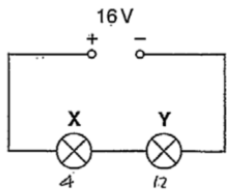
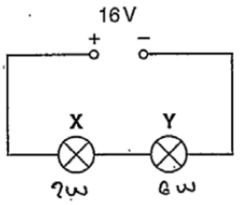
Mark scheme - Power

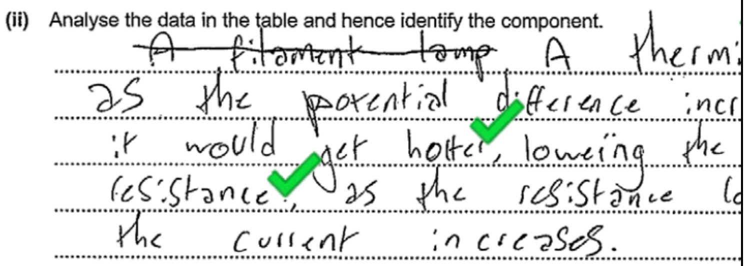
Question	Answer/Indicative content	Marks	Guidance
1	**B**	1	<u>**Examiner's Comments**</u> Candidates answered this question well. A range of techniques could be used to get to the correct answer **B**. This is illustrated by the two exemplars below. **Exemplar 2**  Lamp **X** emits a power of 2.0W and lamp **Y** emits a power of 6.0W. What is the potential difference across the lamp **X**? **A** 1.0V **B** 4.0V **C** 12V **D** 16V Your answer B This shows the thought processes of a top-end candidate. The current in the series circuit is constant, hence the potential difference must be proportional to the power dissipation. These two lines is all it took for this candidate to identify the correct answer **B**. **Exemplar 3**  Lamp **X** emits a power of 2.0W and lamp **Y** emits a power of 6.0W. What is the potential difference across the lamp **X**? **A** 1.0V **B** 4.0V **C** 12V **D** 16V Your answer B

					Here's another equally valid technique, which may have been a bit time–consuming for this grade D candidate. The total power dissipated has been used to determine the current in the circuit. The correct value of 4.0 V across lamp **X** has been calculated using this current and the equation *P* = *VI*. It is worth noting the sensible approach of annotating the figure. This would have helped to steer away from the popular distractor C.
			Total	**1**	
2			C	1	
			Total	**1**	
3			D	1	**Examiner's Comments** All of the questions showed a positive discrimination, and the less able candidates could access the easier questions. The questions in Section A do require careful reading and scrutiny. Candidates are advised to reflect carefully before recording their response in the box. Candidates must endeavour to use a variety of quick techniques when answering multiple choice questions.
			Total	**1**	
4			D	1	
			Total	**1**	
5			**D**	1	
			Total	**1**	
6			A	1	**Examiner's Comments** All of the questions showed a positive discrimination, and the less able candidates could access the easier questions. The questions in Section A do require careful reading and scrutiny. Candidates are advised to reflect carefully before recording their response in the box. Candidates must endeavour to use a variety of quick techniques when answering multiple choice questions.
			Total	**1**	
7			**B**	1	
			Total	**1**	
8			**A**	**1**	
			Total	**1**	
9			**D**	**1**	
			Total	**1**	
10			**B**	1	
			Total	**1**	

1 1			**D**	**1**	
			Total	**1**	
1 2			C	1	
			Total	**1**	
1 3			C	1	
			Total	**1**	
1 4			C	1	
			Total	**1**	
1 5			B	1	
			Total	**1**	
1 6			C	1	
			Total	**1**	
1 7			B	1	**Examiner's Comments** The correct response is **B**. This is another question which was correctly answered by around two thirds of the candidates. The simple solution is through determining the current through **Z** and the p.d. across it thereby finding the product. Working demonstrated some tortuous routes, such as calculating all the resistances, which does indicate a lack of confidence about circuit calculations. However, in many cases this did lead to the correct answer.
			Total	**1**	
1 8			C	1	
			Total	**1**	
1 9			B	1	
			Total	**1**	
2 0			D	1	**Examiner's Comments** The correct response is **D**. It was encouraging to see that a large number of candidates were able to select the correct answer. Although a relatively straightforward calculation, it does involve two unit conversions (mA to A, and hours to seconds), which if not done would generate one of the distractors. Many candidates showed their working here as they would in a structured question and this is always helpful when the calculation involves more than one stage.

