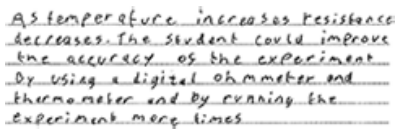
Mark scheme

Question			Answer/Indicative content	Marks	Guidance
1	a		A and B ✓	1 (AO 2.2)	Both A and B are required for this mark **Examiner's Comments** Parts (a) and (b) were generally well answered by all candidates. Many candidates were able to select the correct response in part (c), but often explanations in part (d) were too vague to be credited. Part (e) was correctly answered by many candidates. The most common error was writing 'decreases' rather than 'increases' for the first space.
	b		A and C ✓	1 (AO 2.2)	Both A and C are required for this mark **Examiner's Comments** Parts (a) and (b) were generally well answered by all candidates. Many candidates were able to select the correct response in part (c), but often explanations in part (d) were too vague to be credited. Part (e) was correctly answered by many candidates. The most common error was writing 'decreases' rather than 'increases' for the first space.
	c		Both lamps have the same brightness ✓	1 (AO 2.2)	**Examiner's Comments** Parts (a) and (b) were generally well answered by all candidates. Many candidates were able to select the correct response in part (c), but often explanations in part (d) were too vague to be credited. Part (e) was correctly answered by many candidates. The most common error was writing 'decreases' rather than 'increases' for the first space.
	d		Any **ONE** from: They have the same resistance ✓ Both lamps have the same current ✓	1 (AO 2.2)	**ALLOW** lamps are in parallel **IGNORE** The lamps are identical (repeat of question stem)

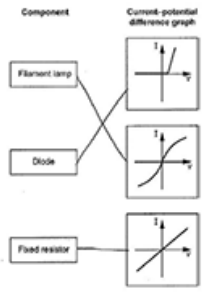
			Both lamps have the same potential difference/voltage ✓ Both lamps have the same current and potential difference ✓		**DO NOT ACCEPT** current/resistance/voltage is the same throughout the circuit **Examiner's Comments** Parts (a) and (b) were generally well answered by all candidates. Many candidates were able to select the correct response in part (c), but often explanations in part (d) were too vague to be credited. Part (e) was correctly answered by many candidates. The most common error was writing 'decreases' rather than 'increases' for the first space.
	e		increases ✓ electrons ✓ thermal ✓	3 (AO 1.2 x 3)	Words must appear in the correct order **ALLOW** heat **Examiner's Comments** Parts (a) and (b) were generally well answered by all candidates. Many candidates were able to select the correct response in part (c), but often explanations in part (d) were too vague to be credited. Part (e) was correctly answered by many candidates. The most common error was writing 'decreases' rather than 'increases' for the first space.
			Total	**7**	
2	a		**First check the answer on the answer line** **If answer = 15 (C) award 3 marks** Q = E / V ✓ Q = $7.5 \times 10^9 / 5.0 \times 10^8$ ✓ Q = 15 (C) ✓	3 (AO 1.2) (AO 2.1) (AO 2.1)	**ALLOW** substituting into original equation for 1 mark. $7.5 \times 10^9 = Q \times 5.0 \times 10^8$ **Examiner's Comments** Question 18 (b) was a simple calculation where candidates had to rearrange and substitute into the equation given. Most middle and higher performing candidates managed full marks. Some less successful candidates, who did not complete the calculation correctly but had written out the rearranged formula and substituted into it correctly, were given 2 marks that were missed by

