1. When an electric motor is switched on, it has a very large current through it, but this rapidly drops to a much smaller value.

Which **two** of the following statements can explain this observation?
Put ticks (✓) in the boxes after the **two** correct statements.

The turning motor acts as a generator which produces a p.d. opposing the battery p.d. ☐

As the motor speeds up, the friction in the turning parts becomes smaller. ☐

Friction in the motor dissipates energy resulting in more energy taken from the supply. ☐

Current heats the coils in the motor which makes their resistance increase. ☐

As the motor turns faster, the force needed to turn it decreases ☐

[2]

2(a). Vikram is building a circuit.

He has a motor that has a resistance of 2400 Ω.

The motor works if the current through it is 0.005 A.

Vikram has some 1.5 V batteries.

How many batteries will be needed to make the motor work correctly?

number of batteries = _____ **[3]**

(b). Draw the circuit that Vikram could use to measure the resistance of the motor at different currents.

Part of the circuit has been done for you.

[2]

3(a). Judy is investigating three different electrical components, **A, B** and **C**.

She changes the temperature of each component and measures the resistance.

She then changes the amount of light on each component and measures the resistance.

Temperature in °C	Resistance in Ω		
	component A	component B	component C
0	403	52	101
10	199	50	98
20	100	49	102
30	53	51	100
40	26	51	99
50	13	50	98
60	6	48	100

Light intensity in lux	Resistance in Ω		
	component A	component B	component C
0	101	76	102
100	100	50	101
200	102	32	99
300	98	21	98
400	99	14	101
500	101	19	102
600	102	8	101

Use the data to decide what type of component **A, B** and **C** are.

component **A** _____

component **B** _____

component **C** _____

[3]

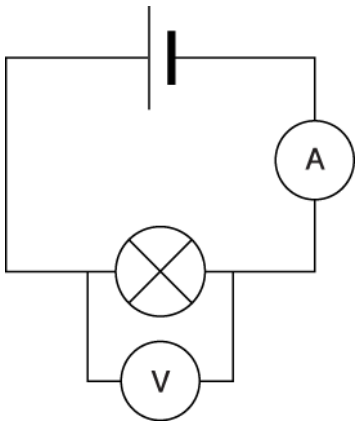
(b). Complete the following table to show whether each statement about Judy's experiment is **true, false** or you **cannot tell.**

Put ticks (✓) in the correct boxes.

	True	False	Cannot tell
Judy repeated her tests three times.			
Judy had an outlier in her results in the temperature experiment.			
Judy had an outlier in her results in the light intensity experiment.			
The temperature in the light intensity experiment was approximately 20 °C.			
The light intensity in the temperature experiment was approximately 200 lux.			

[4]

4(a). Jason sets up the following circuit.



He measures the current and potential difference.

Draw a line from each **quantity** to its best **description**.

quantity	**description**
	the movement of electrons in the wires
current	the amount of energy transferred each second
	the number of electrons in the wires
potential difference	the work done on the charge as it moves between two points
	the total resistance of the circuit

[2]

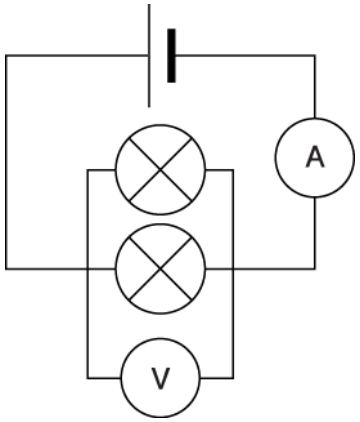
(b). Jason measured the voltage across the lamp to be 1.5 V, and the current through it to be 0.5 A.

Draw a line from each **quantity** to the correct **value**.

quantity	value
	0.33
power (W)	0.75
	1.00
resistance (Ω)	2.00
	3.00

[2]

(c). Jason adds another identical lamp to the circuit, in parallel with the first one.



