving along the flat road to moving uphill at a constant speed.
			Total	8	
28			B ✓	1 (AO 1.1)	<u>Examiner's Comments</u> This question was generally answered well. Some candidate incorrectly selected either A the normal or C. **AfL** With ray diagrams, candidates should always identify the normal, before working out further positions of the rays.
			Total	1	

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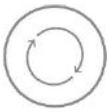
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Question			Answer/Indicative content	Marks	Guidance
29			C ✓	1 (AO 2.2)	Examiner's Comments Higher ability candidates added an extra column to the table to calculate the change in temperature. These candidates were also more likely to write down their workings, even for multiple choice questions. See exemplar 1 Exemplar 1 6 A student wants to find out which heater produces the largest temperature rise. Look at the results she collects and the calculations she makes. Heater / Starting temperature (°C) / Finishing temperature (°C) / Change in temperature (°C) A 18 28 20 10 B 18 36 16 18 C 18 44 26 26 D 18 51 23 33 Which heater has results that are correctly calculated? Your answer C ✓
			Total	1	
30			C ✓	1 (AO 2.2)	Examiner's Comments About two-thirds of the candidates got this question correct: the commonest wrong answer here was A, presumably looking at the symmetry in the bottom part of the diagram.
			Total	1	
31			C ✓	1 (AO 1.2)	Examiner's Comments This question was answered correctly by most candidates and many had added a column to the table to determine the range for each of the four distances.
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
32			B ✓	1 (AO 2.2)	Examiner's Comments Candidates found this question very challenging and the most common response was distractor A.  AfL A better way for candidates to approach this question would be to consider refraction occurring with a change of speed and the effect across a wavefront. In diagram A, a change of speed would change the speed of all parts of the wavefront by the same amount so that the wavefront would continue to move 'in step'. Response B is the correct answer since it would not be possible to have an angle of refraction of 0° with an angle of incidence greater than 0°. Similarly, for the emergent ray it would not be possible to have an angle of refraction greater than 0° if the angle of incidence is 0°.
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
33			A ✓	1 (AO 2.2)	Examiner's Comments This was the most challenging question in Section A. The most common response was distractor D, where candidates multiplied the numbers together rather than dividing wave speed by wavelength. AfL For these type of questions candidates should be encouraged to insert the numbers into the equation. When they do this they will see that the equation needs to be rearranged. Alternatively, candidates could rearrange the equation so that the unknown quantity is on the left-hand side of the equal sign.
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
34		i	Radio / infra-red / microwave ✓	1 (AO 1.1)	
		ii	Ultra-violet / X-rays / gamma-rays ✓	1 (AO 1.1)	
		iii	**Any two from:** Radiotherapy / killing cancer cells ✓ Irradiating food / sterilisation of instruments✓ Tracer / medical imaging✓ Scanning metals / non-destructive testing (NDT) ✓	4 (AO2.1)	**ALLOW** tumours / treatment of cancer **ALLOW** killing bacteria / (harmful) microorganisms / sterilising food Examiner's Comments Candidates had a sounder understanding of the trend in frequency in the electromagnetic spectrum (part ii) than that for wavelength (part i). The most common misconception was by candidates who gave visible light as their response to both part i and part ii. Around half of the candidates knew that gamma-rays are used in the treatment of cancer but other uses, such as the irradiation of food or medical equipment, were known by far fewer. To gain credit, candidates need to ensure that their answers are specific. A number of candidates stated that gamma-rays were used in chemotherapy. Some candidates stated that gamma-rays were used in scans, often with an implication of unborn babies. It was hoped that candidates would understand the use of gamma radiation as a tracer and for sterilising instruments.
			Total	**4**	

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Question			Answer/Indicative content	Marks	Guidance
35	a	i	(Source) **A** ✓ (Source) **A** because (idea that) count rate unaffected by paper and aluminium OR only lead reduces / stops gamma ✓	2 (AO 3.2) (AO 2.1)	**ALLOW** cannot travel through lead <u>Examiner's Comments</u> Candidates were expected to the interpret information from the table. The first mark was credited for identifying the correct source. Candidates then needed to apply their understanding to explain why source A could be the only correct answer for part I (because there was no change in the count rate through paper and aluminium, but the radiation was absorbed by the lead). The most common misconception was to choose source D because it had the largest count rate. For part (ii), half of the candidates correctly identified source B but fewer explained their choice in terms of paper absorbing the radiation.
		ii	(Source) **B** ✓ (Source) **B** because count rate is reduced by paper ✓	2 (AO 3.2a) (AO 2.1)	<u>Examiner's Comments</u> Candidates were expected to the interpret information from the table. The first mark was credited for identifying the correct source. Candidates then needed to apply their understanding to explain why source A could be the only correct answer for part I (because there was no change in the count rate through paper and aluminium, but the radiation was absorbed by the lead). The most common misconception was to choose source D because it had the largest count rate. For part (ii), half of the candidates correctly identified source B but fewer explained their choice in terms of paper absorbing the radiation.

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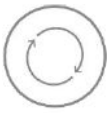
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Question			Answer/Indicative content	Marks	Guidance
		iii	(Source) **D**✓ (Source) **D** because (idea that) count rate decreases after aluminium (beta) <u>and</u> after lead (gamma) ✓	2 (AO 3.2a) (AO 2.1)	**ALLOW** not absorbed by paper <u>Examiner's Comments</u> One in four candidates identified the source correctly as D, but few justified their choice in terms of the count rate decreasing though the aluminium and then further decreasing after the lead.
	b		**Any two from:** Radioactive decay is random ✓ Variations are more pronounced at low count rates ✓ Background radiation ✓	2 (AO 2 x 3.1a)	<u>Examiner's Comments</u> Candidates found this question very challenging and fewer than 5% were credited with any marks. Many candidates responded in terms of the thickness of the lead barrier. It was expected that candidates would state that there was a range of results because of the random nature of radioactivity and that what was being measured was the background radiation.