					candidates who had just written the incorrect answer.
	b		**First check the answer on the answer line** **If answer = 1800 (C) award 3 marks** (Q = It) t = 2 × 60 = 120 (s) ✓ Q = 15 × 120 ✓ Q = 1800 (C) ✓	3 (AO 1.1) (AO 2.1) (AO 2.1)	**ALLOW 2** marks for an answer of 30 (C) – conversion of time not completed **Examiner's Comments** Question 18 (b) was a simple calculation where candidates had to convert 2 minutes into seconds and then substitute into the given formula. More successful candidates correctly converted and calculated and were given 3 marks. Many middle and lower performing candidates did not do the conversion but substituted in correctly and were given 2 marks.
			Total	**6**	
3			D	1 (AO 1.2)	
			Total	**1**	
4			A	1 (AO 2.2)	
			Total	**1**	
5		i	Electrons✓ Light✓	2 (2 × AO 1.1)	**Examiner's Comments** The majority of candidates scored 1 mark. The common errors were confusing atoms with electrons and sound with light.
		ii	**First check the answer on the answer line** **If answer = 240 (J) award 2 marks** (E =) 0.08 x 3000 ✓ (E =) 240 (J) ✓	2 (2 × AO 2.1)	**Examiner's Comments** The majority of candidates correctly multiplied the potential difference by the charge.
		iii	(Risk of) an (electric) shock / electrocution / **AW** ✓	1 (AO 3.2a)	**IGNORE** dangerous / injury / death unqualified **Examiner's Comments** There were many vague answers of the power supply being dangerous or causing death. It was expected that candidates would refer to the risk of electrocution or electric shock.

			Total	**5**	
6			**First check the answer on the answer line** **If answer = 260 (kW h) award 2 marks** (E =) 0.01 x 26 000✓ (E =) 260 (kW h) ✓	2 (2 × AO 2.1)	**Examiner's Comments** This question was answered well. Where errors occurred, it was either using 0.1 instead of 0.01 or calculating the energy transferred for the filament lamp.
			Total	**2**	
7	a		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 of the trend shown by the graph **and** detailed suggestions to improve the experimental method. *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 of the trend shown by the graph **and** some simple suggestions to improve the experimental method. **OR** Detailed description of the trend shown by the graph. **OR** Detailed suggestions to improve the experimental method. *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)** Simple description of the trend indicated. **OR** Some simple suggestions to improve the experimental method.	6 (3 × AO 3.1a) (3 × AO 3.3b)	**AO3.1a Analyses the results to interpret the trend shown by the graph.** For example, • as temperature increases, resistance decreases / **ORA** • relationship is not linear • rate of increase/decrease/change of resistance is higher at lower temperatures / **ORA** • resistance decreases at a decreasing rate • two points from graph to illustrate a change e.g. at 10˚C the resistance is 900Ω / at 25˚C the resistance is 400Ω / at 40˚C the resistance is 200Ω **AO3.3b Analyses the information to improve experimental procedures.** For example, • Stir water (to ensure even temperature) • Use a water bath • Repeat readings and take a mean / ignore anomalies • Use a digital meter / Use a digital thermometer / temperature probe • Take additional temperature readings (3 is not enough) • Use a wider range of temperatures / Use temperatures over 50˚C / Use temperatures below 10˚C • Only submerge the actual thermistor / Don't submerge the crocodile clips/electrical connections

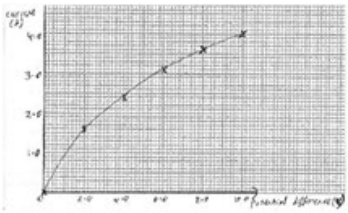
			The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear. **0 mark** *No response or no response worthy of credit.*		• Check ohmmeter for zero error • Thermometer should not touch the sides/bottom of the beaker Thermometer closer to thermistor **Examiner's Comments** This was a relatively straightforward level of response question for most Foundation candidates. Many were able to describe the trend in simple terms. More successful candidates described the curving nature of the relationship or read the graph and gave examples. Suggestions for improvements were seen from the full range of candidates. A proportion of lower performing candidates described improvements to increase reliability, along the lines of taking repeat measurements. Examiners were able to give some marks to those who added that taking the repeats was either to calculate a mean or to discard anomalies. More successful candidates suggested stirring the water, using digital instruments, putting the thermometer closer to the thermistor, and taking a wider range of measurements. The last two of these were the most common correct responses seen. This question was accessible to all candidates, and the majority were able to demonstrate some scientific understanding. Exemplar 2  As temperature increases resistance decreases. The student could improve the accuracy of the experiment by using a digital ohmmeter and thermometer and by running the experiment more times In Exemplar 2, the candidate has described the trend shown by the graph in simple terms. They have also

