OCR GCSE GATEWAY PHYSICS A · J249

PHYSICS



MARK SCHEME

M4 GRAPHS

SCORE	PERCENTAGE
/168	%

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Question			Answer/Indicative content	Marks	Guidance
1	a		14.60/14.6 (1)	1	
	b		16 / 16.0 / 16.00 (2) If answer incomplete or incorrect then 48 – 15.65 – 16.35 or 48 – 32 scores (1)	2	
	c		1.75 (2) But if answer is incomplete or incorrect then: 1.750666 scores (1)	2	
	d	i	All 4 points plotted accurately (1) Straight line (by inspection) (1)	2	**allow** tolerance of +/– ½ square
		ii	Increasing length increases time period / AW (1)	1	
		iii	220 (1) Evidence of working on graph scores (1)	2	**allow** 216 → 224 (1) **allow** ecf from previous parts **allow** value sources from table (rather than graph)
			Total	10	
2		i	(filament) bulb / lamp ✓	1 (AO3.2a)	<u>Examiner's Comments</u> 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 ✓✓ <u>Examiner's Comments</u> 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	

Question			Answer/Indicative content	Marks	Guidance
3		i	1000km takes 105 minutes **and** 2000km takes127–128 minutes (1) not double / use of values to show not double/ 23 difference (1)	2	
		ii	**any one from** scan whole surface of the Earth / can 'see' much of the surface of the Earth / can 'see' the weather patterns (of the Earth) (1) orbit the Earth many times a day / can 'see' changes in weather patterns / can be used to forecast future weather / can see the changes more quickly(1) idea of a more detailed image (due to proximity to the Earth) (1)	1	**ignore** more accurate **allow** clearer image (1)
			Total	3	
4			C ✓	1 (AO2.2)	<u>Examiner's Comments</u> About half of the candidates could correctly calculate the distance travelled from the graph (by area or calculation) and gave C as the answer. Working out was often seen on this question and answer D was a frequently chosen distractor (velocity × time, 8 × 5 = 40m).
			Total	1	
5			B ✓	1 (AO2.1)	<u>Examiner's Comments</u> 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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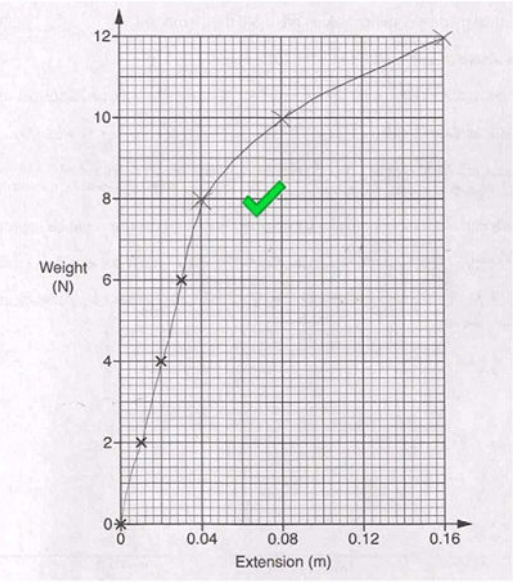
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Question			Answer/Indicative content	Marks	Guidance
6		i	(filament) bulb / lamp ✓	1 (AO3.2a)	Examiner's Comments Most gave the correct answer as a filament lamp. Lamp or bulb was acceptable also.
		ii	gradient / slope (of graph) changes (as potential 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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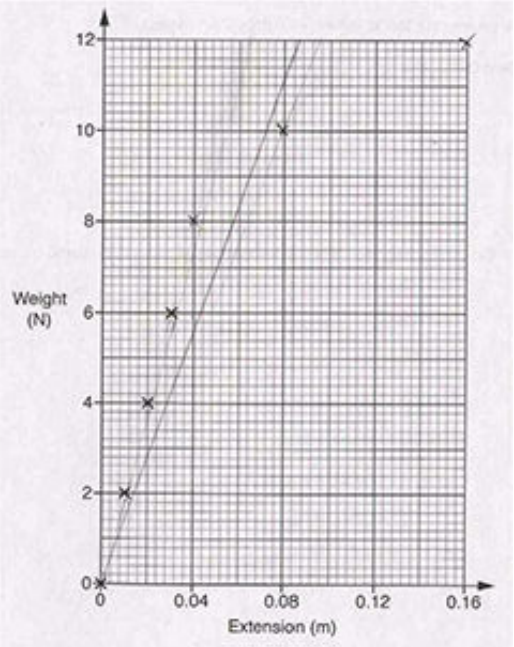
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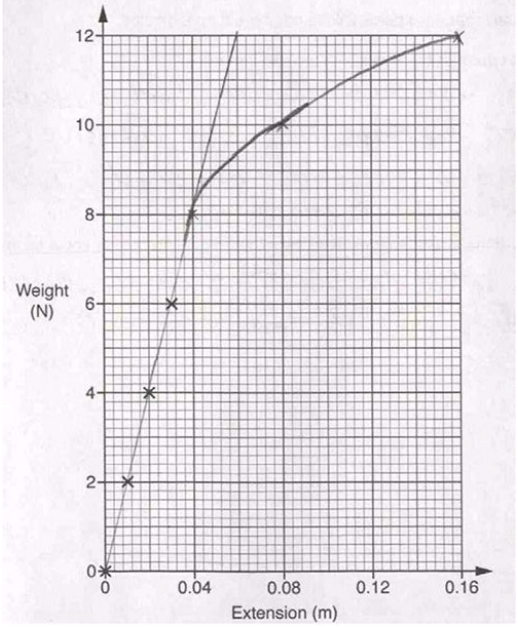
Question			Answer/Indicative content	Marks	Guidance
7	a	i	All three points correctly plotted ✓✓ OR two points correctly plotted ✓	2 (AO 2 × 2.2)	Points should be + / – ½ square or less (by eye) <u>Examiner's Comments</u> All the points were usually plotted correctly.
		ii	straight line up to 0.04, 8 **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. <u>Examiner's Comments</u> 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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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