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Question			Answer/Indicative content	Marks	Guidance
	c		Any two from: Larger number of counts ✓ Less variation in count rate ✓ Gives an average count rate ✓ Gives more repeatable results ✓ Makes it easier to decide what the source is ✓	2 (AO 2 x 3.2b)	 ALLOW more radiation detected ALLOW idea of smoothing out variations ALLOW more reliable IGNORE accurate <u>Examiner's Comments</u> A large number of candidates responded by repeated the stem of the question in their own words, many just stated that the time should be increased. A number of candidates stated that the experiment would be "more accurate" without any explanation and so did not gain any. This was a practical skills question, which also assessed candidates' understanding of Working Scientifically (Appendix 5e). Candidates were expected to understand that the longer recording time would give a larger number of counts and thus there would be less variation in count rate, or it would enable an average count rate to de determined. There were also marks available for stating that the teacher's observations would give more repeatable results.  AfL Candidates should be encouraged to interpret the question paper as to the expected length of their answers. In this question there were three answer lines and two marks available, which indicated that at least two improvements needed to be explained and that a short three-word answer was unlikely to gain both marks.
			Total	10	

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Question			Answer/Indicative content	Marks	Guidance
36		i	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 60 000 (J) award 2 marks 48 000 + 12 000 ✓ = 60 000 (J) ✓	2 (AO 2.2) (AO 2.2)	Check table Examiner's Comments Part was answered well by most candidates. Many candidates showed workings and completed the table which helped them in answering. However, around one in five candidates gave incorrect responses. Most of these candidates had nether completed the table nor shown any workings.
		ii	C ✓	1 (AO 3.2b)	Examiner's Comments Part was answered well by most candidates. Many candidates showed workings and completed the table which helped them in answering. However, around one in five candidates gave incorrect responses. Most of these candidates had nether completed the table nor shown any workings.
		iii	B ✓	1 (AO 3.2b)	Examiner's Comments Part was answered well by most candidates. Many candidates showed workings and completed the table which helped them in answering. However, around one in five candidates gave incorrect responses. Most of these candidates had nether completed the table nor shown any workings.

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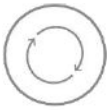
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Question			Answer/Indicative content	Marks	Guidance
		iv	Heat / sound / KE of particles passed to other particles / AW ✓	1 (AO 1.1)	ALLOW (energy) transferred to surroundings / by friction Examiner's Comments A large number of candidates correctly stated that the motor would produce heat and/or sound or indicated that the energy was 'wasted' through friction. Some candidates wrote out all the energy transfers in an electric motor (e.g. "heat, sound and kinetic energy") which could not gain credit as it did not describe how energy is 'wasted'. Credit was given when it was clear that the 'waste' resulted from the transfer of the kinetic energy store of particles passed on to other particles or to the surroundings but not a vague transfer of 'kinetic energy to the atmosphere'.
		v	Lubrication / oil ✓	1 (AO 2.1)	ALLOW reduce friction Examiner's Comments Candidates found this question extremely challenging. There were very few suggestions of specific improvements to the electric motor such as lubricating it or applying oil to the moving parts. Many candidates suggested general energy efficiency tips such as switching it off when it not in use, running the motor at a slower speed or putting insulation around the motor.
			Total	6	

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Question			Answer/Indicative content	Marks	Guidance
37	a		Thinking distance doubles ✓	1 (AO1.1)	ALLOW higher level answer: thinking distance is (directly) proportional to speed Examiner's Comments Around half the candidates stated that thinking distance also doubled and used data from the table to demonstrate their answer. Many of the candidates who did not gain credit stated that the thinking distance increases but without using the information from the question of the speed doubling. Other candidates did not answer the question set but explained factors that could affect thinking distance. A few candidates referred to the 'thinking time' doubling.  AfL When investigating stopping distances, candidates should be encouraged to understand fully the terms thinking distance, braking distance, thinking time, braking time. Encourage candidates to underline the important parts of the question – in this case thinking distance (which was already emboldened) and speed doubles.

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Question			Answer/Indicative content	Marks	Guidance
	b		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.75 (s) award 3 marks Recall: (Reaction) time = (Thinking) distance ÷ Speed ✓ 6÷8 or 12÷16 or 24÷32 ✓ = 0.75 (s) ✓	3 (AO 1.2) (AO 2.1) (AO 2.1)	IGNORE correct substitutions if NOT rearranged Examiner's Comments 10% of candidates recalled the speed equation and rearrange it as *reaction time = thinking distance ÷ speed*. The majority of the candidates were unable to interpret the data from the table and very few realised that the reaction time depended on the thinking distance before calculating the answer.

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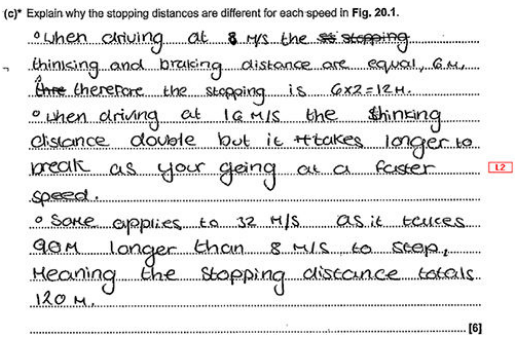
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Question			Answer/Indicative content	Marks	Guidance
	c		Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. Level 3 (5–6 marks) Explains quantitatively why the stopping distances are different for each speed in the table in terms of braking distance and thinking distance. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* Level 2 (3–4 marks) Explains qualitatively why the stopping distances are different for each speed in the table in terms of braking distance or thinking distance increasing with speed from the table *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* Level 1 (1–2 marks) States basic ideas about thinking distance / braking distance / stopping distance OR identifies variation of thinking distance / braking distance / stopping distance with speed *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* 0 marks - *No response or no response worthy of credit.*	6 (AO 2 x 1.1) (AO 2 x 2.1) (AO 2 x 3.2b)	AO1.1a Demonstrates knowledge and understanding of thinking, braking and stopping distance • Thinking distance is the distance the car travels while the driver reacts • Braking distance is the distance travelled while the brakes are applied • Stopping distance is thinking distance + braking distance AO2.1 Applies knowledge and understanding of thinking, braking and stopping distance in relation to the details in the table • Increasing the speed, increases the thinking distance • Increasing the speed, increases the braking distance • Increasing the speed, increases the stopping distance AO3.2b Analyses information to make judgements and draw detailed conclusions from table • Thinking distance is directly proportional to the speed • When speed doubles, thinking distance doubles • Braking distance is proportional to speed2 • When speed doubles, braking distance quadruples <u>Examiner's Comments</u> This question gave candidates the opportunity to apply their knowledge and understanding of stopping distances. The question is deliberately set to be open ended so that candidates had the opportunity of structuring their answers logically. Higher ability candidates explained that the stopping distance was equal to the sum of