					suggested using digital meters to improve the accuracy of the readings. The candidate has mentioned running the experiment several times, which on its own would not be a valid suggestion to improve accuracy as mentioned above. This response is at Level 2 and was given 4 marks.
	b		C ✓ **And any one from:** (Idea that) ammeters A and B cannot measure up to 300 mA ✓ (Idea that) on ammeter D, 300 mA is between marks on the ammeter (so cannot be measured accurately) / smaller resolution ✓	2 (AO 2.2) (AO 3.2a)	**ALLOW** the smallest scale that goes to 300 (mA) **ORA** (idea that) ammeter C has a mark at 300 mA **ORA** (idea that) ammeter C has higher resolution **Examiner's Comments** Many candidates across the range of performance were able to spot that Option C was the best choice. The easiest way to be given the second mark was to say that A and B did not read high enough. Candidates who instead tried to explain that Option D had a higher resolution without using the word 'resolution' often ran into difficulties due to poor communication skills.
	c		Streetlights / phone/screen brightness / automatic (head)lights / security lights / alarm clocks / light meter / smoke detector / digital camera / motion detector ✓ (Light) turns on when it is dark / turns off/dims in dim light / motion is detected when light levels change ✓	2 (AO 1.1) (AO 1.2)	**ALLOW** any sensible suggestion that uses a light sensor **ALLOW** function controlled by change in light level (for suggested use) **Examiner's Comments** Although this was a straightforward recall question, it was generally poorly answered by many candidates. Higher performing candidates were able to recall a suitable use, for example 'streetlights' and give a simple description of how it is used, for example 'turn on when it is dark'.
			Total	**10**	

8	a		 ✓✓	2 (2 × AO 1.2)	All 3 correct = 2 marks 1 or 2 correct = 1 mark **Examiner's Comments** This was generally well answered by all but the lowest performing candidates, suggesting good revision, as it was a straight recall question.
	b	i	Ammeter ✓	1 (AO 1.2)	**IGNORE** Ampmeter / Anmeter **ALLOW** phonetic spellings
		ii	Correct symbol for ammeter ✓ Placed in series (anywhere in the circuit) ✓	2 (AO 1.1) (AO 2.2)	**ALLOW** incorrect symbol for this mark **Examiner's Comments** Many candidates correctly identified ammeter as the correct response for part (i) and were able to draw the correct symbol in series.
		iii	Voltmeter ✓	1 (AO 1.2)	**ALLOW** phonetic spellings
		iv	Correct symbol for voltmeter ✓ Placed in parallel with the resistor ✓	2 (AO 1.1) (AO 2.2)	**ALLOW** incorrect symbol for this mark **Examiner's Comments** Less successful candidates were unable to identify a voltmeter as the correct instrument for measuring potential difference and only the most successful candidates drew the correct symbol in parallel to component X.
	c		**First check the answer on answer line** **If answer = 24 (V) award 3 marks** (V=) IR ✓ (V=) 4 x 6 ✓ (V=) 24 (V) ✓	3 (AO 1.2) (AO 2.1) (AO 2.1)	**ALLOW** V=IR in any form **Examiner's Comments** The equation for potential difference = current × resistance was given on the equation sheet and it did not need rearrangement. Most candidates were given all 3 marks here.
			Total	**11**	

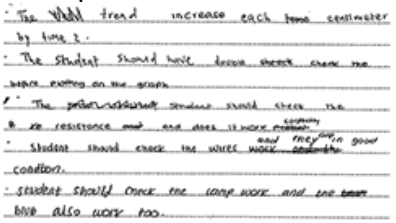
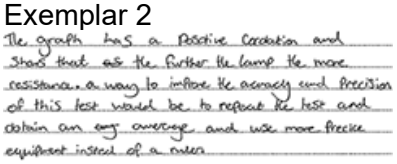
9			**A**	1 (AO 2.1)	**Examiner's Comments** The correct response for this question was Option A. Option D was commonly chosen, suggesting that candidates did not notice that the values were in kΩ rather than Ω,or did not realise what this meant.
			Total	**1**	
10			**A**	1 (AO 2.2)	**Examiner's Comments** The correct response for this question was Option A. Option B was commonly chosen suggesting that candidates did not recognise the variable resistor symbol.
			Total	**1**	
11			**B**	1 (AO 2.2)	**Examiner's Comments** The correct response for this question was Option B. Option A was commonly chosen, suggesting a misunderstanding of the circuit rules.
			Total	**1**	
12		i	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 8 (A) award 3 marks** Current = power ÷' p.d ✓ (Current =) 1840 ÷ 230 ✓ (Current =) 8 (A) ✓	3 (AO1.2) (2 × AO2.1)	Rearrangement of the given equation **Examiner's Comments** This question was well answered. The majority of the candidates correctly worked out the current. A significant minority of candidates multiplied the power by the potential difference.
		ii	**Any two from**: The power would be higher ✓ The water would heat up quicker ✓ (So) more water could be heated (in the same time) ✓	2 (AO3.2a)	**IGNORE** Higher currents are more dangerous **IGNORE** it would get hotter **Examiner's Comments** Many candidates stated that the temperature of the water would increase at a greater rate. Other

