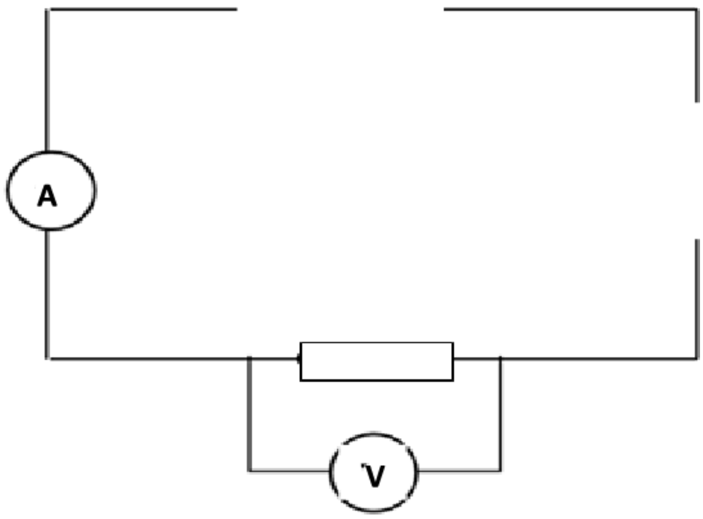
1.

(a) Melanie is learning about electric charge in circuits.

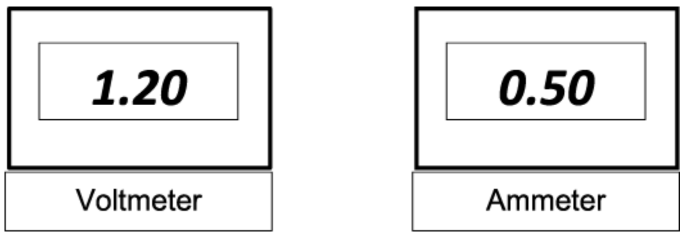
This is an incomplete circuit showing a resistor, a voltmeter and an ammeter.



(i) Complete the diagram, using the correct symbols, by adding a switch and a single cell or battery.

[1]

Melanie switches the circuit on and watches the voltmeter and ammeter readings carefully for **30 seconds.** She notices that both readings remain steady as shown below.



(ii) Calculate the quantity of electrical charge (in C) which flows through the resistor in 0.5 minutes.