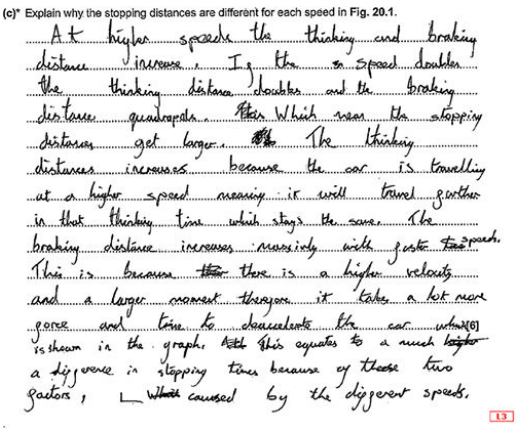
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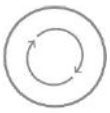
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Question	Answer/Indicative content	Marks	Guidance
			the thinking distance and braking distance before stating that the stopping distances increased with speed. Often candidates demonstrated the change in stopping distance using the data from the table. For the highest marks, candidates were expected to analyse the data quantitatively from the table. A few candidates used part (a) and stated that thinking distance doubled with speed and carried out a similar analysis for braking distance, stating that as speed doubled, braking distance quadrupled. Common misconceptions included thinking time increasing with speed, drivers being under greater pressure at high speed, braking forces increasing with speed. Other candidates discussed factors that affected thinking distance and braking distance rather than using the data in the table. **Exemplar 2**  (c)* Explain why the stopping distances are different for each speed in Fig. 20.1. • When driving at 8 m/s the ~~ss~~ stopping thinking and braking distance are equal, 6 m, ~~thre~~ therefore the stopping is 6x2=12 m. • When driving at 16 m/s the thinking distance double but it takes longer to break as your going at a faster speed. • Same applies to 32 m/s as it takes 90 m longer than 8 m/s to stop, Meaning the stopping distance totals 120 m. [6] This is a four mark, Level 2 response. The candidate has calculated the stopping distance for each speed and provided a limited analysis. They have made good use of mathematical expressions to show that stopping distance is equal to the product of thinking and breaking distance. The information presented is relevant, however there are limited links made between the bullet points. To progress to a Level 3 response the candidate could have added a short introduction and a final bullet point linking the analysis at each speed together

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Question			Answer/Indicative content	Marks	Guidance
					in a summary sentence. Exemplar 3  (c)* Explain why the stopping distances are different for each speed in Fig. 20.1. At higher speeds the thinking and braking distance increase, If the speed doubles the thinking distance doubles and the breaking distance quadrupals. Which mean the stopping distances get larger. The thinking distances increases because the car is travelling at a higher speed meaning it will travel further in that thinking time which stays the same. The breaking distance increases massively with greater speed. This is because there is a higher velocity and a larger momentum therefore it takes a lot more force and time to decelerate the car which is shown in the graph. This equates to a much larger a difference in stopping times because of these two factors, which caused by the different speeds. [6] This is a six mark Level 3 response. This is very clear analysis of the data in the table that is linked together in a clear logical structured way. Although the candidate has not annotated their script (except in their response to (a) it is clear that they have processed the data in the table. They have described the complex mathematical relationships (for example 'if the speed doubles the thinking distance doubles and the breaking distance quadruples') although it would have been easier to present this conclusion numerically.
			Total	10	

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Question			Answer/Indicative content	Marks	Guidance
38	a	i	Reduces <u>pressure</u> / spreads the <u>force</u> / AW ✓	1 (AO 1.1)	<u>Examiner's Comments</u> Many candidates found it difficult to use appropriate technical language in their answers to this question (for example, force and pressure). Many candidates wrote vague responses such as 'it would cover more of the body' without explaining why this was important. Higher ability candidates used specific technical language such as 'reducing the pressure' or 'spreading the force'.  AfL The parts of a question form a story that develops a central theme. In part (a) looks at the pressure the car applies to the road, part (b) looks at the pressure that the force resulting from breaking applies to passengers, and part (c) applies this knowledge to the specific context of child safety seats. Where candidates follow these story lines, it helps them to improve the quality of their answers. However in (i) and (c) most candidates did not make the connection after they were asked to calculate pressure in (a).
		ii	Absorb energy (in a crash) ✓	1 (AO 1.1)	ALLOW higher level answers: eg. Reduces force / acceleration E.g. Increases time / distance to stop <u>Examiner's Comments</u> Higher ability candidates realised that the material was stretchy to absorb energy in a crash. Other responses referred to more generalised reasons such as allowing seatbelts 'to fit around different sized people.' Some candidates described the seat belt material as 'having a little give' or 'movement' without explicitly explain how this would increase time, reducing the rate of deceleration and thus the force exerted on the passenger.

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Question			Answer/Indicative content	Marks	Guidance
	b		Mass / inertia of child is lower ✓ Less force is needed (for the same deceleration)✓	2 (AO 2.1) (AO 1.1)	ALLOW weight of child is lower/child is smaller <u>Examiner's Comments</u> Many candidates suggested that the narrower belts were needed because of child car seats are smaller.
			Total	4	

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Question			Answer/Indicative content	Marks	Guidance
39	a	i	5.2 (billion tonnes oil equivalent) ✓	1 (AO 3.1a)	ALLOW answers between 5.0 and 5.5 IGNORE wrong units Examiner's Comments Many candidates found it difficult to interrogate the stacked line graph and many candidates stated the total energy use in 1971 rather than the increase from 1971 to 2003. As the vertical scale on the graph was only marked at 1 billion tonne increments candidates were allowed to give an answer between 5.0 and 5.5 billion tonnes (oil equivalent).
		ii	Oil ✓	1 (AO 3.1a)	Examiner's Comments Most candidates correctly identified oil as the greatest use. Other candidates suggested coal or renewables.
		iii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 78 (%) award 2 marks 8.3 / 10.6 (× 100) ✓ =78 (%) ✓	2 (AO 2 x 3.1a)	ALLOW answers that round between 77(%) and 80(%) ✓✓ ALLOW 8.2 / 10.6 (× 100) OR 8.4 / 10.6 (× 100) OR 8.5 / 10.6 (× 100) OR answers that round between 0.77 and 0.80 Examiner's Comments Only around 10% of candidates were able to answer this question fully and most other candidates were not credited with any marks. Many candidates struggled to identify coal, oil and gas as fossil fuels. Those less able candidates that attempted to show their working were could be credited with a compensatory mark.

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Question			Answer/Indicative content	Marks	Guidance
	b	i	Fossil fuel may run out / is non-renewable / be in short supply / become very costly ✓ Named damage to environment: Eg (increased) greenhouse gases / global warming / sea levels rise / carbon dioxide / climate change / acid rain ✓	2 (AO 3.1b) (AO 3.1b)	ALLOW being used faster than being produced / finite resource ALLOW ice caps melting / droughts and storms / more polluting gases / other named polluting gases e.g. SO_2 / carbon emissions IGNORE just pollution or bad for the environment / more CFCs Examiner's Comments Most candidates recognised that fossil fuels may run out or be in short supply or stating that they are non-renewable. However, fewer candidates went on to give specific scientific reasons for scientists concerns that were creditable. Most candidates gave generalised responses about fossil fuels damaging the environment or causing 'pollution'.
		ii	To meet demand for electricity / not enough energy from renewable resources ✓ Less named damage to environment: (decreased) greenhouse gases / global warming / sea levels may fall / carbon dioxide / climate change / acid rain / ORA for coal ✓	2 (AO 1.2) (AO 1.2)	ALLOW will not run out as fast (as coal) / to preserve fossil fuels / produces more energy (per kg than coal) ALLOW less polluting gases / carbon emissions / ice caps melting / droughts and storms IGNORE just less pollution or just better for the environment / less CFCs Examiner's Comments Higher ability candidates said that there were not enough renewable energy resources and nuclear power stations would assist in meeting the demand for electricity, or help in preserving fossil fuels. Answers which gave detail about less damage to the environment were also credited, although a number of candidates thought that nuclear power stations would not cause any potential damage to the environment.
			Total	8	