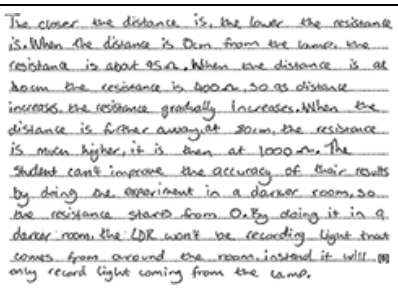
					candidates also mentioned that the power would be greater. For this type of question two distinct suggestions should be made.
			Total	**5**	
13			**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 6 × 10^6 (kWh) award 2 marks** Energy transferred = 3 × 2 × 10^6 ✓ (Energy transferred =) 6 × 10^6 (kWh) ✓	2 (2 × AO2.1)	**ALLOW** 6 000 000 (kWh) **Examiner's Comments** The question was generally well answered with most candidates multiplying the power output by 3. Many candidates (correctly) gave their answer in standard form. A significant number of candidates converted the time to minutes (and some candidates then to seconds).
			Total	**2**	
14	a		(Ammeter position) J ✓ (Voltmeter position) K ✓	2 (2 × AO2.2)	**Examiner's Comments** This very basic question on the position of an ammeter and a voltmeter in a circuit showed that most knew an ammeter should be placed in series, but often candidates did not place the Voltmeter in parallel with the lamp. Some candidates perhaps recognised the circuit (vaguely) and knew that J and K were the correct positions but did not remember the correct usage of the meters. **Assessment for learning** The correct connection of ammeters and voltmeters in a simple series circuit needs frequent practice, both practically and in drawing and labelling circuit diagrams.
	b	i	Both points correctly plotted ✓ Appropriate curved line of best fit drawn ✓	2 (2× AO1.2)	**ALLOW** points plotted within +/− half a small square **ECF candidates own curve from incorrectly plotted points** Must be curved and agree reasonably

					with the first 4 points. Allow ± 1 small square for the line paths near the last two points provided that the curve is smooth. **Examiner's Comments** Most candidates plotted both points on the graph correctly but only about half drew an appropriate line of best fit. Many of the remainder thought it should be a linear relationship and drew a straight line, either from (0,0) to (10.0, 4.0) or else a best fit to the data. Others drew no line at all, possibly because 'line' meant 'straight line' to them, and the points clearly cannot fit to a straight line. **Assessment for learning** This graph, or a similar one, is an excellent exercise in plotting points, drawing best fit curves, reading from the graph and also using *I*-*V* values along the curve to calculate resistance and power. **Misconception** In the Sciences, a line of best fit does not have to be a straight line. In this case it's a curve. It is worth highlighting that the term line of best fit may be used in mathematics GCSE to be a straight line to indicate a correlation in a scatter graph. The Language of Mathematics in Science is a useful reference for science departments. It can help teachers of science to understand how terms can be used differently in maths lessons.