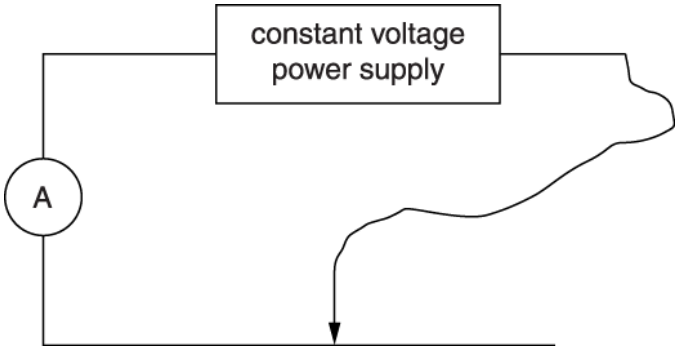
State and explain what happens to the readings on the meters.

---

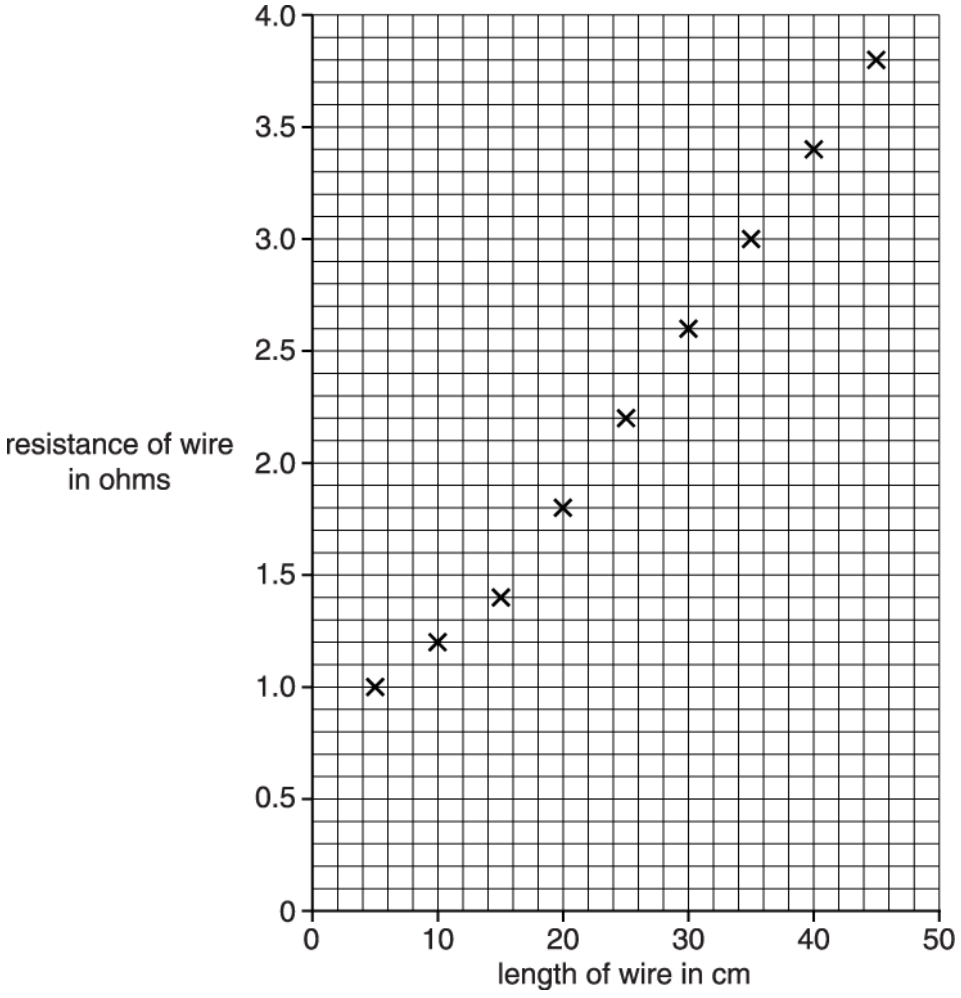
[3]

5. Diane investigates how the resistance of a wire changes with the length of wire.

She uses this circuit.



