Resistance of a wire and of circuits

Answers, marking points and revision notes | AQA Combined Science 8464 and AQA GCSE Physics 8463

GCSE science required practicals

This practical online

Answers

1 For Chen's investigation of the wire, name:

a. the independent variable

b. the dependent variable.

(2 marks)

a) The length of the wire.

b) The resistance of the wire (worked out from the potential difference and the current).

Marking points

- Length of wire
- Resistance (from p.d. and current)

2 Chen used the same wire for every reading. Give one other control variable and explain why it must be kept the same.

(2 marks)

The temperature of the wire. If the wire gets warmer its resistance goes up, so a change in resistance could be caused by heating instead of by the change in length.

Marking points

- A control: temperature, thickness (diameter) or material of the wire
- Reason: it also affects resistance, so the change would not be due to length alone

3 Describe how the ammeter and the voltmeter should be connected in Chen's circuit.

(2 marks)

The ammeter goes in series with the wire, so all the current flows through it. The voltmeter goes in parallel across the length of wire between the two crocodile clips.

Marking points

- Ammeter in series with the wire
- Voltmeter in parallel across the wire between the clips

4 Chen opened the switch after each pair of readings. Explain why this makes his results more accurate.

(2 marks)

A current heats the wire. If the wire got hotter during the experiment its resistance would increase, making the later readings too high. Switching off lets the wire stay at about room temperature.

Marking points

- Current flowing heats the wire
- Higher temperature increases resistance, so keeping it cool keeps temperature controlled

Free for classroom and home use: print, photocopy and share. Not for resale or re-hosting.

5 Give one hazard in this practical and a way of reducing the risk. (2 marks)

The wire can get hot enough to burn. Chen should use a low potential difference, switch off between readings and not touch the wire while current is flowing.

Marking points

- Hazard: hot wire (burns) or short circuit overheating leads
- Matching control: low p.d., switch off between readings, do not touch the wire, keep clips apart

6 Calculate the value of X, the resistance of 60 cm of the wire. (2 marks)

Resistance = 1.50 ÷ 0.40 = 3.75 Ω.

$R = V \div I$

$R = 1.50 \div 0.40$

$R = 3.75\ \Omega$

Marking points

- Resistance = 1.50 ÷ 0.40
- 3.75 Ω

7 One of Chen's results is anomalous. Identify it and say what Chen should do about it. (2 marks)

The result at 80 cm (5.33 Ω) is too high: the pattern suggests about 4.9 Ω. Chen should repeat the readings at 80 cm and leave the odd value out of his mean and his line of best fit.

Marking points

- 80 cm, 5.33 Ω
- Repeat it, and leave it out of the mean or line of best fit

8 Write a conclusion for Chen's investigation of the wire. (2 marks)

As the length of the wire increases, its resistance increases. Apart from the anomaly, each extra 20 cm adds about the same resistance (around 1.1 to 1.2 Ω), so the resistance increases at a steady rate and the graph is a straight line.

Marking points

- Longer wire gives a bigger resistance
- Increases steadily (linear: about the same increase for each extra 20 cm)

Free for classroom and home use: print, photocopy and share. Not for resale or re-hosting.

9 **Higher tier**

Use Chen's results for 20 cm and 100 cm.

a. Calculate the increase in resistance for each centimetre of wire.

b. Use your answer to estimate the resistance of 50 cm of the wire.

Give your answer to part b) to 2 significant figures. Show your working. (4 marks)

a) Increase = 6.03 - 1.43 = 4.60 Ω over 100 - 20 = 80 cm, so 4.60 ÷ 80 = 0.0575 Ω per cm.

b) 50 cm is 30 cm more than 20 cm, so R = 1.43 + (0.0575 × 30) = 1.43 + 1.725 = 3.155 Ω, which is 3.2 Ω to 2 significant figures.

$\Delta R = 6.03 - 1.43$

$\Delta R = 4.60\ \Omega$

$\Delta L = 100 - 20$

$\Delta L = 80\ \text{cm}$

$\text{gradient} = 4.60 \div 80$

$\text{gradient} = 0.0575\ \Omega\ \text{per cm}$

$\text{extra length} = 50 - 20$

$\text{extra length} = 30\ \text{cm}$

$\text{extra resistance} = 0.0575 \times 30$

$\text{extra resistance} = 1.725\ \Omega$

$R = 1.43 + 1.725$

$R = 3.155\ \Omega$

$R = 3.2\ \Omega\ (2\ \text{s.f.})$

Marking points

- Change in resistance 4.60 Ω over 80 cm
- 0.0575 Ω per cm
- Adds 30 × 0.0575 to the 20 cm value (or uses the line)
- 3.2 Ω

10 **Higher tier**

When Chen draws his line of best fit, it cuts the resistance axis at about 0.3 Ω instead of passing through zero. Explain what this shows about his measurements. (2 marks)

There is a systematic error: every resistance value is about 0.3 Ω too big. This is probably the resistance of the crocodile clips and their contact with the wire, which is there even at zero length. It shifts the line up but does not change its gradient.