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Question			Answer/Indicative content	Marks	Guidance
40	a	i	5250 (J/kg°C) ✓	1 (AO1.2)	<u>Examiner's Comments</u> Most candidates (≈ 90%) were able to calculate the mean specific heat capacity efficiently.
		ii	**Any three from:** specific heat capacity increases with temp rises ✓ specific heat capacity increases with energy supplied ✓ temp rise increases with energy supplied ✓ different amounts of energy were supplied ✓ all of the s.h.cs. are close together (within 5%) / within the range 5000 – 5500 ✓ the experiment was repeated / done 3 times ✓	3 (AO3 × 3.2b)	**ALLOW** other reasonable observation, e.g. s.h.c. increases with longer heating <u>Examiner's Comments</u> This question expected the candidate to describe the patterns in the tabulated data and to recognise that the table recorded values from three repeats of the experiment with the control variable changed. There were a number of different marking points to allowed candidates to achieve full marks. However, most candidates' answers were too brief and only described one or two possible conclusions. **AfL** For this style of question which is assessing AO3 it is important to encourage candidates to write about a minimum of three different conclusions that could be drawn. The space provided is indicative of the expected answer, so in this example describing four "conclusions" briefly (Exemplar 4) would be a better approach than one "conclusion" described in greater detail (Exemplar 3). Exemplar 3 (ii) Describe the conclusions that can be drawn from the data. As the energy supplied increases, the specific heat capacity also increases. [3]

Question			Answer/Indicative content	Marks	Guidance
					Exemplar 4 (iii) Describe the conclusions that can be drawn from the data. As the energy supplied increases so does the temperature. The specific heat capacity increases by an interval of 250 J/kg°C after each attempt. Increased temperature and energy supplied causes the specific heat capacity to increase. [3]
	b	i	**Any two from:** more energy (than expected) heated the water ✓ energy losses must have occurred/not all the energy went into the water ✓ energy transferred to environment /AW ✓	2 (AO2 × 3.2b)	**ALLOW** heat for energy Examiner's Comments Only a very few candidates answered this question well. These candidates realised that a "higher" calculated value of specific heat capacity meant that more energy had to be transferred to the beaker than was expected. These candidates concluded that much energy had been lost to the environment.
		ii	**Any two linked answers from:** part of the immersion heater is out of the water ✓ make sure the heater is fully in the water/use a larger/deeper beaker ✓ beaker is not lagged/insulated ✓ lag/insulate the beaker ✓ there is no lid on the beaker ✓ put a lid on the beaker ✓ the temperature rises are quite small ✓ apply more energy to the water ✓ insufficient data ✓ take more readings ✓	4 (AO3.3a) (AO3.3b) (AO3.3a) (AO3.3b) (AO3.3a) (AO3.3b) (AO3.3a) (AO3.3b) (AO3.3a) (AO3.3b)	Examiner's Comments Most candidates appeared not to appreciate how the story of the topic being assessed was developed through Q18 and in particular how their answer to Q18(b)(i) should help them in answering Q18(b)(ii). Most candidates offered random comments unrelated to Q18(b)(i). A popular response was the suggestion that a Bunsen burner should be used rather than an electrical immersion heater.
			Total	**10**	

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Question			Answer/Indicative content	Marks	Guidance
41			C ✓	1 (AO1.1)	Examiner's Comments A number of candidates chose A, assuming that the current was the same in each resistor, or B, assuming that the 10.0 A was equally shared. Candidates should be encouraged to read all of the question without guessing what the question is asking. Many candidates helpfully wrote tables to the right comparing currents and potential differences in series and parallel circuits. Some candidates helpfully wrote 10 – 2.5 and in some cases, this was added to the diagram. It is helpful in these types of question to underline quantities as the question is read.
			Total	1	
42			A ✓	1 (AO1.1)	Examiner's Comments This question was generally answered well. For the cogs shown since the reverse must also be true, response A was straightforward. Candidates who did not gain this mark often chose response B.
			Total	1	
43			B ✓	1 (AO2.1)	Examiner's Comments A very large number of candidates incorrectly chose A. Higher ability candidates worked out the area for each graph. Candidates should be encouraged to check each of the four responses.
			Total	1	

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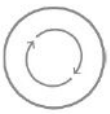
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Question			Answer/Indicative content	Marks	Guidance
44			C ✓	1 (AO2.1)	Examiner's Comments This question was well answered. Candidates should be encouraged to consider each letter of the diagram, adding a small cross to the ones that are eliminated.
			Total	1	

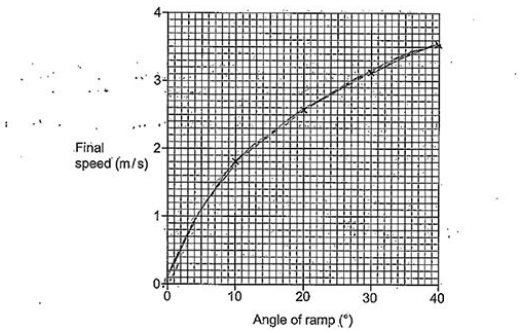
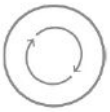
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Question			Answer/Indicative content	Marks	Guidance
45			FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 25 (N/m) award 3 marks	3	
			Recall and rearrange: spring constant = force exerted by a spring ÷ extension ✓	(AO1.2)	
			= 5 ÷ 0.2 ✓	(AO2.1)	ALLOW any other correct pair of points from the graph – points to be read to ±½ a small square
			= 25 (N/m) ✓	(AO2.1)	Final answer between 24 and 26 (N/m) scores three marks Examiner's Comments The majority of candidates scored highly on this question. Higher ability candidates stated either the equation for spring constant or stated that the spring constant was the gradient of the graph. It was then expected that candidates would substitute into their equation appropriate values from the graph. A small but significant minority of candidates tried to use the same equation from the data sheet which had been used to determine the energy transferred and substituted in a force for the energy. This approach was not creditworthy.  AfL Candidates should be able to read information from graphs and determine a gradient.
			Total	3	