Here are her results.



Diane
I expected resistance to be proportional to length of wire.
My graph does not show this.
I noticed the wire got hot when it was short.

Discuss Diane's comments and explain the shape of her graph.

The quality of written communication will be assessed in your answer.

[6]

6. Pat and Chris set up an experiment to find the relationship between the current and voltage for a filament lamp.

When they increase the voltage, the lamp glows brighter.

They record the voltage across the lamp for different values of the current.

Here are their results:

Voltage (V)	0	1.0	2.3	4.2	8.0
Current (A)	0	0.20	0.40	0.60	0.80

Pat says: 'There is no correlation between the voltage and the current.'

Chris says: 'The resistance of the lamp filament does not change because it is the same piece of wire all the time.'

Comment on their statements.
Use the data to justify your answer.

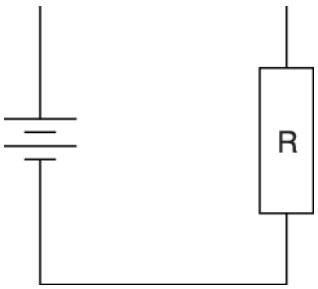
The quality of written communication will be assessed in your answer.

[6]

7(a). Anna is investigating resistors.

She connects a resistor to a battery, an ammeter and a voltmeter to measure the resistance of the resistor.

Complete the circuit that she should use.



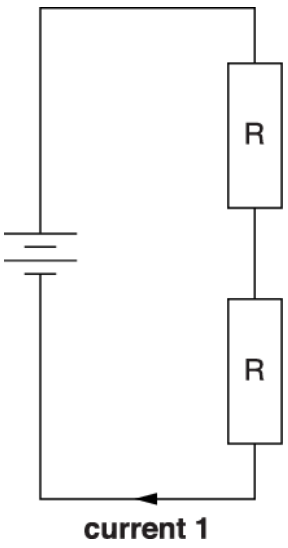
[2]

(b). The current she measures through the resistor, R, in part (a) is 0.2 A.

She then makes changes to her circuit using the same battery and resistor as in part (a).

The following circuits all use resistors and batteries identical to the ones used in part (a).

(i)



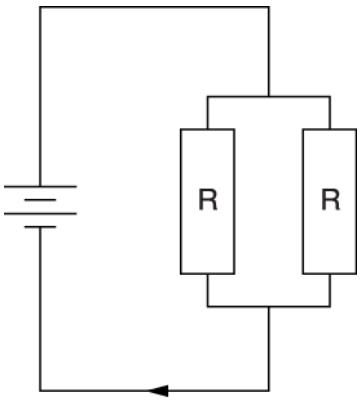
What is current 1?

Put a (ring) around the correct value.

0.1 A 0.2 A 0.3 A 0.4 A

[1]

(ii)



current 2

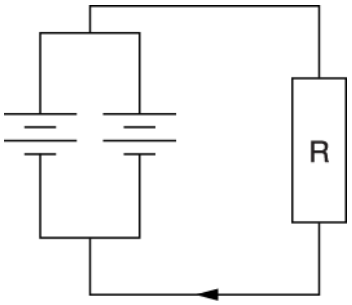
What is current 2?

Put a (ring) around the correct value.