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 ✓✓ <u>Examiner's Comments</u> 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 ✓✓ <u>Examiner's Comments</u> 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	
8			B ✓	1 (AO1.2)	<u>Examiner's Comments</u> 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	

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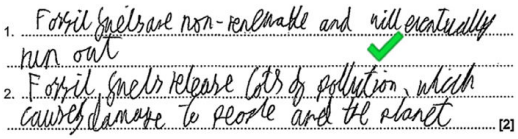
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Question			Answer/Indicative content	Marks	Guidance
9	a	i	5.2 (billion tonnes oil equivalent) ✓	1 (AO3.1a)	ALLOW answers between 5.0 and 5.5 IGNORE wrong units
		ii	Oil ✓	1 (AO3.1a)	Examiner's Comments Part (a)(i) and (ii) assessed AO3 and required 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
10			C ✓	1 (AO 2.2)	Examiner's Comments Almost half of the candidates correctly recalled that an alpha particle had 2 protons and 2 neutrons and were able to show that they understood standard nuclear notation (conventional representation for nuclei).
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
11	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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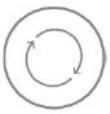
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Question			Answer/Indicative content	Marks	Guidance
12			B ✓	1 (AO1.2)	Examiner's Comments Overall this question was very well answered. Some lower ability candidates incorrectly selected response C.
			Total	1	
13			B ✓	1 (AO2.1)	Examiner's Comments 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	
14			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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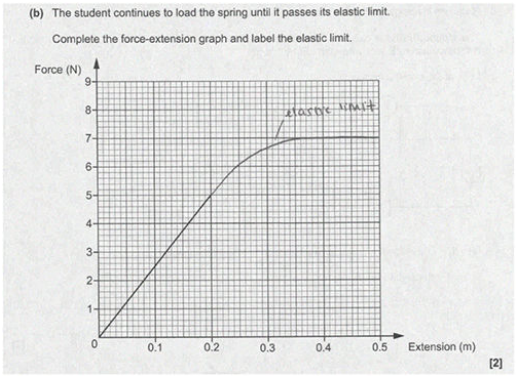
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Question			Answer/Indicative content	Marks	Guidance
15	a		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 25 (N/m) award 3 marks	3	
			Recall and rearrange: spring constant = force exerted by a spring ÷ extension ✓	(AO1.2)	
			= 5 ÷ 0.2 ✓	(AO2.1)	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.