			Total	**1**	
21			**D**	1	
			Total	**1**	
22			**C**	1	**<u>Examiner's Comments</u>** This was a tough question on the kilowatt hour, but almost all candidates picked up a mark here. On most scripts there were not much evidence of number crunching; calculations must have been done on calculators – sensible time saving strategy. Some candidates did use elaborate routes to get to the correct answer of C. The annual saving in pounds (£) is calculated as follows: annual savings = (0.060 – 0.012) × 10 × 2000 × 0.154 = £147.84 It is worth pointing out the rationale behind the distractors. A was the answer when the 2000 had been omitted from the calculation above. B was the answer for just using 12 W and finally D was the answer for just using 60 W.
			Total	**1**	
23			150 (× 10^{-3}) × 5 × 16 12 (p)	C1 A1	**Not** time in minutes or seconds **Allow** ECF for POT on power
			Total	**2**	
24	a	i	$R = \frac{230^2}{3500} = 15.11$ 15 (Ω)	**M1** **A0**	**Allow** calculation of current (15.2) and *R* = *V* / *I* **Not** 3500 / 230 = 15.2 **Examiner's Comments** This question asked candidates to show that the resistance of one of the heaters was 15 Ohms. Some candidates divided 3500 W by 230 V which gave an answer of 15.2 A which was the current. If these candidates then divided 230 V by 15.2 A they still gained the mark.
		ii	$A = \pi \times 0.00055^2 (= 9.5 \times 10^{-7}\ \text{m}^2)$ $L = \frac{15 \times 9.5 \times 10^{-7}}{1.6 \times 10^{-6}}$ 8.9 (m)	**C1** **C1** **A1**	**Note** 8.9 × 10^n scores two marks **Allow** 15.1 gives 9.0 m **Examiner's Comments** It was pleasing to see many good answers to the determination of the length of the wire. Candidates showed clearly how they determined the area and then substituted correctly into the rearranged equation for resistivity. Some candidates round their answer to one significant figure.
		iii	(Ohm's law states that) *V* proportional to *I* (provided the physical conditions / temperature remain constant)	**B1**	

			Since the temperature is not constant, Ohm's law will not apply	**B1**	**Allow** one mark for Ohm's law will not apply because as temperature changes the resistance changes **Examiner's Comments** Candidates often scored a mark for stating Ohm's law; candidates should define any symbols used. Candidates often did not refer to any temperature change in the heater. Vague answers referring to "heating" did not score.
	b		3.5 × 7 or 3.5 × 7 × 7 or 10.5 × 7 or 10.5 × 7 × 7 or 514.5 514.5 × 7.6p = £39.10 or £39.11	**C1** **A1**	**Note** for use of 17 hours £94.96 scores one mark **Allow** 3910p or 3911 p or £39.1 or £39.102 **Examiner's Comments** A surprising number of candidates did not correctly determine the cost of electricity. Many candidates did not use three heaters or seven days. For the award of the intermediate mark, clear working needed to be shown.
			Total	**8**	
25			(V_R =) 2.7 (V) **or** (current =) 0.018 (A) (ratio = $\frac{0.018 \times 1.8}{0.018 \times 2.7}$) ratio = 0.67	C1 A1	**Note** the mark can be scored on circuit diagram **Note** values of powers are: 0.0324 W and 0.0486 W **Allow** 2/3; **Not** 0.66 (rounding error)
			Total	**2**	
26			p.d. across resistor = 1.50 − 0.62 = 0.88 (V)	C1	
			current = 0.88 / 120 = 7.33… × 10^{-3} (A)	C1	
			power = VI = 1.50 × 7.33 × 10^{-3} = 1.1 × 10^{-2} (W)	A1	
			Total	**3**	
27		i	(P = VI = 10.0 × 0.030) power = 0.30 (W)	**B1**	**Allow** 0.3 (W) without any SF penalty **Allow** 300 **m**(W)
		ii	The component is (an NTC) thermistor. (As V or I increases the) resistance of the component decreases Any one from: Component cannot be a diode / LED because of current in one direction	**B1** **B1** **B1**	**Allow** calculations at 5 V and 10 V to support this, **ignore** POT errors **Examiner's Comments** The question was effective in two parts. Use the data to determine