0.1 A 0.2 A 0.3 A 0.4 A

[1]

(iii)



current 3

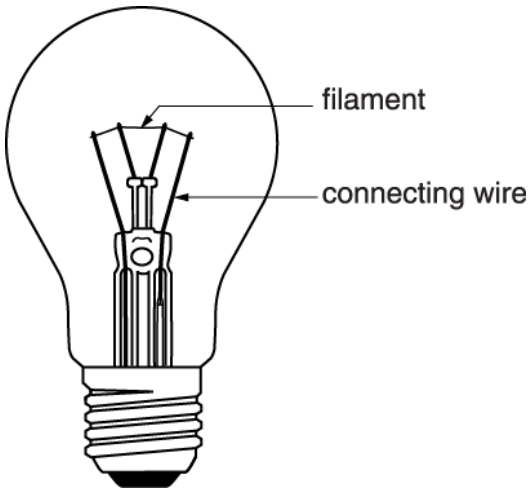
What is current 3?

Put a (ring) around the correct value.

0.1 A 0.2 A 0.3 A 0.4 A

[1]

8. A filament lamp emits light when a current is passed through it.



The filament wires in the lamp are much thinner than the connecting wires.

When the lamp is turned on the filament emits visible light but the connecting wires do not.
Explain why this happens.

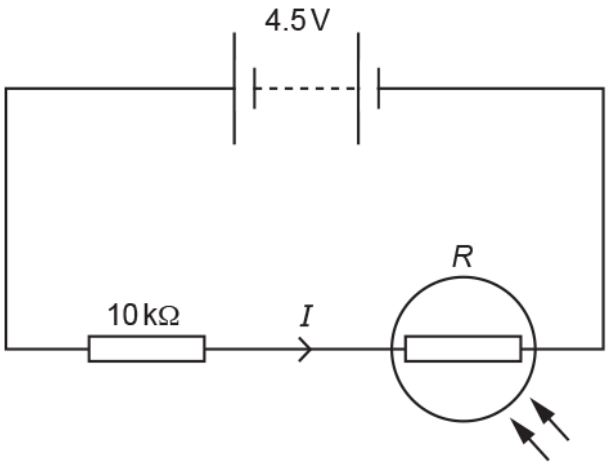
The quality of written communication will be assessed in your answer.

[6]

9. This question is about using an LDR (light-dependent resistor) to measure light intensity.

The LDR is connected in series with a fixed resistor of resistance 10 kΩ and a 4.5 V battery.

The **total** resistance at 30 lux is 22 000 Ω.



(i) Calculate the current in the circuit.

Current = _____ A **[3]**

(ii) Calculate the potential difference across the fixed 10 kΩ resistor when the illuminance is 30lux.

Potential difference = _____ V **[3]**

(iii) Describe, without any calculations, how the potential difference across the fixed resistor will change when the illuminance increases from 30 lux to 100 lux.

---[3]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1			The turning motor acts _ _ _ (1) Current heats the coils _ _ _ (1)	2	
			Total	2	
2	a		attempt to calculate current from one cell (I = V/R =) 1.5/2400 = 0.0006(25)(A) OR attempt to calculate voltage to make motor work (V = IR =) 2400 × 0.005 = 12 (V) 8 batteries are required	3	1 mark for selection of appropriate equation and substitution of appropriate numbers 1 mark for correct calculation 1 mark for correct conclusion based on their numbers (ecf allowed) Final answer 8 = 3 marks Examiner's Comments Candidates usually either scored all 3 marks or 0 marks on this question. A significant minority of answers were well presented, with working clearly shown and appropriate use made of the formulae at the front of the paper. Weaker candidates showed no working and therefore if, as was often the case, the obtained the wrong final answer, no partial credit could be given.
	b		at least 2 correct circuit symbols used for battery / power supply, ammeter, voltmeter (1) Ammeter in series, voltmeter in parallel with motor, correctly connected to battery / power supply (1)	2	**ignore** any other symbols Examiner's Comments The standard of circuit drawing seen across the ability range on this paper was, on the whole, poor. Even if correctly selected, most circuit symbols were roughly drawn, with gaps often present in wiring, incorrect/partially complete battery symbols and lots of examples of short-circuiting.
			Total	5	