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Question			Answer/Indicative content	Marks	Guidance
46	a	i	Both points correctly plotted ✓ Smooth curve correctly drawn ✓	2 (AO1.2)	**ALLOW** within ½ small square for plotting **DO NOT ALLOW** straight lines between data points **IGNORE** any line drawn for <10° <u>Examiner's Comments</u> Candidates needed to plot the last two data points before drawing the best fit line. Many candidates incorrectly drew a straight line through plots that appeared to lie on a curved trend. Other candidates did not draw smooth curves, or had many lines. **Exemplar 5**  This candidate has clearly indicated the correct positions of the two missing plots using two small crosses. The smooth line was not considered good enough in that there appeared to be more than one line in several places. This candidate has correctly assumed that the graph starts from the origin.  **AfL** Candidates should be encouraged to plot graphs using a sharp pencil. The points should be indicated with a small cross. It may help candidates to draw smooth curves by rotating the paper so that the

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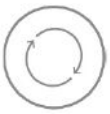
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Question			Answer/Indicative content	Marks	Guidance
					curve can be drawn naturally with the arc of the candidates' arm. Candidates should be encouraged to check the plotting of their data points - particularly points which do not appear to fit a pattern. The line of best fit may not pass through every data point. There should be a balance of data points about the line of best fit.

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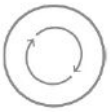
Question			Answer/Indicative content	Marks	Guidance
		ii	Increase in angle of ramp increases speed (at bottom ramp) ORA✓ Increase is not linear/doubling angle does not double final speed / AW ✓ Reference to quantitative data for two calculations, for example, increase from 10˚ to 20˚ the speed increases by 0.76 whilst 20˚ to 30˚ the speed increases by 0.54 ✓	3 (AO3.1a) (AO3.1a) (AO3.1b)	IGNORE correlation ALLOW Not directly proportional / Not constant increase **NOTE comparison of two increases required** **NOTE** Speed increase from 0˚ to 10˚ is 1.81 and speed increase from 30˚ to 40˚ is 0.40 Examiner's Comments Most candidates correctly stated that the as the angle of the ramp increased the speed increased. It was essential that candidates included a comparison between the angle of the ramp and the speed. The next two marks were more challenging and required candidates to state that the angle of the ramp and the speed were not directly proportional or linear since there was not a constant increase in speed for the same increase in angle. Candidates were expected to demonstrate this by carrying out two calculations using data from the table or graph.  AfL Understand how to test from a graph whether two quantities are directly proportional. 1 Take the quantity on the x-axis and double it and read off the y-axis values and see whether they double as well 2 See whether there is a straight line through the origin.

Question			Answer/Indicative content	Marks	Guidance
		iii	(Increase in angle) increases potential energy of the trolley/more work is done raising trolley to that point on the ramp ✓ This **increases** the / **more** kinetic energy at the bottom of the ramp ✓	2 (AO1.1 x2)	**ALLOW more** PE is transferred to KE Examiner's Comments Most candidates found this question challenging to gain two marks due to some vague answers relating to the transfer energy from the PE store to the KE store without specifically referring to the greater energy in the PE store being transferred so that there more energy in the KE store.
		iv	Attempt 1 at 30˚ (is only recorded to 1 decimal place)/ 3.1 ✓ Student should record data to a consistent number of decimal places or 2 dp / the reading should by recorded as 3.10 / AW ✓	2 (AO3.3a) (AO3.3b)	**ALLOW** only recorded to 2 significant figures **ALLOW** should be recorded to 3 significant figures **NOT** same accuracy Examiner's Comments Many candidates correctly identified that the first attempt (3.1) at an angle of 30° was only recorded to one decimal place. Most candidates then suggested that that the raw data should have been recorded to the same number of decimal places and the reading should have been recorded as 3.10. Some candidates referred to significant figures, which was allowed this year. Candidates need to understand that raw data should be recorded to the same number of decimal places while calculated data is recorded to a number of significant figures which is dependent on the number of significant figures in the raw data.

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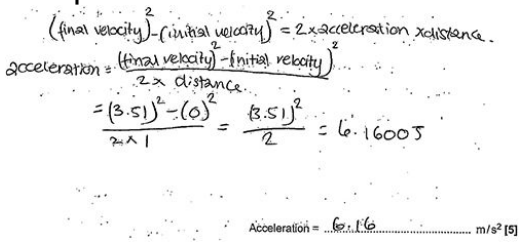
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Question			Answer/Indicative content	Marks	Guidance
		v	**Any two from:** Reproducible means that the results can be reproduced by someone else ✓ Only one student has collected this data ✓ The experiment is repeatable (as the repeated readings are close together) ✓	2 (AO2.2 x2)	**NOT** experiment can be repeated Examiner's Comments Most candidates discussed apparatus details such as not indicating what sort of surface was used, etc. Few candidates realised that reproducible results would need to be reproduced by someone else. A few candidates did state that the experiment is repeatable since the repeated reading are close to each other.  AfL Understand the terms used in the language of measurement. See the Glossary of terms on the OCR website at: https://www.ocr.org.uk/Images/467774-glossary-of-terms.doc
	b	i	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 6.16 (m/s^2) award 5 marks** $v^2 - u^2 = 2as$ (no mark – on formula sheet) $u = 0$ ✓ $a = v^2 \div 2s$ ✓ $a = 3.51^2 \div (2x1.0)$ ✓ $a = 6.16005$ (m/s^2) ✓ $a = 6.16$ (m/s^2) (2 decimal places) ✓	5 (AO2.1) (AO1.2) (AO2.1) (AO2.1) (AO1.2)	NOTE must be rearranged **ALLOW** Any number which rounds to 6.16 **ALLOW** one mark for any calculated answer to 2dp Examiner's Comments About half the candidates gained full marks for this question. It was expected that candidates would

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Question			Answer/Indicative content	Marks	Guidance
					select an appropriate equation from the data sheet, rearrange the equation and substitute in the numbers from the question before calculating the answer. It was expected that the initial speed of zero would be shown in any calculation. Many candidates who did not gain full marks attempted to gain the answer by using the definition of acceleration and the equation linking average speed with distance and time without realising the importance of the word "average". Candidates using this method often arrived with an incorrect answer of 12.32 m / s^2. **Exemplar 6**  This candidate has correctly selected the equation from data sheet. The candidate has then rearranged the equation before substituting in the values form the question. Helpfully the candidate has indicated that the initial velocity was zero. The candidate then correctly calculates the answer as 6.16005 before correctly rounding the answer to two decimal places.
		ii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 9 (J) award 3 marks** kinetic energy (J) = 0.5 x mass (kg) x (speed (m/s))^2 / KE = ½ mv^2 / KE = 0.5mv^2 ✓ KE = 0.5 x 2.0 x 3.0^2 ✓ KE = 9 (J) ✓	3 (AO1.2) (AO2.1) (AO2.1)	<u>Examiner's Comments</u> Candidates who were able to recall the equation for kinetic energy scored well on this question. Candidates should be encouraged to show their working.
			Total	**19**	