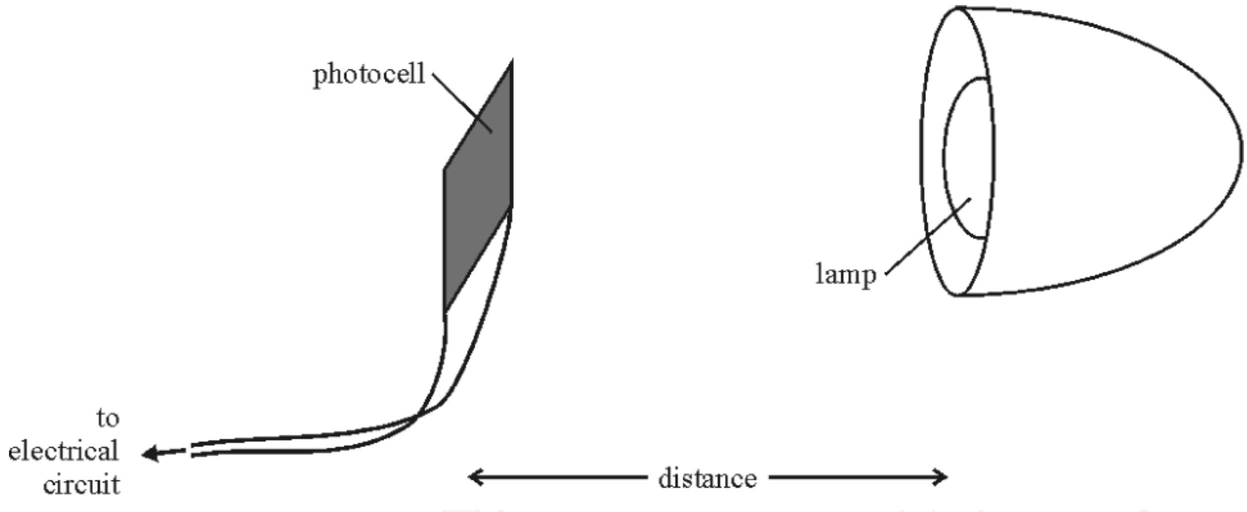
______________ C **[3]**

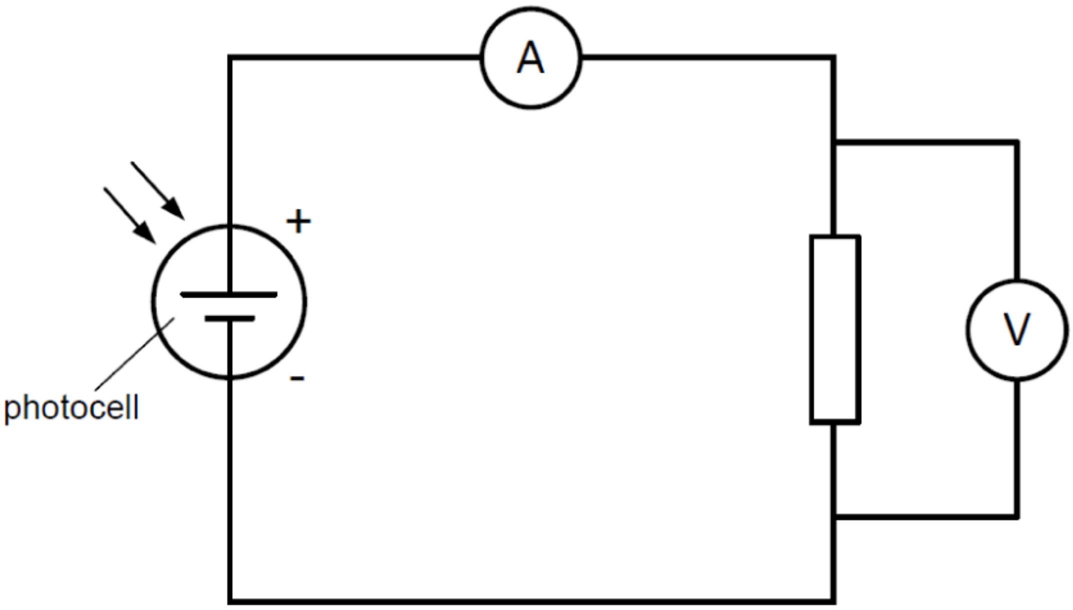
(iii) Calculate the resistance of the resistor in the circuit.

______________ Ω **[3]**

2(a). Sam is doing an experiment to investigate the output of a solar panel. She is using a small photocell to model the panel.

She is measuring the power output of the photocell when it is at different distances from a lamp, as shown below.





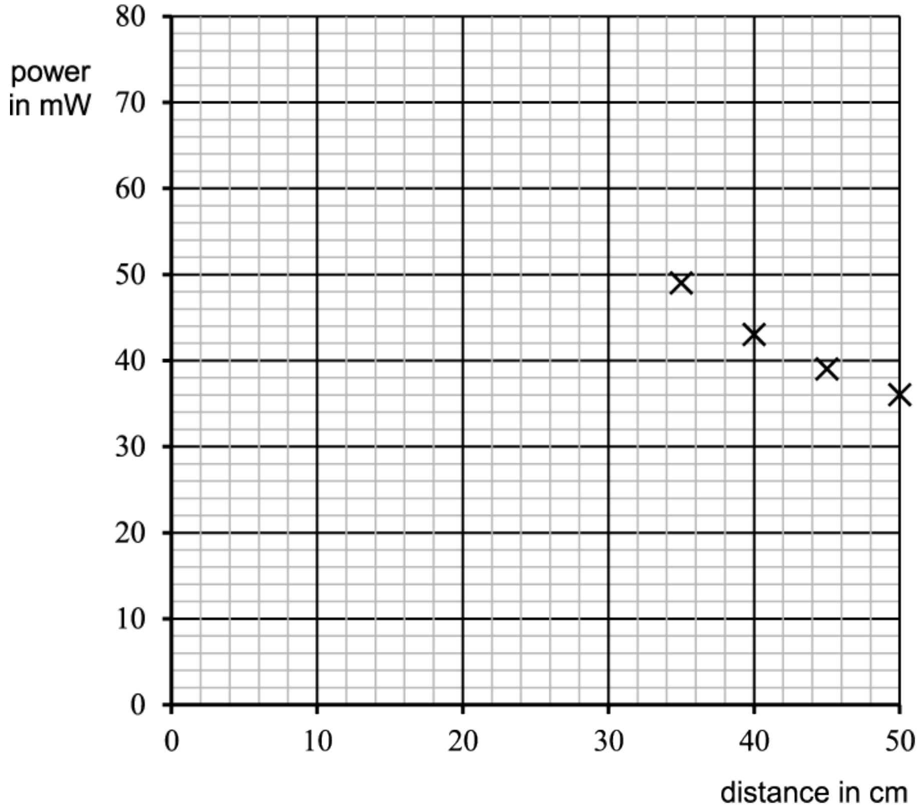
Sam obtained a range of values of power at different distances, as shown in the table below.

distance (cm)	25	30	35	40	45	50
power (mW)	72	57	49	43	39	36

Four data points have been plotted on the graph axes below.

(i) Plot the remaining two data points and add a best-fit curve.

[2]



(i) What does the graph show?

--- **[1]**

(ii) At a distance of 25cm the power was 72 mW. The voltage across the photocell was recorded as 12 V. In your answer use the equation: power = potential difference × current.
Calculate the current through the photocell.