			only (AW) (As V or I increases the) component gets warmer / increase in number density (of free charge carriers)		the resistance of the component at different potential difference, and then use this data to make judgement in identifying the component. Most candidates gained two or more marks. Some descriptions went astray with mention of Ohm's law or *I-V* characteristics. A significant number of candidates gave good reasoning but spoilt their answers by opting for a diode, an LDR or a filament lamp. **Exemplar 10**  (ii) Analyse the data in the table and hence identify the component. ~~A filament lamp~~ A therm as the potential difference incr it would get hotter, lowering the resistance, as the resistance l the current increases. This exemplar illustrates how a brief answer can score maximum marks. This answer is from a grade C candidate. Answers from top'end candidates were verbose and supported by values of resistances.
			Total	**4**	
28	a		There is no contact force between the astronaut and the (floor of the) space station (so no method of measuring / experiencing weight)	B1	**Allow** astronaut and the space station have same acceleration (towards Earth) / floor is falling (beneath astronaut) __**Examiner's Comments**__ **Misconception** Experiencing weightlessness is not the same as being in freefall There was a lack of understanding of the nature of feeling weightless. The sensation of 'weightlessness' is a lack of the physiological sensation of 'weight'. The skeletal and muscular systems are no longer in a state of stress. This sensation is caused by a lack of contact forces as a result of the ISS and the astronaut experiencing the same acceleration. Common incorrect responses included: • the astronaut is weightless because he is falling • there is no resultant force on the astronaut • gravity is too weak to have any effect on the astronaut • the ISS orbits in a vacuum where there is no gravity.
	b	i	$M = 5.97 \times 10^{24}$(kg) **or** ISS orbital radius $R = 6.78 \times 10^{6}$(m) **or** $g \propto 1/r^2$ (gr^2 = constant so) $g \times (6.78 \times 10^{6})^2 = 9.81 \times (6.37 \times 10^{6})^2$	C1 C1 A1	**or** g (= GM/R^2) = $6.67 \times 10^{-11} \times 5.97 \times 10^{24} / (6.78 \times 10^{6})^2$ **Allow** rounding of final answer to 2 SF i.e. 8.7 (N kg^{-1})