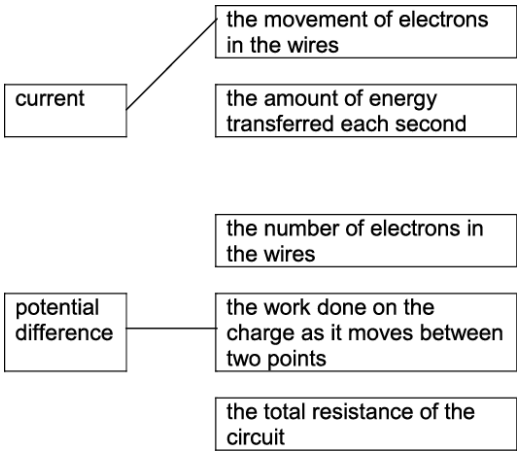
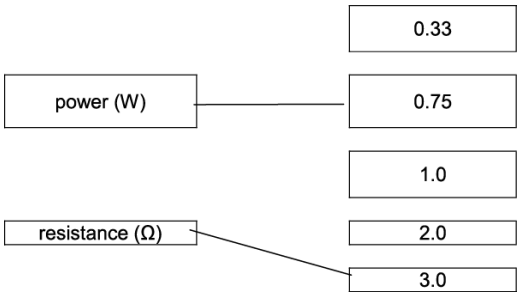
<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>3</td><td>a</td><td></td><td>component A – thermistor
component B – LDR
component C – (fixed) resistor</td><td>3</td><td>1 mark for each correct line.

<u>Examiner's Comments</u>

Most candidates correctly identified component C as a resistor, but only the strongest candidates successfully identified A as a thermistor and B as an LDR. A large number of candidates got A and B the wrong way round and no credit was given in such cases. A significant number of the weakest candidates seemed to write words with no relation to the question asked, but words which cropped-up elsewhere in the paper e.g. alpha, beta, gamma or motor, generator etc.</td></tr>
<tr><td></td><td>b</td><td></td><td>
<table>
<tr><th></th><th>True</th><th>False</th><th>Cannot tell</th></tr>
<tr><td>Judy repeated her tests three times.</td><td></td><td></td><td>?</td></tr>
<tr><td>Judy had an outlier in her results in the temperature experiment.</td><td></td><td>?</td><td></td></tr>
<tr><td>Judy had an outlier in her results in the light intensity experiment.</td><td>?</td><td></td><td></td></tr>
<tr><td>The temperature in the light intensity experiment was 20°C.</td><td>?</td><td></td><td></td></tr>
<tr><td>The light intensity in the temperature experiment was 200 lux.</td><td></td><td>?</td><td></td></tr>
</table>
</td><td>4</td><td>5 rows correct: 4 marks
4 rows correct: 3 marks
3 rows correct: 2 marks
1 or 2 rows correct: 1 mark

<u>Examiner's Comments</u>

This multiple choice question probing understanding of data proved very challenging, as the data was quite complex. Most candidates scored a mark for one or two of the first three statements correctly identified. The last two statements were rarely correctly chosen, reflecting the complex processing required to ascertain the correct answer; the most common response for both of these was ‘cannot tell’.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>7</td><td></td></tr>
</table>

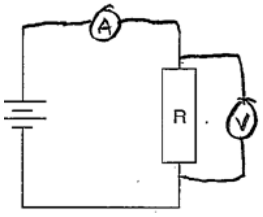
Question			Answer/Indicative content	Marks	Guidance
4	a			2	Examiner's Comments The descriptions of current and potential difference were consistently answered correctly by all but the very weakest candidates.
	b			2	Examiner's Comments The descriptions of the calculations were consistently answered correctly by all but the very weakest candidates
	c		V is the same / I gets bigger why voltage stays the same why current goes up (because resistance is lower)	3	e.g. voltage is the same – as the same number of batteries / cells current is higher – as resistance is lower resistance is lower – as more paths (for charges) current is higher as more paths (for charges) gains one mark if no mention of resistance **accept** higher level answers regarding internal resistance / delivery of current **ignore** mention of lamps and brightness Examiner's Comments Understanding of parallel circuits was very weak, with many candidates unable to differentiate between the voltage and the current correctly. Almost no responses were seen which considered the effect on the overall resistance of the circuit.