______________ A **[4]**

(iii) Calculate the resistance in ohms of the resistor using the equation:
potential difference = current × resistance.

______________ Ω **[3]**

(b). Describe how this experiment should be completed to get a valid set of data.

____

____

____

____ [4]

(c). Tom has done an identical experiment to Sam's in a **different part** of the same lab.

He used an identical lamp, photocell and resistor, but his values of power were much lower than Sam's for the same distances.

He thinks that his part of the lab must have been different from Sam's.

Suggest and explain a reason for the difference in their results.

____

____

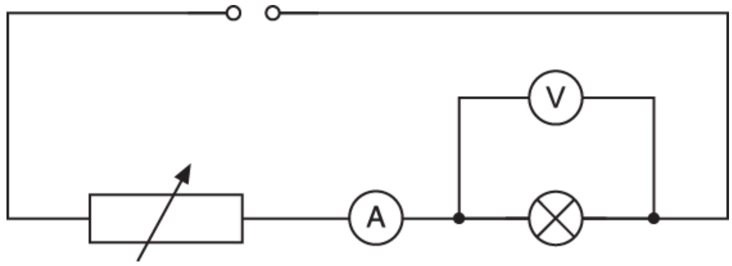
____

____ [2]

3. Jason is investigating how the resistance of a filament lamp changes with the current through it.

He connects the lamp to a power supply and a variable resistor.

He uses an ammeter to measure the current through the lamp and a voltmeter to measure the voltage across it.



(i) On the diagram put a ring around the symbol for the ammeter. **[1]**

(ii) These are Jason's results.

Voltage (V)	1.0	3.0
Current (A)	0.10	0.20

How does the resistance of the lamp change as the current increases?
Justify your conclusion by doing calculations with Jason's results.

____

____ **[3]**

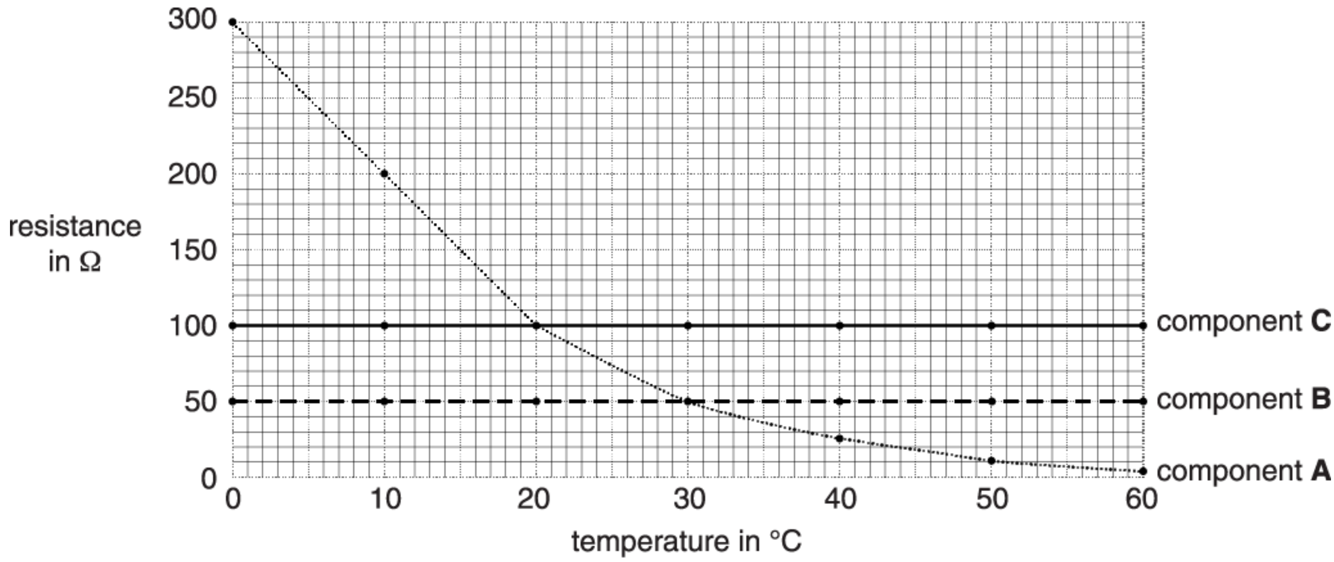
(iii) Suggest what Jason can do to ensure his results are accurate.

