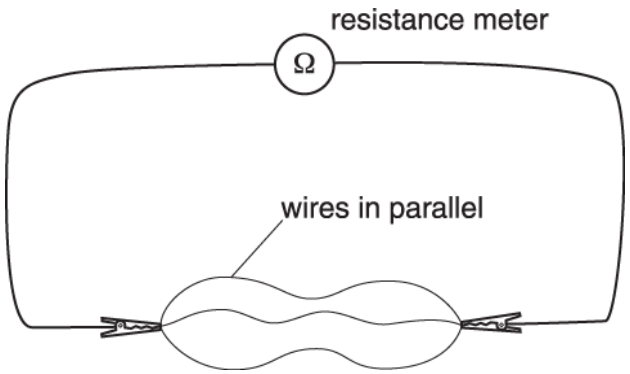
1. Sarah is investigating the resistance of wires connected in parallel.

She uses three wires that are all the same as each other.

She connects the three wires in parallel and uses a resistance meter to measure the resistance.



Sarah does this again for two wires in parallel.

These are her results:

Number of wires in parallel arrangement	Resistance (?)
2	6
3	4

Sarah thinks that there is a correlation between the number of wires and the resistance of the parallel arrangement.
Explain the correlation in Sarah's results and describe ways she could improve this investigation.

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

---

[6]

2. This question is about electric lamps.

The table gives information about different types of lamps.

The information is stated on the lamp and refers to its normal operating conditions.

Type of lamp	Information
fluorescent	230V, 8W
spiral	110V, 11W
filament	3V, 2W
LED	1.5V, 1W

(i) Which lamp uses most electrical energy every second when operating normally?

Put a ring around the correct answer.

fluorescent spiral filament LED

[1]

(ii) Which lamp is designed to be connected to the mains supply in a house in the UK?

Put a ring around the correct answer.

fluorescent spiral filament LED

[1]

(iii) The filament lamp can be powered by cells.

How many 1.5 V cells need to be connected in series so the lamp lights normally?

Put a ring around the correct answer.

one two three four

[1]

3(a). Susan is investigating electrical circuits.

She starts by researching voltage.

(i) What is another name for voltage? _____

[1]

(ii) Complete the following sentences about voltage.
Use words from the list.

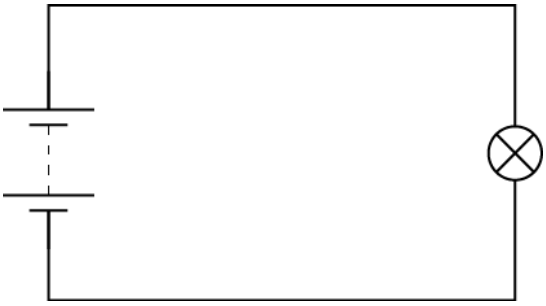
battery **charge** **current** **lamp** **wire**

The voltage is a measure of the 'push' given to the charges in a circuit by a _____.

The voltage between two points depends on the work done on a _____, as it moves between the two points.

[2]

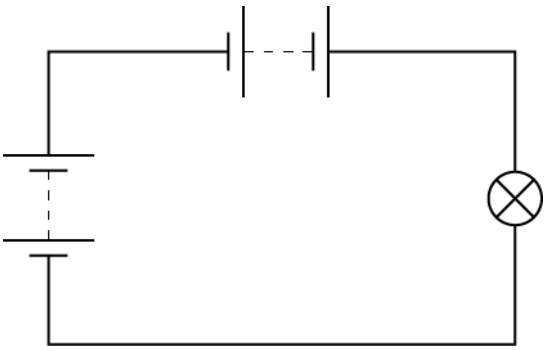
(b). Susan wants to measure the voltage across the battery in a simple circuit.



Add a voltmeter to the circuit diagram to show how the voltmeter should be connected to measure the voltage across the battery.

[2]

(c). Susan adds another battery to the circuit, in **series** with the first battery.