Question			Answer/Indicative content	Marks	Guidance
			Total	7	

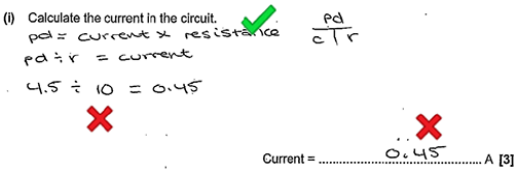
Question			Answer/Indicative content	Marks	Guidance
5			(Level 3) Shows understanding of proportionality in relation to this data. Explains heating effect due to current and relates to shorter wire having higher resistance than expected. May suggest improvements to method. Quality of written communication does not impede communication of the science at this level. (5–6 marks) (Level 2) Clearly identifies how this data is not proportional at short lengths and / or recognises proportionality at longer lengths. Idea that more current in shorter wire leads to heating effect and / or increased resistance. Quality of written communication partly impedes communication of the science at this level. (3–4 marks) (Level 1) Describes how they know the data is not proportional. Links increased temperature to simple model of charge collision at short lengths. Quality of written communication impedes communication of the science at this level. (1–2 marks) (Level 0) Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)	6	This question is targeted at grades up to A Relevant points include: • doesn't go through origin so • not proportional or reverse argument • heating effect of a large current • this increases the resistance of the wire • discussion of heating effects of current • for large lengths, double length = double resistance • so proportional • discussion of data e.g. 15cm could be anomalous • discussion of zero error / systematic error in the data • discussion of energy in circuit. Note at Level 3 candidates will typically be expected to describe resistive heating in terms of electron collisions with other particles in the wire. Use the L1, L2, L3 annotations in Scoris; do not use ticks. Examiner's Comments This was a six mark extended writing question targeted up to grade A. Very few candidates displayed any understanding of the term proportionality, with almost all of them using the term interchangeably with positive correlation. It is important that candidates are reminded of the correct use of this term and how to use data to confirm proportionality or otherwise. More able candidates could describe a mechanism for resistive heating, but often failed to provide a convincing explanation as to why this should lead to the wire getting hot when it is shorter. Most candidates simply described the general trend in the data i.e. " as the wire gets longer the resistance will get larger".
			Total	6	

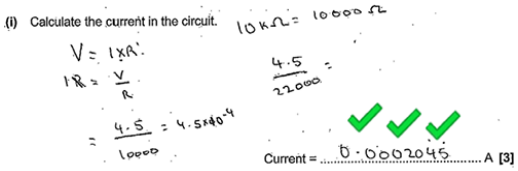
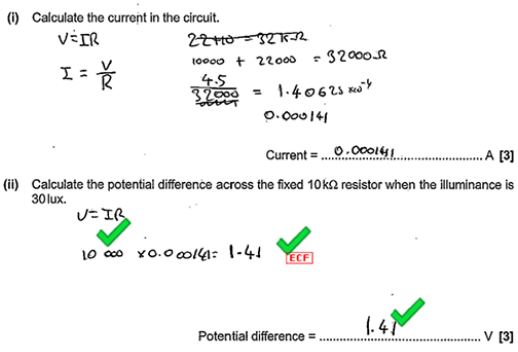
Question			Answer/Indicative content	Marks	Guidance
6			**(Level 3)** Valid comment on Pat's statement **and** on Chris's statement, with use of data to justify **both** of the comments. Quality of written communication does not impede communication of the science at this level. (5–6 marks) **(Level 2)** Valid comment on Pat's statement **and** on Chris's statement, with use of data to justify one of the comments. Quality of written communication partly impedes communication of the science at this level. (3–4 marks) **(Level 1)** Valid comment on Pat's statement **and** on Chris's statement. **OR** does a correct resistance calculation without comment or justification. Quality of written communication impedes communication of the science at this level. (1–2 marks) **(Level 0)** Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)	6	**This question is targeted at grades up to A** **Indicative scientific points may include:** **Correlation:** • Pat is wrong • Larger voltage gives larger current • There is a correlation as both increase • Not linear / proportional relationship • Would not give straight line graph • Use data to show not proportional **Resistance:** • Chris is wrong • Use of resistance formula using data • Resistance increases with current • Not linear / proportional relationship • Would not give straight line graph • Lamp filament gets hotter • Hotter wire has more resistance • Calculates resistance values (5; 5.75; 7; 10) **Use the L1, L2, L3 annotations in Scoris; do not use ticks.** (Check table in question for candidate's resistance values) **Examiner's Comments** The majority of candidates achieved at least level 2 when responding to this question, as they commented on both statements and used the data to support one of their comments. Usually the data were used to say why Pat was wrong, but a few candidates confused correlation with proportionality. A much smaller number of candidates used the data to calculate at least two values of resistance to explain why Chris was wrong. Some candidates described a mechanism to support their comment on Chris's statement rather than, as instructed in the question, the data and consequently did not receive credit for this.