____

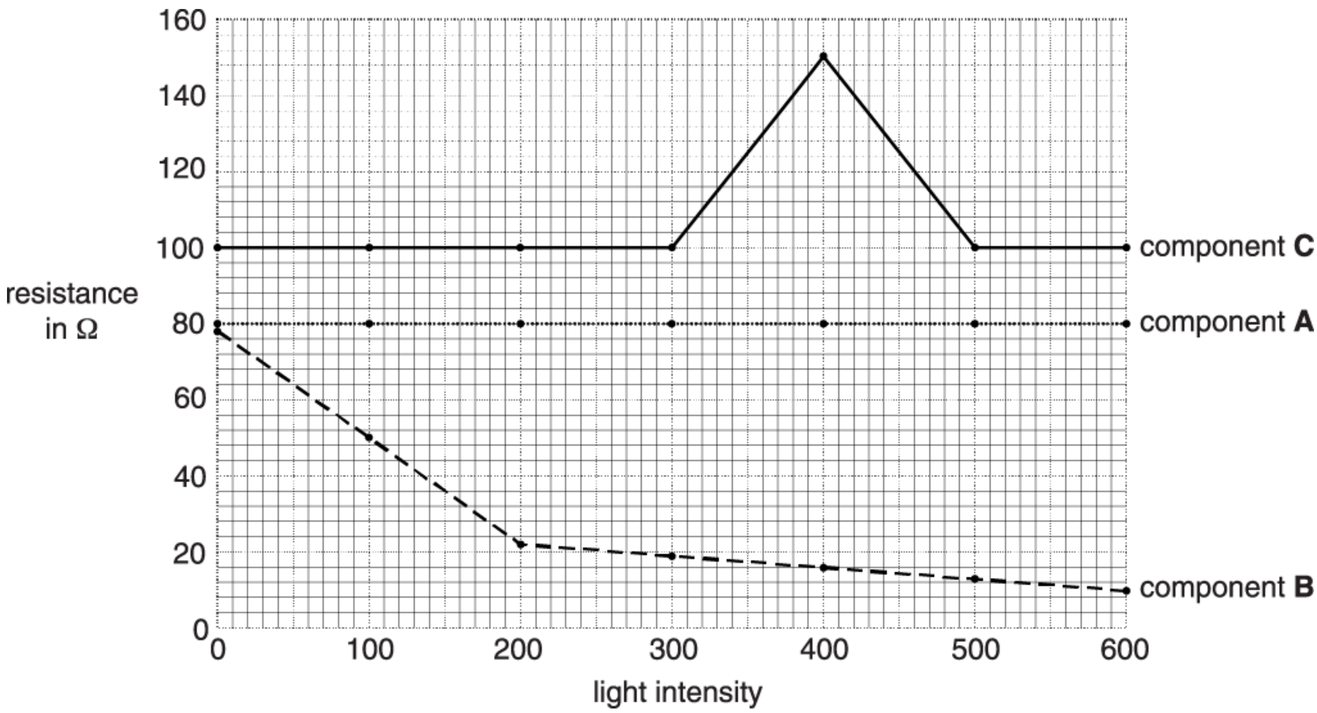
____ **[1]**

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

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

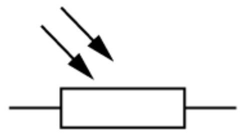
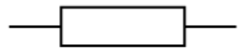
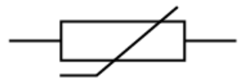


She then changes the amount of light on each component and measures the resistance.



(i) Use the data to decide what each component is.

Draw straight lines to link each **component** to its **type**, and each **type** to its **symbol**.

component	type	symbol
A	fixed resistor	
B	LDR	
C	thermistor	

[4]

(ii) Use the data to decide whether each statement about Anita's experiment is **true, false** or you **cannot tell.**

Put ticks (✓) in the correct boxes.

	true	false	cannot tell
Anita repeated her experiment three times.			
Anita had an outlier in her results.			

[2]

(b).

(i) Anita measured the voltage and current of component **A**.

She used a 6 V power supply. The current through the component was 0.06 A.

Calculate the resistance of the component.

Show your working.

resistance = ____________________ Ω **[2]**

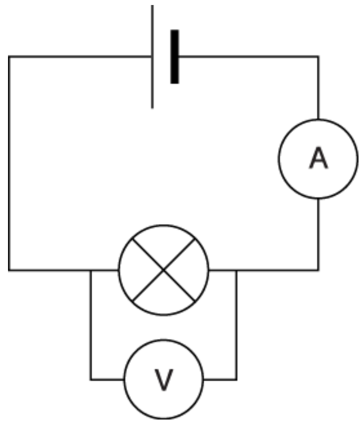
(ii) Later, Anita used component **A** to find an unknown temperature.

The resistance of component **A** was 200 Ω.

Use the first graph to find the unknown temperature.

temperature = ____________________ °C **[1]**

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



He measures the current and voltage.

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

quantity	description
	the flow of charge in a circuit
current	the number of lamps in the circuit
voltage	the length of the wires in the circuit
	the push of the battery on the charges in the circuit

[2]

(b). The voltage is 1.5 V and the current is 0.5 A.

Jason then calculates the power and resistance of the lamp.

Draw a line from each **quantity** to the correct **calculation** for it.