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Question			Answer/Indicative content	Marks	Guidance
47			Pressure is inversely proportional to volume OR ρV = constant for a particular gas OR for any of the gases calculation of p x V ✓ For gas B: 10 x 0.4 = 4 and for gas C: 20 x 0.2 =4 OR Pressure of C is double the pressure of B and volume of C is half the volume of B ✓ B and C ✓	3 (AO3.2b) (AO3.1a) (AO3.2b)	**NOTE** could be written next to table Examiner's Comments This question required candidates to use the data in the table which was generally well answered by all candidates. Higher ability candidates clearly stated that pressure is inversely proportional to volume and then went on to state that pressure × volume = constant. Most candidates then calculated for each gas pressure × volume before stating that B and C were the same. A few candidates demonstrated that doubling the pressure halved the volume and gained full credit with the appropriate conclusion.
			Total	3	
48			B ✓	1 (AO2.2)	Examiner's Comments Candidates clearly recalled that the current-voltage graph for a filament lamp was non-linear and they then had to choose between options B and D. Option D, the graph for a thermistor, was chosen by many. Option C is the correct answer as the increased current heats the lamp filament, a hotter filament has an increased resistance and therefore a smaller current is observed than might be expected.
			Total	1	
49			B ✓	1 (AO2.1)	
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
50	a	i	50 (m) ✓	1 (AO2.2)	Examiner's Comments 16(a) was a gentle introduction to the structured questions in Section B and almost all candidates were awarded all three marks.
		ii	60 (s) ✓	1 (AO2.2)	Examiner's Comments 16(a) was a gentle introduction to the structured questions in Section B and almost all candidates were awarded all three marks.
		iii	Any one from: Tape measure/ Measuring tape ✓ Trundle wheel ✓	1 (AO1.1)	ALLOW Metre ruler / metre stick / metre wheel / surveyors' wheel DO NOT ALLOW ruler ALLOW Fitbit/smartphone app Examiner's Comments 16(a) was a gentle introduction to the structured questions in Section B and almost all candidates were awarded all three marks.
	b	i	C ✓ It has the steepest line/gradient/slope / greatest change in distance per second / AW ✓	2 (AO 2.2) (AO 1.1)	ALLOW calculation of all 4 speeds NOT 'highest distance change in shortest amount of time' Examiner's Comments 16(b) provided the first questions where more than one mark was available, and this helped a number who could identify the important factor but had selected the wrong option A – D. In (i) a number calculated all four speeds (including 0) in order to identify C. Most candidates appreciated that it was the section with the highest gradient/steepness which they needed to identify.

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Question			Answer/Indicative content	Marks	Guidance
		ii	B ✓ The line is horizontal/flat /distance does **not** change/AW ✓	2 (AO 2.2) (AO 1.1)	Examiner's Comments 16(b) provided the first questions where more than one mark was available, and this helped a number who could identify the important factor but had selected the wrong option A – D. In (i) a number calculated all four speeds (including 0) in order to identify C. Most candidates appreciated that it was the section with the highest gradient/steepness which they needed to identify.
			Total	7	

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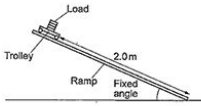
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Question			Answer/Indicative content	Marks	Guidance
51			Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. **Level 3 (5–6 marks)** States that there is no clear trend. **AND** Detailed identification of at least two problems with the experiment with suggestions of detailed improvements. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Recognises that the average speeds are similar. **AND** Identifies at least one problem with the experiment with a suggested improvement. *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** Refers to data from the table. **AND** Suggests an improvement to the experiment or identifies one problem with the experiment. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*	6 (AO2×3.1a) (AO2×3.2a) (AO2×3.3b)	**AO3.1a Analyse information and ideas to describe trend in results** For example: • No obvious/discernible trend • As loads increased time ≈ the same • As loads increased speeds ≈ the same • 20N and 60N mean speeds the same • 20N and 60N times the same • 40N and 80N mean speeds the same • 40N and 80N times the same **AO3.2a Analyse information and ideas to make judgements and identify problems with the experiment** For example: • Only 4 loads tested • Ramp distance too short • No repeated readings • Mass/weight of trolley ignored • Reaction times an issue for short times **AO3.3b Analyse information and ideas to improve experimental procedures** For example: • Test more loads • Include mass/weight of the trolley • Use a longer ramp • Have a smaller angle of ramp • Start higher up the ramp • Electronic timing method • Repeat readings and take a mean Examiner's Comments Because there was no systematic pattern in the data this was a demanding level of response question for a foundation tier candidates. Exemplar 5 is a candidate who scored Level 3, 6 marks for clearly identifying the absence of a trend and suggesting improvement to the experiment. Exemplar 6 is a Level 2 response, gaining 4 marks as the candidate has identified

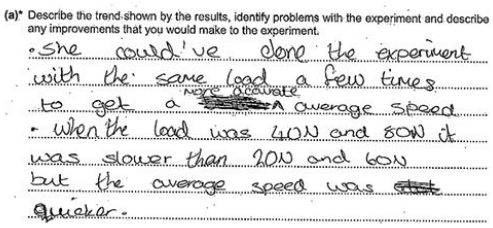
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Question	Answer/Indicative content	Marks	Guidance
			that the times and speeds are essentially similar and suggested improvements to the procedure. Exemplar 7 is a Level 1 response. The candidate makes reference to the data and makes a suggestion for doing a better experiment. This was judged to fit the Level 1 criteria exactly and was given 2 marks. **Exemplar 5** 21 A student investigates the average speed at which a trolley with different loads travels down a ramp. Look at the diagram of her experiment.  She releases the trolley from a distance of 2.0 m from the bottom of the ramp. The student uses a stop-clock to measure the time it takes to reach the bottom of the ramp. She calculates the average speed. Look at her results. Load (N) / Time taken (s) / Average speed (m/s) 20 / 2.3 / 0.87 40 / 2.4 / 0.83 60 / 2.3 / 0.87 80 / 2.4 / 0.83 (a)* Describe the trend shown by the results, identify problems with the experiment and describe any improvements that you would make to the experiment. There is no clear trend. When the speed is higher it takes less time to cover the distance. The problem is that the ramp is too short so time is not allowed for it to accelerate meaning that all speeds are extremely similar and a correlation is not shown between the load and speed. To improve she could make the ramp longer. She could experiment with different fixed angles in order to have a larger collection of results. If there was a bigger difference in the load, the may be more to see a clear trend. they are all too close in range. [6] **Exemplar 6** (a)* Describe the trend shown by the results, identify problems with the experiment and describe any improvements that you would make to the experiment. Firstly, the table shows a trend, that the time taken of a similar average speed for example all the 2.3s have an average speed of 0.87m/s and 2.4s has also 0.83m/s. The student could learn something up against the ramp to make sure it stays in a fix angle, the student could also instead use a light gate and not a stop watch to reduce human error and timing. [6]