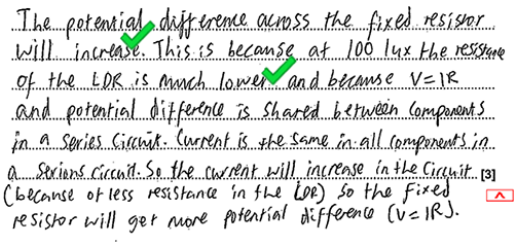
Question			Answer/Indicative content	Marks	Guidance
			Total	6	

Question			Answer/Indicative content	Marks	Guidance
7	a		correct symbol for ammeter in series with R (1) correct symbol for voltmeter in parallel with R or battery (1)	2	symbols are free-hand circles with a capital letter **ignore** lines through symbols e.g. an ammeter or voltmeter drawn on solid lines **ignore** small gaps next to symbols e.g. of answer gaining 2 marks:  (= 2 marks) **but** if no other mark awarded: **allow** 1 mark if both correct symbols for ammeter **and** voltmeter are seen **Examiner's Comments** The majority of candidates were able to draw the symbol correctly for an ammeter and put it in series with the resistor. Although the voltmeter symbol was drawn correctly its positioning was often incorrect, usually in series with the ammeter and resistor. Some candidates failed to get any marks as their symbols were incorrectly drawn, some as boxes.
	b	i	0.1A (first answer)	1	
		ii	0.4A (fourth answer)	1	
		iii	0.2A (second answer)	1	**Examiner's Comments** Very few candidates gave correct choices for all three parts of this question. Part (iii) was the one most candidates chose wrongly. Often parts (ii) and (iii) were interchanged.
			Total	**5**	

Question			Answer/Indicative content	Marks	Guidance
8			**(Level 3)** Links high resistance of filament to thinness (ORA) and links resistance to temperature / energy transfer. Quality of written communication does not impede communication of the science at this level. (5–6 marks) **(Level 2)** Links high resistance of filament to thinness (ORA). Quality of written communication partly impedes communication of the science at this level. (3–4 marks) **(Level 1)** Identifies resistance as key difference between filament and connecting wires OR links temperature of filament to light emission. Quality of written communication impedes communication of the science at this level. (1–2 marks) **(Level 0)** Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)	6	This question is targeted at grades up to A* Indicative scientific points may include: • an electric current / charge does work on a component. Explanation: • heating effect caused by collisions / interactions between moving electrons and stationary ions in the wire • filament is thin and supports are thick • thick wires have a smaller resistance / thinner wires have higher resistance • higher resistance will transfer more energy per second • more work is done by the charges when they pass through. Use the L1, L2, L3 annotations in Scoris; do not use ticks. Examiner's Comments This question about a lamp filament was a six-mark extended writing question. The majority of candidates failed to meet the criteria for levels 2 and 3 since they did not link the thinness of the filament to resistance (or a description of resistance) and to the production of light. Some candidates achieved level 1 by realising that the light emission was linked to the temperature of the wire or the heat produced. Many candidates wrongly thought that the connecting wires were covered in a material such as plastic or that they were too thick to let light escape.
			Total	6	