			$g = 8.66$ (N kg^{-1})		**Examiner's Comments** The simplest method here was to use the fact that g is inversely proportional to r^2, so gr^2 = constant. If this was not used, a value for the mass of the Sun had to be calculated, which introduced a further step. Candidates who omitted this calculation and used a memorised value of the Sun's mass instead were unable to gain full marks, because they invariably knew it to 1 s.f. only, whereas 3 were required. Errors occurred when candidates used the incorrect distance in the formula for g. Common errors included: • forgetting to square the radius • using the Earth's radius rather than the orbital radius of the satellite • calculating $(6.37 \times 10^6 + 4.1 \times 10^5)$ incorrectly.
		ii	$2\pi r / T = v$ **or** $T = 2 \times 3.14 \times 6.78 \times 10^6 / 7.7 \times 10^3$ $T = 5.5 \times 10^3$ s (= 92 min)	M1 A1	**ECF** incorrect value of R from **b(i)**
	c		$\frac{1}{2}Mc^2$ $(\frac{1}{2}N_A mc^2) = \frac{3}{2}RT$ $c^2 = 3 \times 8.31 \times 293 / 2.9 \times 10^{-2} = 2.52 \times 10^5$ $\sqrt{c^2} = 500$ (m s^{-1}) $(= 7.7 \times 10^3 / 15)$	C1 C1 A1 A0	**or** $\frac{1}{2}mc^2 = \frac{3}{2}kT$ **or** $c^2 = 3kT/m$ **or** $c^2 = 3 \times 1.38 \times 10^{-23} \times 6.02 \times 10^{23} \times 293/2.9 \times 10^{-2} = 2.52 \times 10^5$ **not** $(7.7 \times 10^3 / 15) = 510$ (m s^{-1}) **Examiner's Comments** The success in this question depended on understanding the meaning of the term m in the formula $\frac{1}{2}m\overline{c^2} = \frac{3}{2}kT$ given in the Data, Formulae and Relationship booklet. A significant number of candidates took m to be the mass of one mole (the molar mass, M) whereas m is actually the mass of one molecule. Candidates who used the formula $\frac{1}{2}M\overline{c^2} = \frac{3}{2}RT$ were usually more successful because the molar mass had been given in the question stem.
	d		power reaching cells (= IA) $= 1.4 \times 10^3 \times 2500 = 3.5 \times 10^6$ W power absorbed $= 0.07 \times 3.5 \times 10^6 = 2.45 \times 10^5$ W cells in Sun for (92 – 35 =) 57 minutes average power $= 57/92 \times 2.45 \times 10^5 = 1.5 \times 10^5$ (W)	C1 C1 C1 A1	mark given for multiplication by 0.07 at any stage of calculation (90 – 35 =) 55 minutes using $T = 90$ minutes **ECF** value of T from **b(ii)** $55/90 \times 2.45 \times 10^5 = 1.5 \times 10^5$ (W) using $T = 90$ minutes **Examiner's Comments** Although this question looked daunting, it was actually quite linear and many candidates who attempted it were able to gain two or three marks even if they did not eventually get to the correct response. Candidates who set out their reasoning and working clearly were more liable to gain these compensatory marks.

<table>
<tr><td></td><td></td><td></td><td>Total</td><td>13</td><td></td></tr>
<tr><td>29</td><td>a</td><td></td><td>E = y-intercept

r = - gradient</td><td>B1

B1</td><td>E must be the subject

R must be the subject
Do not accept gradient = - r</td></tr>
<tr><td></td><td>b</td><td>i</td><td>$\left(R = \frac{5.68}{0.025} =\right) 230\ \Omega$</td><td>A1</td><td>Allow 227</td></tr>
<tr><td></td><td></td><td>ii</td><td>$\left(\frac{5.68^2}{\mathbf{(c)(i)}} \text{ or } 0.025^2 \times \mathbf{(c)(i)} \text{ or } 0.025 \times 5.68 =\right)$

0.14 × 300 = 42 (J)</td><td>C1

A1</td><td>Allow ECF from (c) (i)
0.140 or 0.142 or 0.144

Allow 43 (J) (for 0.142 or 0.144)</td></tr>
<tr><td></td><td></td><td>iii</td><td>$\left(Q = \frac{\text{(c)(ii)}}{5.68} \text{ or } 0.025 \times 300 =\right) 7.4 \text{ or } 7.5$

C</td><td>B1

B1</td><td>Allow ECF from (c) (ii)</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>7</td><td></td></tr>
<tr><td>30</td><td></td><td></td><td>Level 3 (5–6 marks)
E and r calculated correctly and table completed correctly and clear description of P and R

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)
Table completed correctly and some description of P and R / some attempt at E and r
OR
E and r calculated correctly
OR
Some attempt at calculating E and r and some description of P and R

There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.