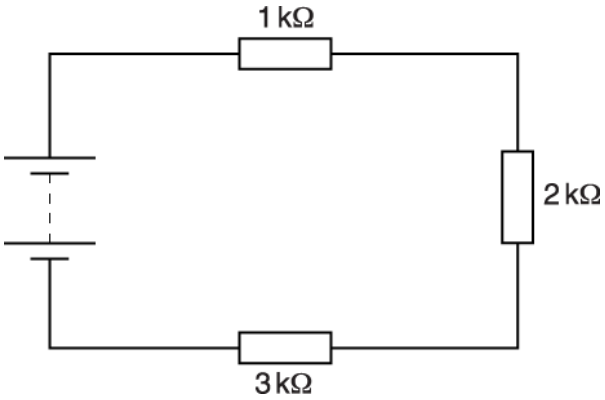


What will happen to the voltage across the lamp and the current through it? Put a tick (?) in the box next to the correct answer.

voltage increases, current increases	☐
voltage increases, current decreases	☐
voltage decreases, current increases	☐
voltage decreases, current decreases	☐

[1]

(d). Susan builds a circuit with three resistors in series.



(i) Here are statements about the current in the circuit.
Put a tick (?) in the box next to the correct statement

There is no current in the circuit. ☐

The largest current is in the 3 k? resistor. ☐

The smallest current is in the 3 k? resistor. ☐

The current is the same in all three resistors. ☐

[1]

(ii) Which resistor has the largest voltage across it?
Justify your answer.

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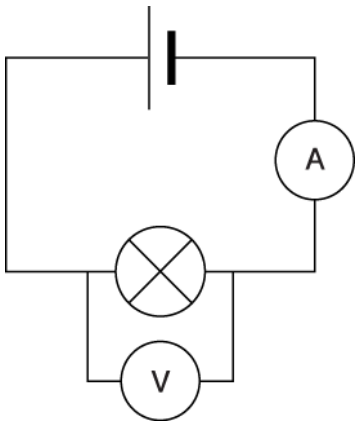
[2]

4. Jason sets up the following circuit.



Jason doubles the length of the **connecting** wires in his circuit, but keeps all other components the same.

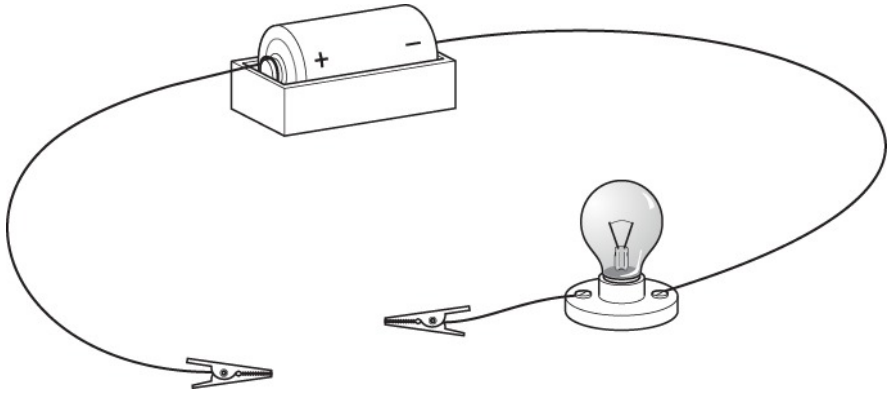
He finds that the power of the lamp does not change.

Explain why.

---

[2]

5(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.