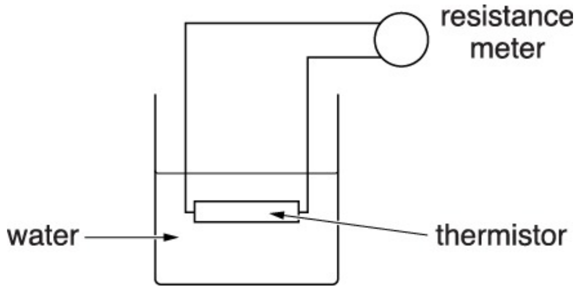
quantity	calculation
	$1.5\,\text{V} \times 0.5\,\text{A}$
power (W)	$1.5\,\text{V} + 0.5\,\text{A}$
	$1.5\,\text{V} - 0.5\,\text{A}$
resistance (Ω)	$\frac{1.5\,\text{V}}{0.5\,\text{A}}$
	$\frac{0.5\,\text{A}}{1.5\,\text{V}}$

[2]

6. Sarah is doing an experiment with a thermistor.

She connects a meter to the thermistor to measure its resistance.

She puts the thermistor in a beaker of cold water and then warm water and records its resistance each time.



Here are Sarah's results.

Temperature of water	Resistance of thermistor in k?
cold	33.0
warm	28.5

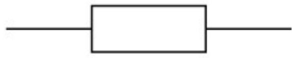
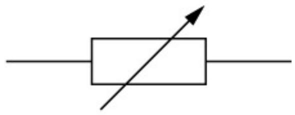
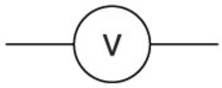
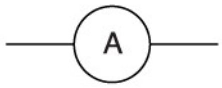
Sarah thinks that there is a correlation between the temperature of the water and the resistance of the thermistor.

Is Sarah right about a correlation and what should she do to confirm her conclusion?

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

[6]

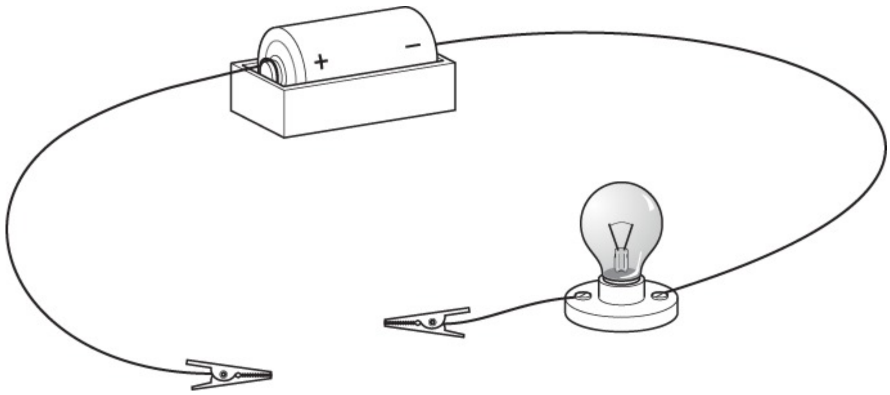
7. Draw one straight line from each symbol to its correct name.

Symbol





Name
Ammeter
Fixed resistor
Variable resistor
Voltmeter

[3]

8(a). Anna sets up an electrical circuit to test different materials.



The lamp glows when she puts a piece of copper into the circuit between the clips.

(i) Why is there a current in the circuit?

--- [2]

(ii) Suggest a change Anna could make to the circuit so that this lamp is brighter.

--- [1]

(b). Anna replaces the copper in the circuit with plastic. The lamp does not light.

Explain why the plastic is not a conductor.

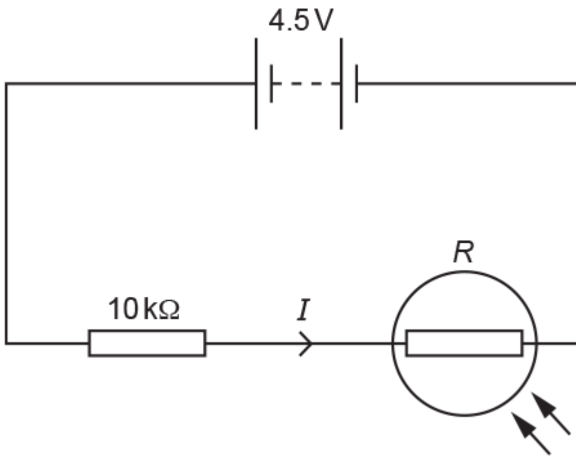
----

[1]

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 30 lux.

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.

____

____

____

____

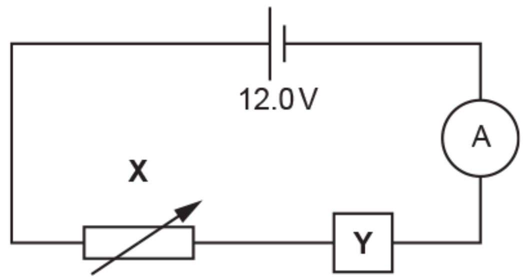
____

____ [3]

10(a) Sundip builds a circuit to investigate a mystery component.