Level 1 (1–2 marks)
Limited calculation of E and r
OR
Table completed correctly
OR
Limited description of relationship between P and R

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</td><td>B1×6</td><td>Indicative scientific points may include:

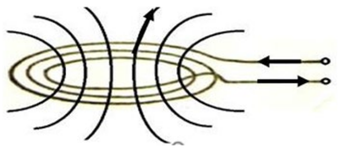
Calculating E and r
• E = Ir + V
• gradient = (-) r
• y-intercept = E
• Line extrapolated to y-axis
• E = 1.2 (V)
• r = 0.8(0 Ω)

Table and description
• Table completed (ignore SF) – see below
• R increases as V increases (or I decreases)
• P increases and decreases
• Maximum power is when internal resistance is equal to R (0.8 Ω)

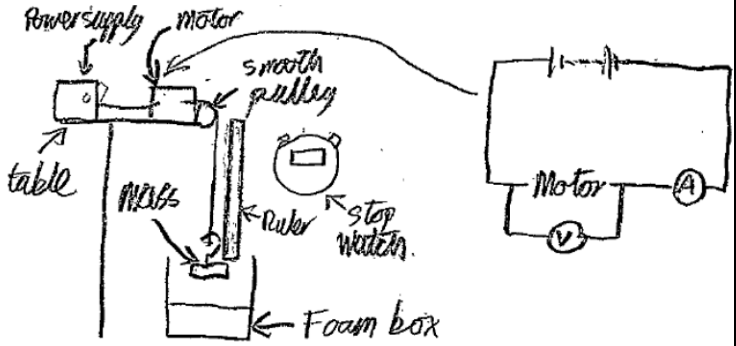
<table>
<tr><th>V / V</th><th>I / A</th><th>R / Ω</th><th>P / W</th></tr>
<tr><td>0.20</td><td>1.25</td><td>0.16</td><td>0.25</td></tr>
<tr><td>0.40</td><td>1.00</td><td>0.40</td><td>0.40</td></tr>
<tr><td>0.60</td><td>0.75</td><td>0.80</td><td>0.45</td></tr>
<tr><td>0.80</td><td>0.50</td><td>1.60</td><td>0.40</td></tr>
<tr><td>1.00</td><td>0.25</td><td>4.00</td><td>0.25</td></tr>
</table>

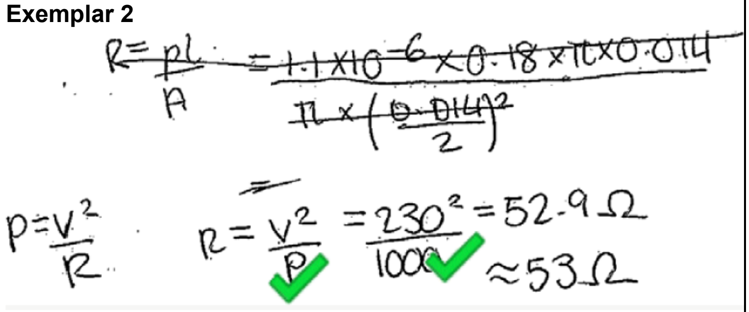
<u>Examiner's Comments</u>

This is the first LoR question on the paper. This question is based on a standard physics practical, so the experimental set up should have been familiar to many candidates. While a holistic approach is taken to the marking, there are key points which should be present for the award of given levels. The question is structured in two main</td></tr>
</table>

			0 marks No response or no response worthy of credit		parts: the determination of E and r, and then the calculation of R and P for the table. However, each of these parts contain additional instructions which were often ignored by the candidates. For the emf and internal resistance, an explanation of the method used was required, the most usual way would be based around a rearrangement of $E = V + Ir$. For the resistance and power, a qualitative description of how they are related is needed, along with an appreciation that when the internal resistance equals the load resistance the power is at its maximum. For the most part, candidates carried out the calculations well, completing the table and identifying *E* and *r* correctly, but did not give suitable and detailed descriptions leading to them being limited to lower levels. Very few discussed the resistance and power relationship at all, despite it being a reasonably simple pattern. It is very important that candidates make note of all that is required in a LoR question if they are to access the higher levels. The vast majority of candidates did sufficient work to place them in Level 2. **Misconception** Many candidates missed opportunities to achieve a higher level by not explaining their reasoning and not describing the pattern of *R* with *P*.
			Total	**6**	
3 1		i		B1 B1	One correct line (or dot and cross) drawn Line must go through centre of coil **Allow** an incomplete line or a complete circle round the coil **Ignore** direction of arrow More than one line drawn All lines drawn must go through centre of coil and follow correct shape and direction of field **Ignore** spacing of lines **Ignore** any lines to the right of the coil
		ii	(the magnetic) flux (of the coil) links the base / saucepan (the size/direction of) the flux linkage (constantly) changes/alternates (causing an alternating induced e.m.f.) (induced) current is large because metal/base/ saucepan has low resistance	B1 x 2	2 out of 3 possible marking points **Allow** (the magnetic) field lines cut the (base of the) saucepan **Allow** the (magnetic) field constantly changes/alternates **Allow** a bald statement of Faraday's Law
		iii	The resistance of glass-ceramic/the (cook"s) hand is (very) large So (induced) current (or heating effect of current) is zero/negligible	M1 A1	**Allow** glass-ceramic/hand is an insulator/not a (good) conductor **Do not allow** the induced e.m.f. is (very) small