Question			Answer/Indicative content	Marks	Guidance
9		i	FIRST CHECK THE ANSWER ON THE ANSWER LINE. If answer= 0.000 20(5)/2.0(5) ×10 $^{-4}$ (A) award 3 marks		IGNORE significant figure errors or rounding errors
			current = *V*/*R* ✓	3 (AO 1.2)	ALLOW any form of equation for mp1 and mp 2
			= 4.5 (V) / 22 000 (Ω) ✓	(AO 2.1)	Incorrect *R* loses mp2
			= 0.000 20(5) / 2.0(5) x 10^{-4} (A) ✓	(AO 2.1)	ECF own values but penalise for power of ten errors
					Examiner's Comments Most candidates found part (b) more challenging. Many ignored the statement in the question stem that the total resistance at 30 lux is 22000 Ω. These candidates used 10 Ω, or 10000 Ω, or 12000 Ω, or even 32000 Ω. About one fifth of candidates gained all three marks. OCR support The Mathematical Skills handbook provides advice and guidance on the use of units, rounding and conversions. Exemplar 1 Exemplar 1 is not untypical and shows how many candidates were able to be credited with a compensatory mark for their correct recall of the equation. Although like Exemplar 1, they forgot to convert 10kΩ to 10000Ω.  Exemplar 2 In Exemplar 2 the candidate has answered the question correctly but uses the

Question			Answer/Indicative content	Marks	Guidance
					recurring decimal notation. It would have been more appropriate to round the result to 0.00020 Ω or 2.0×10^{-4} Ω. 
		ii	FIRST CHECK THE ANSWER ON THE ANSWER LINE. If answer = 2.0(5) (V) award 3 marks Unit conversion 10 k(Ω = 10000 (Ω) ✓ p.d. = 0.000 20(5) (A) × 10 000 (Ω) ✓ = 2.0(5) (V) ✓ OR p.d. = 4.5 (V) × {R/R_{total}}✓ = 4.5 (V) × 10 000 (Ω) ÷ 22 000 (Ω) ✓ = 2.0(5) (V) ✓	(AO 1.2) (AO 1.2) 3 (AO 2.1)	ECF from (b)(i) <u>Examiner's Comments</u> Exemplar 3 In Exemplar 3 the candidate has made an error in Q1(b)(i) but fortunately error carried forward (ECF) was applied to Q1(b)(ii) which allowed the candidate to gain full credit for their answer to Q1(b)(i). 

Question			Answer/Indicative content	Marks	Guidance
		iii	(As illuminance increases) resistance decreases /current increases ✓ p.d. (across 10 kΩ resistor) increases. ✓ Resistance changes get smaller / less as illuminance increases, so change in p.d. becomes smaller ✓	(AO 2.2) 3 (AO 3.1a x 2)	ALLOW potential divider argument for mp2 & mp3 <u>Examiner's Comments</u> Exemplar 4 Exemplar 4 is a rare example here of a candidate who understands what is happening in the circuit; a number of others gained marks for increase in p.d., or decrease in resistance, even if their explanations were not as clearly expressed as they could be.  The potential difference across the fixed resistor will increase. This is because at 100 lux the resistance of the LDR is much lower and because V=IR and potential difference is shared between components in a series circuit. Current is the same in all components in a series circuit. So the current will increase in the circuit [3] (because of less resistance in the LDR) so the fixed resistor will get more potential difference (V=IR).
			Total	9	