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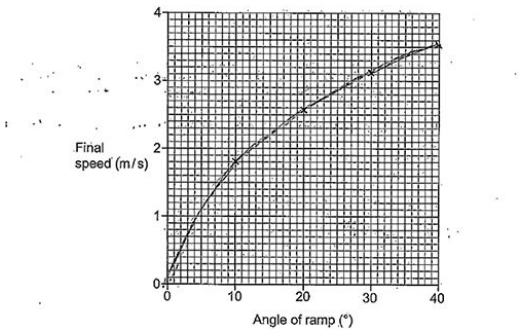
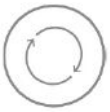
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Question			Answer/Indicative content	Marks	Guidance
	b		Line curves and gradient decreases ✓ Point at the end of the linear section of the line labelled 'elastic limit' ✓	2 (AO2x 1.2)	IGNORE poorly drawn curves/thick lines DO NOT ALLOW curve with negative gradient at any point <u>Examiner's Comments</u> This question required candidates to demonstrate that they understood how a spring stretched with an increasing force and the term "elastic limit". For marks to be given the straight line section (if any) should be drawn with a ruler and the curve should be smooth. Sometimes the labelling of the elastic limit was vague. Higher ability candidates added a small cross at the elastic limit and then labelled the cross. Exemplar 2  This candidate has clearly extended a straight line and then drawn a curve with decreasing gradient which gains the first mark. The labelling of the elastic limit is vague and incorrect. It would have been helpful if this candidate had indicated precisely on the line with a dot or cross where the elastic limit is located and then added a label.
			Total	5	

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Question			Answer/Indicative content	Marks	Guidance
16	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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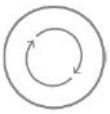
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Question			Answer/Indicative content	Marks	Guidance
					curve can be drawn naturally with the arc of the candidates' arm. Candidates should be encouraged to check the plotting of their data points - particularly points which do not appear to fit a 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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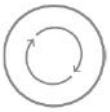
Question			Answer/Indicative content	Marks	Guidance
		ii	Increase in angle of ramp increases speed (at bottom ramp) ORA✓ Increase is not linear/doubling angle does not double final speed / AW ✓ Reference to quantitative data for two calculations, for example, increase from 10˚ to 20˚ the speed increases 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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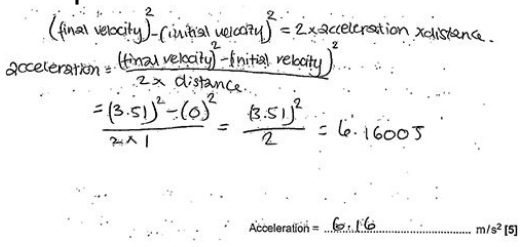
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Question			Answer/Indicative content	Marks	Guidance
		v	**Any two from:** Reproducible means that the results can be reproduced by someone else ✓ Only one student has collected this data ✓ The experiment is repeatable (as the repeated readings are 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
17			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	
18			B ✓	1 (AO2.1)	
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
19	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.
	c		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.5 (m/s^2) award 2 marks $v = 20 \div 40$ ✓ $v = 0.5$ (m/s^2) ✓	2 (AO2.1) (AO2.1)	Mp2 dependent on correct substitution for mp1 Examiner's Comments The equation for acceleration was given and it required no rearrangement. Most candidates were credited with both marks here.
			Total	9	

Question			Answer/Indicative content	Marks	Guidance
20		i	Bar C drawn to the correct height of 12s ✓	1 (AO1.2)	Examiner's Comments Most candidates drew the correct bar in (a)(i) and then went on to carry out an accurate calculation of the mean time.
		ii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 12 (s) award 2 marks 14 + 10 + 12 = 36 / (14 + 10 + 12)/3 without the 36 ✓ 36 ÷ 3 = 12 (s) ✓	2 (AO3.1a) (AO1.2)	ECF from (a)(i) ECF from mp1 above Examiner's Comments Most candidates drew the correct bar in (a)(i) and then went on to carry out an accurate calculation of the mean time.
		iii	Lift B ✓ Takes the least time (power is work done ÷ time taken)/AW ✓	2 (AO3.1b) (AO1.2)	If A chosen and correct explanation (for B) given, award mp2 but not mp1 Examiner's Comments Many candidates identified lift B uses the most power correctly but did not provide an explanation of why it use the most power for the second mark. Some candidates clearly thought the highest bar in the bar chart indicated a greater height reached by the lift and so chose lift A.
			Total	5	
21			C ✓	1 (AO2.2)	
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
22		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
23			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
24		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 ✓	2 (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**	
25			B	1 (AO1.2)	
			Total	**1**	
26			B	1 (AO2.1)	
			Total	**1**	