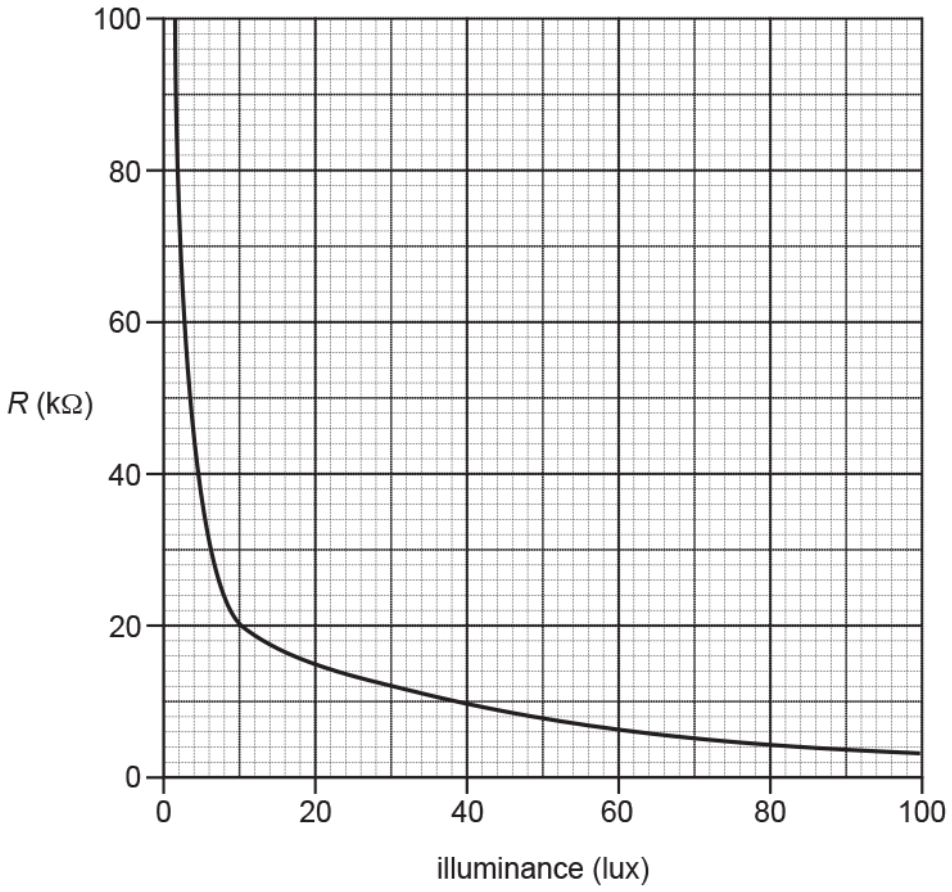
Explain why the plastic is not a conductor.

---

[1]

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

The resistance *R* of an LDR varies with illuminance (the amount of light energy per unit area hitting a surface) as shown in the graph.



(i) Which of the following statements correctly describes this variation?

Tick (✓) **one** box.

The resistance is directly proportional to the illuminance. ☐

The resistance and the illuminance have a positive correlation. ☐

As the illuminance increases, the change in resistance becomes less and less. ☐

The resistance is greater at 80 lux than at 20 lux. ☐

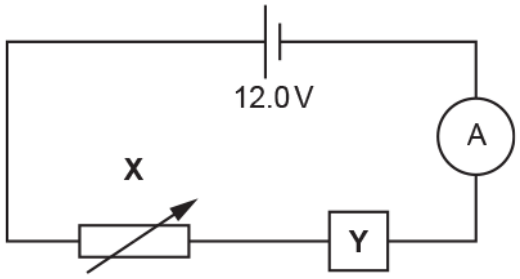
[1]

(ii) Use the graph to estimate the change in resistance of the LDR when the illuminance increases from 10 lux to 70 lux.

Change in resistance = ---------- k Ω **[2]**

7. 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.

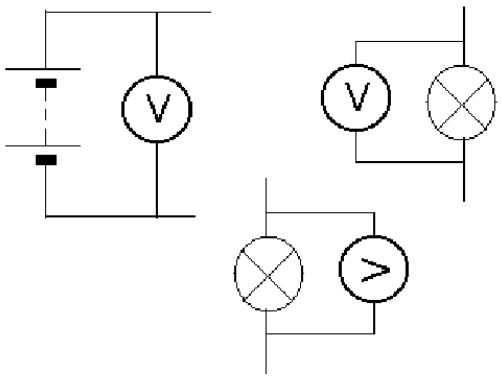
---

[2]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1			[Level 3] States and explains the correlation **AND** describes at least two improvements. Quality of written communication does not impede communication of the science at this level. (5 – 6 marks) [Level 2] States the correlation **AND** describes two improvements. Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) [Level 1] States the correlation **OR** describes two improvements. 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 grade D/C Indicative scientific points may include: Correlation: Statement of correlation • resistance decreases with more wires / paths / branches • negative correlation Explanation of correlation • more wires gives more paths for current / electrons / charge • greater cross sectional area • easier for current / electrons / charge to get through • Use of V = IR Improvements: • more wires / longer wires / thicker wires / other wire types • repeat readings • find mean / average reading • control variables (use same meter, leads, temperature) • connect meter to known resistor • description of other suitable correct method • someone else could reproduce the experiment Use the L1, L2, L3 annotations in RM ASSESSOR; do not use ticks. Examiner's Comments This question was common to the higher paper and as such should be a challenging question on this paper. Many candidates gained 3 marks on this question by describing the correlation and then giving one improvement; a second improvement would have increased this to 4 marks. Many candidates used the term “negative correlation” which was pleasing to see.