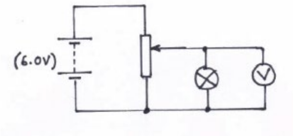
			Total	**6**	
3 2			**Level 3 (5–6 marks)** Clear diagrams and procedure and measurements **and** analysis *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** A diagram, some procedure, some measurements and some analysis. *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* **Level 1 (1–2 marks)** Limited procedure and limited measurements **or** limited analysis *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.	**B1 × 6** **6**	**Indicative scientific points may include:** **Diagram and procedure** • labelled diagram • correct circuit diagram • description of procedure • use of cushion in case load falls • repeats experiment. **Measurements** • use of balance to measure load • use of ruler to measure height • use stopwatch to measure time • use of ammeter to measure current • use of voltmeter to measure p.d. **Analysis** • equation to determine input power/energy (*IV*/*IVt*) • equation to determine output power/energy (*mgh/t or mgh*) • equation to determine efficiency • use of gradient of appropriate graph <u>**Examiner's Comments**</u> This question is assessing candidates' abilities to plan an investigation. The question is set to help candidates e.g. "lift light loads" should have given the hint of gravitational potential energy. The stem of the question indicates that a suitable diagram should be drawn. Many candidates did not label their diagrams, or the diagrams were not workable. It was expected that there would be a workable circuit diagram with appropriate measuring instruments to determine the input power or energy; correct circuit symbols should be used. There also needed to be a diagram indicting how the useful power or energy could be determined. See Exemplar 1. When answering planning questions, candidates should identify the measurements that need to be taken and indicate appropriate measuring instruments. Candidates also needed to explain how the data would be analysed.

					This required them to give the appropriate equations using their measurements to determine the input power/energy, the output power/energy and the efficiency. Good candidates suggested the plotting of an appropriate graph and explained how the efficiency could be determined from the gradient. **Exemplar 1**  This candidate has drawn two diagrams – one diagram indicating clearly how the motor is connected to a cell with an ammeter and voltmeter which could be used to determine the input power. The left-hand diagram is an arrangement of the apparatus which indicates the basic set up and included a foam box for the mass to fall into if the experiment does not work properly. This candidate has also underlined key words from the question.
			Total	**6**	
3 3		i	$R = \frac{150}{1.5^2}$ 67 Ω	C1 A1	**Allow** $V = \frac{150}{1.5} = 100\text{ V}$ <u>and</u> $R = \frac{100}{1.5}$
		ii	*Q* = 1.5 × 5.0 × 60 × 60 or 27000 $N = \frac{1.5 \times 5.0 \times 60 \times 60}{1.6 \times 10^{-19}}$ =1.7 x 10^{23}	C1 A1	**Note** use of 150 (W) does not score 1.7 × 10^{25} 1.68 × 10^{23} 4.7 × 10^{19} scores one mark **Not** 1.7 × 10^{25} (uses 150 W)
		iii	$v = \frac{1.5}{7.9 \times 10^{28} \times 4.1 \times 10^{-9} \times 1.6 \times 10^{-19}}$ 0.029 (m s^{-1})	C1 A1	
			Total	**6**	
3 4		i	*R* = V^2/P or *P* = V^2/R *R* = $230^2/1000$ = 52.9 or 53(Ω)	**C1** **A1**	**or** *P* = *VI* and *R* = *V*/*I* with *I* = 4.34 (A) This is a 'show that' question so the A1 mark is for giving both the full substitution of values and the final answer. The final answer may be to 2 or more SF.
		ii	number of turns, n = 180/1.5 (= 120)	**C1** **A1**	