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Question			Answer/Indicative content	Marks	Guidance
27		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 (AO2x3.1 a)	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 ✓✓
		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

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Question			Answer/Indicative content	Marks	Guidance
		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	9	

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Question			Answer/Indicative content	Marks	Guidance
28	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	

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Question			Answer/Indicative content	Marks	Guidance
29		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
30			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**	
31		i	0.0022 (m) ✓	1 (AO2.2)	
		ii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 2.0×10^6 (Hz) award 4 marks** (Rearrange: frequency =) speed / wavelength **OR** (f =) 4500 / 0.0022 ✓ (f =) 2 045 455 (Hz) ✓ (f =) 2 000 000 (Hz) ✓ (f =) 2.0×10^6 (Hz) ✓	4 (AO1.2) (AO2 x 2.1) (AO1.2)	**ALLOW** ecf from **(i)** **ALLOW** three marks for 2.0 MHz **ALLOW** a mark for their answer to 2 significant figures **ALLOW** a mark for their answer in standard form
			Total	**5**	

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Question			Answer/Indicative content	Marks	Guidance
32	a		(All galaxies) showed <u>red-shift</u> ✓ (Hubble measured the) wavelength/frequency of <u>light</u> (from the galaxy) ✓	2 (AO2 × 1.1)	**ALLOW** (all galaxies) showed <u>light</u> with a longer wavelength/lower frequency for 2 marks
	b	i	Readings of speed taken for two different values of distance ✓ Working to show that the factor increase in speed is the same as distance ✓	2 (AO2 × 3.1a)	**ALLOW** +/- ½ a small square **ALLOW** a statement for the second mark e.g. as the distance doubles so does the speed. <u>Example:</u> At 20 Mpc, speed = 1400 km/s At 40 Mpc, speed = 2800 km/s 40/20 = 2 = 2800/1400 **ALLOW** 1 mark maximum for it is a (straight) line of best fit through the origin (therefore it is proportional)
		ii	**Any one from:** The more distant galaxies are travelling faster ✓ The evidence suggests the universe is expanding ✓ The universe was smaller in the past ✓	1 (AO1.1)	**ALLOW** galaxies are moving away from each other
	c		To ensure results are reproducible / check the work is of high enough quality / claims are not false / for new theories to be accepted / to develop theories / AW ✓	1 (AO1.1)	**ALLOW** check validity / for mistakes/anomalies / AW **ALLOW** check that it's not biased / AW
	d	i	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 5 800 000 (m/s) award 2 marks** (Reads off speed from graph =) 5800 (km/s) ✓ Speed = 5800 × 1000 = 5 800 000 (m/s) ✓	2 (AO2.2) (AO1.2)	**ALLOW** 5.8×10^6 (m/s) **ALLOW** ecf for their speed from graph x 1000

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Question			Answer/Indicative content	Marks	Guidance
		ii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 4.36 × 10^{17} (s) award 3 marks time = distance / speed ✓ (time =) 2.53 × 10^{24} / 5 800 000 ✓ (time =) 4.36 × 10^{17} (s) ✓	3 (AO1.2) (AO2.1) (AO2.1)	ALLOW ecf from (i) ALLOW 4.4 x 10^{17} (s) ALLOW equation in any form
			Total	11	
33			A	1 (AO2.1)	
			Total	1	
34			C	1 (AO2.2)	
			Total	1	
35	a		Any one set of readings from the graph multiplied together to give a correct number ✓ Any second set of readings from the graph multiplied together to give the same constant ✓	2 (AO3.1b x 2)	e.g. 5×500 = 10×250 = 20×125 = 25× 100 = 2500
	b		Any two from: As temperature increases, pressure increases / AW✓ Linear /straight line relationship ✓ Higher temperature means more (frequent) collisions (between particles and container) / AW✓	2 (AO1.1.x 2)	ALLOW higher temperature means bigger pressure DO NOT ALLOW *T* & *P* in wrong order DO NOT ALLOW (directly) proportional relationship ALLOW pressure goes up at the same rate as temperature IGNORE idea of more collisions with other particles
			Total	4	

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