		ii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 14 (W) award 2 marks** 5 × 2.8 ✓ 14 (W) ✓	2 (2× AO2.1)	**ALLOW** ECF for incorrect reading/plotting of current from graph within +/− half a small square **Examiner's Comments** Where candidates drew the line incorrectly, or where they did not but the interpolation was reasonable, 'error-carried-forward' was applied and many got full marks here.
		iii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 1680 (J) award 3 marks** 2 minutes = 120 seconds ✓ 14 × 120 ✓ = 1680/1700 (J) ✓	3 (AO1.2) (AO2.1) (AO2.1)	**ALLOW** ECF from (c)(ii) **ALLOW** 2 marks for 28 (J) (no unit conversion) **ALLOW** 3 marks for 1.68/1.7 k(J) if k inserted **Examiner's Comments** Many candidates lost the conversion mark (for minutes to seconds) and scored 2/3 here. **Assessment for learning** Questions 17 (c) (ii) and 17 (c) (iii) each require the use of equations. Students should learn to be systematic in laying these out showing all steps. This will help them to avoid mistakes, and it can also allow them to gain marks for the correct method if there is a calculation error.
			Total	**9**	
15			**Level 3 (5–6 marks)** Detailed description of the trend shown with use of data **AND** detailed suggestions to improve the accuracy [A] **AND** precision [P] of the results. *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)**	6 (4× AO3.1a) (2 × AO3.3b)	**AO3.1a Analyses the results to interpret the trend shown by the graph**. For example • as distance (from the lamp) increases, resistance increases or the inverse • as light intensity increases, resistance decreases • relationship is not linear

			Basic description of the trend shown and suggestions to improve the accuracy / precision of the results. **OR** Detailed description of the trend shown with use of data . *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)** Basic description of the trend shown, e.g. resistance goes up with distance. **OR** Basic suggestion to improve the accuracy or precision of the results, e.g. repeat readings. *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear*. **0 mark** *No response or no response worthy of credit*.		• rate of increase of resistance is higher further from / lower closer to the lamp • resistance increases at an increasing rate • at 0cm from the lamp the resistance is 100Ω; • at 20cm from the lamp the resistance is 240Ω; • at 40cm from the lamp the resistance is 400Ω; • at 60cm from the lamp the resistance is 600Ω; • at 80cm from the lamp the resistance is 1000Ω; **AO3.3b Analyses the information to improve experimental procedures**. For example • put the lamp directly in line with the LDR [A] • measure from the bulb directly to the LDR [A] • use a digital meter [P] • use resistance meter with higher resolution [P] • reduce other light sources, e.g. close blinds [A] • repeat readings (and calculate a mean) [P] • reduce the interval between readings/take readings every 10cm [P] • repeat readings and discard anomalies [A] **<u>Examiner's Comments</u>** This level of response was answered well with very good, well-structured responses. Very few candidates were given fewer than 2 marks, and most achieved 4 or more. Less successful responses would have gained more marks if they recognised that to improve accuracy and precision for any experiment they should repeat the results , calculate a mean and investigate / discard anomalies: Many

					only said, ‘repeat results.’ Three student exemplars, one at each level, are given on the following pages. Exemplar 1  The italicised part of the mark scheme for Level 1 states ‘The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.’ This response fits that description. The mark scheme requires either a basic description of the trend or a basic suggestion to improve accuracy or precision: the first two lines (bullet point 1) cover the trend; lines 3 and 4 (bullet point 2) are not enough for a precision/accuracy comment. The remaining three bullet points do not address the question at all and get no credit. Exemplar 2  The positive correlation between distance and resistance is noted (‘Basic description of the trend shown’) and ‘repeat the test and obtain an average’ is enough for a suggestion to improve the accuracy and precision of the results. This fits the Level 2 criteria and so gets 4 marks. Exemplar 3

					 The communication aspect part of the mark scheme for Level 3 states 'There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.' This is true here. As regards the physics content, the trend is well described with the non-linearity made clear (…at 80 cm, the resistance is much higher) and the data is quoted sensibly. The sentence 'The student can't improve…starts from 0.' Contributes nothing to the response, but the final sentence describes a good practical improvement of avoiding extraneous light and so eliminating a confounding variable. Although this improvement is to accuracy, not precision, the quality of the response is such that this merits a full 6 marks.
			Total	**6**	
16			A ✓	1 (AO2.1)	
			Total	**1**	
17			A ✓ D ✓	2 (2× AO3.2a)	**<u>Examiner's Comments</u>** Answers to this part were no better than would be expected from a random choice of two boxes.
			Total	**2**	
18			C ✓	1 (AO1.2)	
			Total	**1**	