.

She builds this circuit. The mystery component is the box labelled **Y**.



(i) Add a voltmeter to the circuit to measure the potential difference across component **Y**.

[1]

(ii) Describe how to use component **X** to vary the current in the circuit.

-- **[2]**

(b). The table shows Sundip's results.

Potential difference (V)	Current (A)	Resistance (Ω)
1.0	0.68	1.47
2.0	0.93	2.15
3.0	1.13	2.65
4.0	1.30	3.08
5.0	1.45	3.45
6.0	1.59	

(i) Calculate the resistance when the potential difference is 6.0 V.

Give your answer to **3** significant figures.

Resistance = ... Ω **[4]**

(ii) Describe the relationship between current and resistance.

-- [1]

(iii) Suggest what component **Y** is.

Explain your answer.

Component **Y** is --

Explanation --

-- [2]

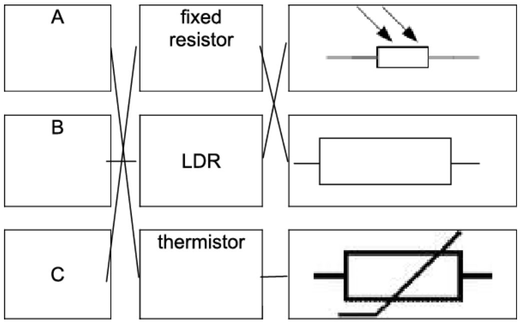
END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1		i	Correct symbols for battery / single cell **and** switch 	1	at least one of them must be correctly labelled
		ii	**FIRST CHECK THE ANSWER ON ANSWER LINE.** **If answer = 15 (C) award 3 marks** Recall: Charge = current × time (1) = 0.5 mins = 30 secs (1) = 0.5 × 30 = 15 (C) (1)	3	correct substitution gains first 2 marks (if equation is missing)
		iii	**FIRST CHECK THE ANSWER ON ANSWER LINE.** **If answer = 2.4 (Ω) award 3 marks** Recall: Resistance = voltage ÷ current (1) = 1.20 ÷ 0.50 (1) = 2.4 (Ω) (1)	3	correct substitution gains first 2 marks (if equation is missing)
			Total	**7**	
2	a	i	Both points correctly plotted (1) Smooth curve drawn (1)	2	
		ii	Power goes down with distance (non-uniformly) (1)	1	**allow** negative correlation correctly described

Question			Answer/Indicative content	Marks	Guidance
		iii	FIRST CHECK ANSWER ON ANSWER LINE **If answer = 6×10^{-3} (A) award 4 marks** Rearranges equation to give Current = power ÷ potential difference (1) Converts mW to W = 0.072 W (1) = 0.072 ÷ 12 (1) = 6×10^{-3} A (1) Or 6mA	4	
		iv	FIRST CHECK ANSWER ON ANSWER LINE **If answer = 2000 (Ω) award 3 marks** Rearrange equation to give Resistance = Potential difference ÷ current (1) 12v ÷ 6×10^{-3} A (1) = 2000 (Ω)	3	
	b		Lamp at fixed distance from photocell and read *I* and *V* (1) Repeat reading at each distance (1) Repeat for any outliers (1) Take mean *I* and *V* for each distance (1)	4	

Question			Answer/Indicative content	Marks	Guidance
	c		Recognises that Tom's photocell is getting less light (1) Suggested reason (1)	2	e.g. Sam was near a window (so more light) while Tom was in a dark corner; allow systematic mismeasurement of distance by one or the other if correctly justified e.g. the end of Sam's ruler wasn't near the actual lamp but some distance from it, so all her distances are too small. **allow** any situation where Tom would receive less light than Sam
			Total	16	

Question			Answer/Indicative content	Marks	Guidance
3		i	ammeter symbol ringed	1	**Examiner's Comments** The vast majority of candidates were correct when circling the ammeter symbol in the circuit. A significant minority did not answer this question and candidates should be reminded to read the instructions carefully.
		ii	use of equation R = V/I (1); two values of R calculated (1); resistance increases (as current increases) (1)	3	10 and 15 gains the first two marks **Examiner's Comments** Candidates fared well on this mathematical question. It was pleasing to see the large numbers of candidates carrying out the correct calculations and then using these to describe the correlation.
		iii	repeat readings / more data	1	**Examiner's Comments** Almost all the candidates could suggest that repeating the results was a way to improve the experiment.
			Total	5	

<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>4</td><td>a</td><td>i</td><td>
</td><td>4</td><td>mark per side
3 lines correct on either side, 2 marks for that side
1 or 2 lines correct per side, 1 mark for that side