			length *(l = π*dn*)*= 3.14 (or π*)* × 0.014 × 120 = 5.28 (m)		This is a 'show that' question so the A1 mark is for giving both the full substitution of values and the final answer. The final answer may be to 2 or more SF.
		iii	*A* = (*ρl*/*R*) =1.1 × 10^{-6} × 5.28/52.9 *A* = 0.11 × 10^{-6} (m^2) so swg = 28	M1 A1 A1	**allow** 53 **allow** solution which calculates diameter of wire using $\pi d^2/4$ rather than finding *A* **give max** 1/3 for using data from the table, i.e. finding *R* = 53 Ω using correct value of *A* **or** *d* = 0.37 (mm) the A marks cannot be-awarded unless the M mark is awarded. **<u>Examiner's Comments</u>** The purpose of this question was to challenge the candidates to use their knowledge to solve a laboratory based practical problem. The majority approached part (i) correctly by considering the power data for the fire element. A significant minority were drawn to the formula relating resistance and resistivity. Many of these realised that this approach was incorrect and changed to the correct approach. Here is a typical example (exemplar 2) of a script where the candidate continued to complete the whole question correctly. The rest remained at a loss and did not gain any marks for parts (ii) and (iii). **Exemplar 2**  In part (ii) a minority again tried the resistivity formula rather than an approach using geometry. Finally in part (iii) the resistivity formula was applied with success. The question overall proved to be a good discriminator of ability and understanding.
			Total	**7**	
35	a		**Level 3 (5-6 marks)** Clear evaluation of Fig. 22.1 **and** clear analysis	**B1×6**	Use level of response annotations in RM Assessor, e.g. L2 for 4 marks, L2^ for 3 marks, etc. **Ignore** incorrect references to the terms precision and accuracy **Indicative scientific points may include:** **Evaluation of Fig. 22.1** • Comment on the line

			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)** Some evaluation of Fig. 22.1 **and** some analysis *There is a line of reasoning presented with some structure.* *The information presented is in the most part relevant and supported by some evidence.* **Level 1 (1-2 marks)** Limited evaluation of Fig. 22.1 **or** limited analysis *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.*		• The straight line misses one error bar / anomalous point ringed or indicated • Too few data points plotted • The triangle used to calculate the gradient is (too) small • Some plots should have been repeated / checked • No error bars for current • 'Not regular intervals' (for current) • No origin shown (AW) **Evaluation of analysis** • The value of *B* is close to the accepted value • The difference of only 7% • No absolute or percentage uncertainty in *B* shown (AW) • Worst-fit line or maximum / minimum gradient line could have been used to determine the (absolute or percentage) uncertainty in *B* • *F* against *I* graph should be a straight line or • *BL* = gradient (any subject) **Examiner's Comment** This was the second level of response (LoR) question in the paper. It required evaluation of a graph drawn by a student and the analysis shown in the box on page 24. Most candidates realised that the graph had few data points, the triangle used for the gradient was too small and the line drawn totally missed one of the error bars. The analysis shown by the candidate did not include an absolute uncertainty in *B,* which made the statement written by the student lack credibility. Many candidates wrote about drawing doing a line of worst-fit and determining the percentage uncertainty. This was only possible if there were more data points and the error bars for the *F* values reduced by perhaps repeating the measurements. Once again, there was a good spread of marks amongst the three levels.
	b	i	There is a changing / fluctuating (magnetic) field / flux (linkage) (magnetic) field / flux (linkage) in <u>core</u> and <u>secondary</u> (coil) Statement of Faraday's law: e.m.f. (induced) ∝ <u>*rate*</u> of change of (magnetic) flux <u>linkage</u>	**M1** **A1** **B1**	**Note:** This changing flux can be anywhere **Allow '**the direction of the field oscillates' **Allow** 'the core helps to link the flux to the secondary coil' **Allow** 'equal to / =' **Ignore** 'cutting of flux' **Not** just $E = (-)\Delta(N\phi)/\Delta t$ **Examiner's Comment** The topic electromagnetic induction always challenges candidates. Successful responses often showed correct use of technical terms such as *magnetic flux* or *flux linkage.* Most candidates scored a mark for correctly stating Faraday's law of electromagnetic induction. Many realised that an alternating current produced an alternating magnetic flux within the iron core and this change in flux produced an e.m.f. at the secondary coil. One of the popular