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Question			Answer/Indicative content	Marks	Guidance
					Exemplar 7  (a)* Describe the trend shown by the results, identify problems with the experiment and describe any improvements that you would make to the experiment. • She could've done the experiment with the same load a few times to get a more accurate average speed • When the load was 40N and 80N it was slower than 20N and 60N but the average speed was ~~that~~ quicker.
			Total	6	
52			C ✓	1 (AO1.2)	
			Total	1	
53		i	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.06 (m / s) award 3 marks Speed = 0.6 × 0.1 ✓ Speed = 0.06 (m / s) ✓	2 (AO2 × 2.1)	
		ii	Distance is measured with a metre-rule OR tape measure ✓ Time is measured with a stop-watch ✓	2 (AO2 × 1.2)	ACCEPT metre-ruler DO NOT ALLOW ruler
		iii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.08 (m / s) award 3 marks Speed = distance ÷ time ✓ = 2.4 ÷ 30 ✓ = 0.08 (m / s) ✓	3 (AO1 × 1.2) (AO2 × 2.1)	
		iv	Uncertainty/difficulty in measuring distance ✓ OR Human reaction time in starting/stopping stopwatch ✓	1 (AO3.2a)	ALLOW AW
			Total	8	

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Question			Answer/Indicative content	Marks	Guidance
54		i	(9 + 14) = 23 (m) ✓	1 (AO2.2)	
		ii	Stopping distance at 50 mph = 53 m ✓ Stopping distance is greater than 40 m / Car hits the barrier ✓	2 (AO3.1a) (AO3.2a)	ALLOW 52-54m
		iii	Factor: larger mass (of car) ✓ Reason: Braking distance is increased ✓ because deceleration is less / larger KE to dissipate ✓ OR Factor: Poor quality brakes / tyres ✓ Reason: Braking distance is increased ✓ Less friction / smaller deceleration ✓ OR Factor: Icy / wet / slippery road ✓ Reason: Braking distance is increased ✓ Less friction / smaller deceleration ✓ OR Factor: Going uphill ✓ Reason: Braking distance is decreased ✓ Weight of car increases deceleration ✓ OR Factor: Going downhill ✓ Reason: Braking distance is decreased ✓ Weight of car decreases deceleration ✓	3 (AO1.1) (AO2 × 2.1) (AO1.1) (AO2 × 2.1) (AO1.1) (AO2 × 2.1) (AO1.1) (AO2 × 2.1) (AO1.1) (AO2 × 2.1)	DO NOT ALLOW distance for braking/thinking distance DO NOT ALLOW stopping distance
			Total	6	

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Question			Answer/Indicative content	Marks	Guidance
55			Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. **Level 3 (5–6 marks)** States that greater orbital distance goes with a longer time period but that the relationship is not proportional. Attempts to explain orbital motion in terms of gravity. **AND** Relates data from the graph to at least two named planets. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** States that greater orbital distance goes with a longer time period. **AND** Relates the curve to different named planets in the solar system. **OR** Reads data from the graph. *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** States that greater orbital distance goes with a longer time period. **OR** Relates the curve to the properties of at least one planet in the solar system. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** No response or no response worthy of credit.	6 (AO3 × 2.1) (AO3 × 3.1a)	**AO3.1a Analyses information and ideas by interpreting graph** • As distance increases, orbit time increases. • Time read correctly for a specific distance. • Comparison of two data points. • Recognises that the data for the Earth is very close to the origin • Outermost planets have periods of over a century • Time is **not** proportional to distance. • Time increases faster than distance. • Gradient of line increases. • Calculation using data to show non-proportionality, e.g. when distance doubles from 1 to 2, time more than doubles. **AO2.1 Applies knowledge and understanding of the solar system** • Inner planets are Mercury, Venus, Earth and Mars. • Outer planets are Jupiter, Saturn, Uranus and Neptune. • As distance from Sun increases, orbital period of planet increases. • Period of Earth's orbit is 1 year • Distance planet travels in one orbit increases with distance from the Sun. • If distance is larger, time will be greater (for same speed) • As speed is smaller, time will be greater by a greater factor.
			Total	**6**	

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Question			Answer/Indicative content	Marks	Guidance
56		i	Mean = 2(.00) ✓ Median = 2.02 ✓ Mode = 2.08 ✓	3 (AO1.2 x 3)	ALLOW 2.04 for mean (for ignoring 1.84) ALLOW 2.06 for median if 2.04 calculated for the mean
		ii	(They have a) wide spread/range / AW ✓	1 (AO3.2a)	ALLOW (they are) not all close together / don't have a small difference / not similar / AW ALLOW they are too different / have a big gap / not concordant / 0.24 gap / attempt 1 is very different / AW IGNORE not consistent
		iii	Improvement must be linked to error Error: Reaction time / difficulty in starting/stopping timer at exact time / AW ✓ Improvement: Video/record the drop (and replay using timings from the recording) / use an electronic timing method / use light gates / AW ✓ OR Error: Not dropping ball from exact height / AW Improvement: Indication of marking the point from where the ball should be dropped from / AW	2 (AO3.3b) (AO3.3a)	Marks can be awarded for errors/improvements in either section IGNORE difficulty in timing without a reason IGNORE human error unless qualified ALLOW use larger distances (so that % error in time is reduced)
			Total	6	
57			As temperature increases, density decreases / ORA✓	1 (AO3.1a)	IGNORE negative correlation / inversely proportional
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
58	a			4	**ALLOW** sig. fig. for d.p. throughout **ALLOW** answers in any order
			Mistake 1: Unit for acceleration is missing ✓ Correction 1: Unit should be m/s/s or m/s^2 or ms^{-2} ✓	(AO3.2a) (AO3.3b)	**ALLOW** include units for acceleration
			Mistake 2: Acceleration at 3.0 N is only recorded to 1 significant figure ✓ Correction 2: Acceleration should be recorded to 2 significant figures /4.0 (m/s^2) ✓	(AO3.2a) (AO3.3b)	**ALLOW** not recorded to 1 decimal place (like the others) **ALLOW** should be recorded to 1 d.p./same number of d.p.
	b	i	Point correctly plotted at (5.7 m/s^2, 4N) within ½ a small square ✓	1 (AO2.2)	
		ii	Force is (directly) proportional to acceleration ✓✓ **OR** Maximum of one mark from: Linear relationship (through the origin)✓ As force increases, acceleration increases / ORA ✓	2 (AO2x3.1a)	**ALLOW** (directly) proportional to each other / they are (directly) proportional **ALLOW** y = mx + c, c = 0 so y = mx **IGNORE** positive correlation
		iii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 0.7, 0.71 or 0.72 (kg) award 2 marks** Change in y / change in x **or** 5(.0)/7(.0) ✓ (mass =) 0.7(0) / 0.71 / 0.72 (kg) ✓	2 (AO2.2) (AO2.2)	**ALLOW** eg 4.3/6.0, 4.0/5.6 etc. to within +/- ½ small square **ALLOW** other answers between 0.65 and 0.75 only if workings shown using correct values read from the graph to within +/- ½ small square ✓✓