Examiner's Comments

This question was about electrical components, their symbols and how they can be identified from their resistance characteristics. Candidates were expected to recognise and use conventions appropriately and interpret data. Overall this question differentiated well. Candidates looked at graphs displaying the resistance characteristics of three components against light intensity and temperature. They had to match each component to the correct resistor type and select the correct symbol.</td></tr>
<tr><td></td><td></td><td>ii</td><td><table><tr><th></th><th>true</th><th>false</th><th>cannot tell</th></tr><tr><td>Anita repeated her experiment three times.</td><td></td><td></td><td>?</td></tr><tr><td>Anita had an outlier in her results.</td><td>?</td><td></td><td></td></tr></table></td><td>2</td><td>1 mark per correct row

Examiner's Comments

The majority of candidates performed well on this question.</td></tr>
<tr><td></td><td>b</td><td>i</td><td>resistance = V/I = 6/0.06
= 100 ?</td><td>2</td><td></td></tr>
<tr><td></td><td></td><td>ii</td><td>10 °C</td><td>1</td><td>Examiner's Comments

The calculation of resistance and the interpretation of the graph to determine temperature at a given resistance were answered generally very well.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>9</td><td></td></tr>
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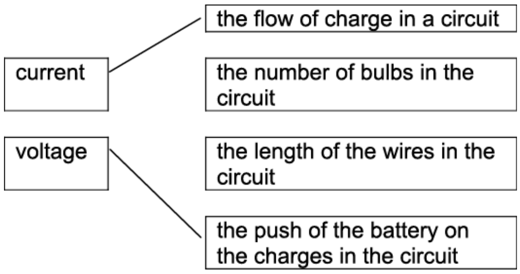
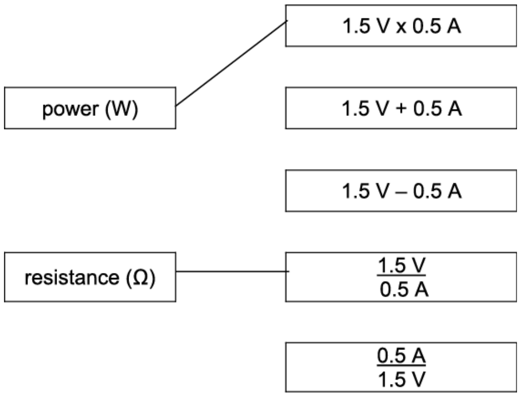
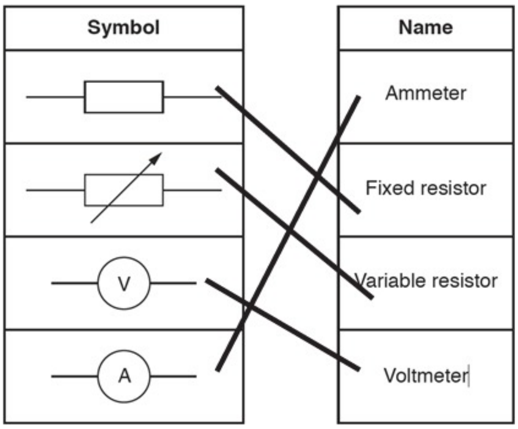
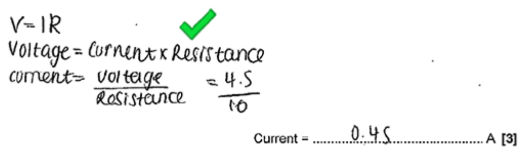
Question			Answer/Indicative content	Marks	Guidance
5	a			2	**Examiner's Comments** Most candidates gave two correct answers. Those who did not get these marks either got the links the wrong way round or drew more than one line from each box.
	b			2	
			Total	4	

Question			Answer/Indicative content	Marks	Guidance
6			**[Level 3]** Describes the correlation **and** gives some ways of confirming it. Quality of written communication does not impede communication of the science at this level. (5 – 6 marks) **[Level 2]** EITHER Describes the correlation **or** gives some ways of confirming it. OR Makes a statement about correlation **and** gives a way of confirming it. Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) **[Level 1]** Makes a statement about correlation **or** gives a way of confirming it. 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 C** **Indicative scientific points may include:** **Correlation:** • there is a correlation • resistance decreases as it gets warmer **What to do:** • (cold and warm not quantified) so use thermometer • (limited range so) extend temperature range • (not enough readings) so repeat them **Use the L1, L2, L3 annotations in Scoris; do not use ticks.** **Examiner's Comments** This six-mark question assessed about Ideas in Science, and was well answered b many candidates. Few candidates suggested the use of a thermometer to measure the temperature, and many assumed that being able to draw a graph of the existing pair of results was enough to confirm the correlation.
			Total	6	
7				3	all correct = 3 marks 3 or 2 correct = 2 marks 1 correct = 1 mark **Examiner's Comments** Most candidates were able to correctly identify all of the electrical circuit symbols in this question; some candidates confused the fixed and variable resistor.
			Total	5	