					misconceptions was that there was an alternating current (or induced e.m.f.) within the iron-core. A small number of candidates referred to **electro**magnetic field in their descriptions rather than magnetic field.
		ii	1 (I_S =) 24/12 or 2.0 (A) (I_P =) $\frac{20}{400} \times 2.0$ (current in primary =) 0.10 (A) or (V_P =) 12 × 20 or 240 (V) (I_P =) $\frac{24}{240}$ (current in primary =) 0.10 (A) 2 Idea of changing / increasing (magnetic) field / flux / current (in primary) at the start Eventually current and flux (linkage) are constant, therefore no e.m.f.	**C1** **A1** **C1** **A1** **B1** **B1**	**Allow** 1 sf answer **Allow** 1 sf answer **Note:** Any labels used must be clearly defined **Examiner's Comment** This question on current in the primary coil was successfully answered by most candidates. The most favourable method was to calculate the current in the secondary and then the current in the primary coil. The turn-ratio equation and *P* = *VI* were effortlessly used to arrive at the correct answer of 0.10 A. Full marks were rarely scored but many top-end candidates did manage to score a mark for suggesting that the lamp was lit for a short period of time at the start because *'there was a changing magnetic flux as the current increased from zero to a steady value'.* Too many answers focussed on the requirement of an alternating supply for an induced e.m.f. in the secondary coil and how a battery is not an alternating supply.
			Total	**13**	
36		i	($F = ma$ =) 190 × 10^3 = 2.1 × 10^5 a a = 0.90 (m s^{-2})	M1 A0	a = 0.905 to 3 SF
		ii	($v^2 = u^2 + 2as$ gives) 36 = 2 × 0.90 × s s = 20 (m)	C1 A1	**Allow** any valid suvat approach; **allow ECF** from (i) **Note** using a = 1 gives s = 18(m)
		iii	**1** *P* = *F*v One correct calculation e.g. F = 100 × 10^3 and v = 42 gives *P* = 4.2 ×10^6 (W) *F*v = constant	B1 B1 B1 C1	Equation must be seen (not inferred from working) **Allow** any corresponding values of F and v; working must be shown. No credit for finding area below curve **Allow** *F* is proportional to 1/v or graph is hyperbolic *or* correct calculation of *Fv* at <u>two</u> points (or more)

			2 (P = VI = 4.2MW so) $4.2 \times 10^6 = 25 \times 10^3 \times I$ I = 170 (A)	A1	**Allow** P = 4MW or **ECF from (iii)1** Expect answers between 160 - 170 (A)
			Total	**8**	
3 7		i	Correct circuit with a battery, potential divider, lamp and voltmeter.  	B1	
		i	Correct symbols used for all components.	B1	**Allow**: A cell symbol for a battery
		ii	Description: The temperature of the filament increases. (AW)	B1	
		ii	The resistance of the lamp increases	M1	
		ii	from a non-zero value of resistance.	A1	**Allow** ‘when cold the resistance is small’
		ii	Explanation: Resistance increases because electrons/charge carriers make frequent collisions with ions. (AW)	B1	
		iii	($P = VI$) current in **X** is 3 times the current in **Y** Or area of **X** is 4 times smaller than area of **Y**	C1	**Allow** other correct methods.
		iii	$I = Anev$ and ratio = $\frac{3}{0.25}$	C1	
		iii	ratio = 12	A1	
			Total	**9**	