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Question			Answer/Indicative content	Marks	Guidance
		iv	**Any two from:** Not all of the energy is transferred to the trolley / energy is transferred/lost to other stores It assumes all of the force on the trolley is equal to the weight added on the string ✓ Friction on the pulley / between the wheels and the surface ✓ Mass of the string/card is ignored ✓ The card on the trolley was not measured properly✓ The card on the trolley did not pass through the light gates vertically/at 90° ✓	2 (AO2x3.2 a)	**ALLOW** energy is transferred/lost to the surroundings/due to friction/air resistance ✓ **ALLOW** table is not smooth / friction in the wheels
		v	**Any two from:** Compensate for/reduce friction, e.g. by raising the ramp / use a linear air-track / oil/grease pulley ✓ Repeat the experiment and calculate the mean ✓ Measure the acceleration between two points which are further apart ✓ Use different equipment (to check if it produces similar results) ✓ Use equipment with higher resolution/precision ✓ Use string/card with less mass/weight ✓	2 (AO2x3.3 b)	**ALLOW** repeat to remove/identify anomalies **ALLOW** use lighter string/card / subtract mass of card/string (from measurements) **ALLOW** use a pulley with less mass to reduce energy wasted when turning pulley / AW
			Total	13	

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Question			Answer/Indicative content	Marks	Guidance
59	a		FIRST CHECK THE ANSWERS ON ANSWER LINES If answer = 385 (J/kg˚C) AND material = zinc award 5 marks	5	ALLOW ecf for missing or incorrect unit conversion e.g. 0.385 (J/kg°C) for 3 marks
			c = (E / mθ) ✓ (θ = 900 – 420 =) 480 (°C) ✓ (c =) 462000 / (2.5) x 480) ✓ (c =) 385 (J/kg°C) ✓	(AO1.2) (AO2.2) (AO2.2) (AO2.2)	(E = mcθ does not score a mark)
			(substance is) zinc ✓	(AO3.2b)	ALLOW ecf for closest material to the answer calculated for shc if answer is incorrect. IGNORE another material quoted with its value from the table given as the answer unless workings shown
	b		Any two from: Not all substances are shown in the table / it could be a substance not in the table ✓ Named uncertainties/errors in the experiment ✓ It assumes all of the energy went to heat the material ✓ The value is (very) close to other values ✓ It assumes the substance is pure/not a mixture ✓	2 (AO2x3.1 b)	ALLOW there could be more than one substance with the same shc ALLOW assumes no energy transferred to other stores / no energy/heat loss ALLOW ecf from the part above ALLOW maximum of 1 mark for idea of results not repeated/reproduced
			Total	7	
60			C ✓	1 (AO1.2)	
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
61		i	5 or 4 points correctly plotted to within ½ small square ✓✓	2 (AO2 × 2.2)	3 or 2 correctly plotted points gains 1 mark **IGNORE** 'blobs' more than ½ square diameter
		ii	Smooth curved line of best fit through most points ✓	1 (AO1.2)	**DO NOT ALLOW** a straight line of best fit
		iii	Temperature decreases (with time) ✓ At a decreasing rate / by a smaller change in temperature for each increase in time ✓	2 (AO2 × 3.1a)	**IGNORE** non-linear relationship / positive/negative correlation **ALLOW** inverse proportion for this mark only **ALLOW** gradient decreases / temperature decreases more quickly at the start (than at the end) **ALLOW** use of data from the graph to show decreasing rate
		iv	Line starts at 90°C and decreases but remains <u>above</u> their LOBF ✓	1 (AO3.2b)	**IGNORE** shape of the line but no mark for a horizontal line **ALLOW** 90 +/- 2 °C
		v	**Any one from:** Repeat (and find a mean) / check reproducibility/repeatability ✓ Use smaller time intervals ✓ Use more precise timer/thermometer ✓	1 (AO3.3b)	**ALLOW** any sensible suggestion **IGNORE** a longer time / use more thicknesses **ALLOW** use equipment with higher resolution / data logger **IGNORE** better equipment unless qualified
			Total	**7**	

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Question			Answer/Indicative content	Marks	Guidance
62			Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. **Level 3 (5–6 marks)** Detailed evaluation of the advantages and disadvantages of wind power **AND** Analysis of Fig. 18.1 and Fig. 18.2 **AND** An attempt to give a conclusion about the use of wind power *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Evaluation of the advantages and disadvantages of wind power **AND** Analysis of Fig. 18.1 and Fig. 18.2 **OR** Evaluation of the advantages and disadvantages of wind power **AND** An attempt to give a conclusion about the use of wind power **OR** Analysis of Fig. 18.1 and Fig. 18.2 **AND** An attempt to give a conclusion about the use of wind power *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** Evaluation of the advantages or disadvantages of wind power **OR** Analysis of Fig. 18.1 or Fig. 18.2 **OR** An attempt to give a basic conclusion	6 (AO2 × 1.1) (AO2 × 3.1a) (AO3 × 3.2b)	**AO1.1 Demonstrates knowledge and understanding of advantages and disadvantages of wind power** Advantages • Wind is renewable • Does not create greenhouse gases (CO_2) • Does not contribute to global warming/climate change • Cheap to run (once built) • Less fossil fuels used Disadvantages • Unreliable – when wind drops so does power output / turbines switched off if it is too windy • Takes up lots of land • Some people think they are unsightly/noisy • Expensive to build **AO3.1a Analyses information by interpreting graphs of power output and use** • Wind pattern/power generated does not follow demand • Power generation is (always) below that of demand • Demand peaks at 17.00, lowest at ~5.00 • Peak demand is ~48000MW or Lowest demand is ~27000MW • Greatest power generation is ~11000MW or lowest power generation is ~5300MW • Power generation fluctuates **AO3.2b Analyses information to draw conclusions about use of wind power** • Current wind power cannot meet the demand for the UK • To meet the demand lots more wind turbines need to be built • Even more land/sea will be taken up with wind turbines

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Question			Answer/Indicative content	Marks	Guidance
			about the use of wind power *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* 0 marks No response or no response worthy of credit.		• Expensive to build as so many wind turbines required • There will still be some days when wind cannot meet the demand requirements • There will need to be other power generation systems (examples given) • We need to be able to store the energy generated
			Total	6	

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