Question			Answer/Indicative content	Marks	Guidance
8	a	i	ANY TWO from: • complete circuit / no gaps • with a battery • copper is a conductor • conductors contain free charges / electrons • battery pushes free charges / electrons around circuit • charge / electrons move round the circuit	2	Examiner's Comments Although few candidates earned both marks for, many earned one, usually for mentioning that copper is a conductor, the circuit was complete or it contained a battery. Too many candidates seemed to ignore the mark allocation and writing space provided, writing only a single statement which could only earn one mark.
		ii	use more cells / battery (in series)	1	**allow** use greater voltage / use greater current / connects clips to each other / better conductor than copper / shorter leads / more powerful battery / connect another piece of copper in parallel **ignore** a different lamp Examiner's Comments Candidates fared much better with this part; most candidates correctly suggested adding another battery.
	b		contains no free charges / electrons / (plastic) is an insulator / electrons cannot flow through	1	**not** current can't pass through **ignore** not a metal **ignore** not a conductor Examiner's Comments This was very poorly answered; few candidates mentioned the lack of free electrons or that plastic was an insulator, with many repeating the stem and saying that plastic is not a conductor.
			Total	4	

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** current = V/R ✓ = 4.5 (V) / 22 000 (Ω) = 0.000 20(5) / 2.0(5) × 10^{-4} (A) ✓	3 (AO 1.2) (AO 2.1) (AO 2.1)	**IGNORE** significant figure errors or rounding errors **ALLOW** any form of equation for mp1 and mp 2 Incorrect R loses mp2 **ECF** own values but penalise for power of ten errors <u>Examiner's Comments</u> Only the most able candidates were able to complete this question. There was a mark for recalling the equation. Some candidates successfully recalled $V = I \times R$ but did not substitute in the correct values. Exemplar 6  Exemplar 6 shows how by setting out the answer enabled they were credited for recall of the equation even though they used a value of 10 Ω rather than 22 000 Ω for resistance.
		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) ✓	3 (AO 1.2) (AO 1.2) (AO 2.1)	 **ECF** from (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 ✓	3 (AO 2.2) (AO 3.1a × 2)	**ALLOW** potential divider argument for mp2 & mp3 <u>Examiner's Comments</u> No candidates were credited with full marks for this question and the majority did not provide any creditworthy response. Some candidates correctly stated that the resistance of the LDR or the total resistance of the circuit would decrease and were credited with one mark. A few also stated that the potential difference across the fixed resistor would increase. Some candidates thought the fixed resistor was the light-dependent resistor.
			Total	9	

Question			Answer/Indicative content	Marks	Guidance
10	a	i	correct symbol (circle containing V) connected in parallel with component Y ✓	1 (AO 2.2)	<u>Examiner's Comments</u> The majority of candidates used the correct symbol for a voltmeter in the circuit but many of them put it in series, instead of in parallel across component Y.
		ii	variable resistor / change resistance ✓ increase resistance to decrease current / ORA ✓	2 (AO 2.1 ×2)	<u>Examiner's Comments</u> Although candidates did not specifically need to state that component X was a variable resistor, they did need to state that the resistance could be varied, rather than just switched on or off in order to gain the first marking point. The second marking point here seemed much more difficult as candidates needed to state the direction of change i.e. increasing resistance means that the current is reduced.
	b	i	FIRST CHECK THE ANSWER IN TABLE **If answer = 3.77 (Ω) award 4 marks** Recall and rearrange: $R = V/I$ ✓ 6.0 / 1.59 ✓ 3.77 (Ω) (ignore s.f.) ✓ correct rounding to s.f. ✓	4 (AO 1.2) (AO 2.1) (AO 2.1) (AO 1.2)	<u>Examiner's Comments</u> This question was generally well answered, and for those candidates who were able to recall and rearrange the equation to calculate resistance it was a relatively easy 4 marks to achieve. Nearly all the candidates who did the calculation correctly were also able to give the answer to the correct number of significant figures as well.
		ii	as current increases, resistance increases ✓	1 (AO 3.1a)	**ALLOW** positive correlation. <u>Examiner's Comments</u> This question was often misinterpreted as many candidates knew that increasing resistance in a circuit reduces the current flowing, but they needed to realise here that this question related to the results given above.

Question			Answer/Indicative content	Marks	Guidance
		iii	(filament) lamp / bulb / heating element / fuse ✓ resistance increases as it heats up ✓	2 (AO 3.2b ×2)	<u>Examiner's Comments</u> This was yet another AO3 question which proved to be very difficult, linking the observations given to knowledge. Although many candidates did suggest that component Y was a filament bulb, most were unable to explain why. Common incorrect responses included the following; circuits usually have bulbs in, so you can tell if the circuit is working. Candidates needed to appreciate that the resistance of a bulb varies because the current flowing causes it to get hot.
			Total	10	