Question			Answer/Indicative content	Marks	Guidance
					Very few candidates on this paper attempted to explain why the resistance decreased as more wires were added. Some did use the “more paths” argument, which was enough to gain full marks.
			Total	6	
2		i	spiral (2nd answer)	1	Examiner's Comments Many candidates found this difficult and could not use the power given in the table to work out that the spiral bulb used the most energy each second.
		ii	fluorescent (1st answer)	1	Examiner's Comments More candidates recognised that 230V was the mains supply in the UK and therefore the fluorescent bulb was the correct answer.
		iii	two (2nd answer)	1	Examiner's Comments The majority of candidates worked out that two cells would power the filament lamp in this case.
			Total	3	

Question			Answer/Indicative content	Marks	Guidance
3	a	i	potential difference	1	**allow** p.d. **not** volts Examiner's Comments This question was about electricity, a topic that challenges most Foundation Tier candidates. It was therefore not surprising that only a small minority knew that potential difference was an alternative name for voltage. Although many candidates knew that the battery established the voltage across its circuit, only a minority knew the definition of voltage difference as work done on a charge moving through a circuit.
		ii	battery	1	
		ii	charge	1	
	b		correct symbol	1	**look for** a circle around V e.g. **accept** lines which are not straight
			connections to wires on either side of battery or lamp	1	 Examiner's Comments Most candidates could draw a correct voltmeter symbol, many placed it incorrectly in series with the battery instead of in parallel; however, it was good to find that a substantial minority were able to earn full marks.

Question			Answer/Indicative content	Marks	Guidance
	c		voltage increases, current increases: ? voltage increases, current decreases: voltage decreases, current increases: voltage deceases, current decreases:	1	Examiner's Comments Many candidates realised that inserting a second cell increased both voltage and current.
	d	i	There is no current in circuit.: The largest current is in the 3k? resistor: The smallest current is in the 3k? resistor: The current is the same in all three resistors: ?	1	
		ii	3(k?)	1	
		ii	(largest voltage across) the largest resistance	1	**accept** largest ohms / kilohms **don't award** second mark if an incorrect resistor is identified Examiner's Comments This question presented candidates with a circuit of three different resistors in series. Only a small minority knew that the current was the same in all three resistors (most went for the idea that the largest resistor had the largest current), and even fewer knew that the largest resistor had the largest voltage difference.
			Total	9	

Question			Answer/Indicative content	Marks	Guidance
4			connecting wires have no resistance / resistance can be ignored (1) (so) no change (to circuit) / same components / same current / same voltage / same resistance (1)	2	**do not accept** same electricity going through **do not accept** same power for battery **Examiner's Comments** This question was not answered well. Very few candidates stated that the wires had little or no resistance. Some candidates did achieve a mark by saying that the voltage or current stayed the same or the components did not change, though their answers were not succinct. Answers such as ‘power stays the same’ or ‘energy does not change’ were not given credit.
			Total	2	

Question			Answer/Indicative content	Marks	Guidance
5	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
6		i	As the illuminance increases, the change in resistance becomes less and less. (3rd option) ✓	1 (AO 1.2)	Examiner's Comments Higher ability candidates did well on this question. A few candidates across the ability range ticked two boxes here rather than one; the first and the third responses.
		ii	FIRST CHECK THE ANSWER ON THE ANSWER LINE. If answer is between 14.0 & 16.0 (kΩ) award 2 marks R (at 10 lux) = 20 (kΩ) OR R (at 70 lux) = {5 ± 1} (kΩ) ✓ Second R and ΔR = 20 (kΩ) – {5 ± 1}(kΩ) = 14.0 – 16.0 (kΩ) ✓	2 (AO 2.2 × 2)	ALLOW + or – for ΔR as this is a decrease Examiner's Comments This was well answered by higher ability candidates and many others scored 1 mark for recognising that the resistance at 10 lux was 20 kΩ. Some lower ability candidates did not realise that the change was the difference in the values and some calculated the difference between the lux values.
			Total	3	

Question			Answer/Indicative content	Marks	Guidance
7		i	correct symbol (circle containing V) connected in parallel with component Y ✓	1 (AO 2.2)	Examiner's Comments 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)	Examiner's Comments 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.
			Total	3	