Marking points

- Systematic (zero) error: every reading too high by the same amount
- Caused by resistance of clips or contacts (or leads), so the gradient is still valid

Free for classroom and home use: print, photocopy and share. Not for resale or re-hosting.

11 Bethany connected a 22 Ω resistor and a 33 Ω resistor in series. The voltmeter across both resistors read 6.0 V and the ammeter read 0.11 A.

Calculate the total resistance from her readings and compare it with the sum of the two resistances. Give your answer to 2 significant figures. Show your working. (3 marks)

Total resistance = 6.0 ÷ 0.11 = 54.5 Ω, which is 55 Ω to 2 significant figures.

The sum of the resistors is 22 + 33 = 55 Ω, so her measured value agrees: in series the resistances add up.

$R = V \div I$

$R = 6.0 \div 0.11$

$R = 54.5\ \Omega$

$R = 55\ \Omega$ (2 s.f.)

$22 + 33 = 55\ \Omega$

Marking points

- R = 6.0 ÷ 0.11
- 55 Ω
- Compares with 22 + 33 = 55 Ω, so the resistances add in series

12 Bethany then connected the same two resistors in parallel. The voltmeter still read 6.0 V and the ammeter now read 0.46 A.

Calculate the total resistance of the parallel combination to 2 significant figures, and explain how it compares with the resistance of each resistor. Show your working. (3 marks)

Total resistance = 6.0 ÷ 0.46 = 13.0 Ω, which is 13 Ω to 2 significant figures.

This is less than the smaller resistor (22 Ω). In parallel the current has two paths to flow through, so more current flows for the same potential difference and the total resistance goes down.

$R = V \div I$

$R = 6.0 \div 0.46$

$R = 13.04\ \Omega$

$R = 13\ \Omega$ (2 s.f.)

Marking points

- R = 6.0 ÷ 0.46
- 13 Ω
- Less than the smallest resistor because there are more paths for the current

13 Chen's crocodile clips have wide jaws, so it is hard to tell exactly where along the rule they touch the wire. Suggest an improvement and explain how it helps. (2 marks)

Use a jockey or a clip with a narrow, pointed contact and line it up by looking straight down at the scale. This makes the length measurement more accurate, because the point of contact is clear and there is no parallax error.

Marking points

- A specific improvement: narrow contact (jockey or pointed clip), or read the scale at eye level directly above
- Reason: length is measured more accurately (exact contact point, no parallax)

Free for classroom and home use: print, photocopy and share. Not for resale or re-hosting.

14 Plan an investigation to find out how the thickness (diameter) of a wire affects its resistance. You have five constantan wires of different diameters. (6 marks)

Measure the diameter of each wire with a micrometer, taking readings in three places and finding a mean. Cut the same length of each wire, for example 50 cm, measured with a metre rule, and tape it straight along the rule. Connect each wire in turn in series with a low voltage power supply, a switch and an ammeter, and connect a voltmeter in parallel across the 50 cm of wire. Close the switch, read the ammeter and voltmeter, and open the switch straight away so the wire does not heat up. Keep the supply setting the same for every wire. Calculate the resistance using resistance = potential difference ÷ current. Repeat the readings three times for each wire and work out a mean resistance. Plot a graph of resistance against diameter. I would expect thicker wires to have a smaller resistance. Do not touch the wires while the current is on, as they can get hot.

Marking points (any 6, with the method in a logical order)

- Measure diameter with a micrometer (several places, mean)
- Same length and same material for every wire
- Ammeter in series with the wire
- Voltmeter in parallel across the wire
- Calculate resistance = potential difference ÷ current
- Keep temperature constant: low current, switch off between readings
- Repeat readings and calculate a mean resistance
- Plot resistance against diameter (or compare results)
- Safety: wire may get hot, do not touch while on

How it is marked

- 5-6 marks: a clear, logical plan that controls length and material, measures diameter, connects the meters correctly, calculates resistance and repeats to find means.
- 3-4 marks: a workable plan with the meters and the resistance calculation, but some controls or how the diameter is measured are missing.
- 1-2 marks: a few relevant points, such as using an ammeter or changing the wire, but no clear method that would give the resistance of each wire.

Revision notes: the method

Aim: To find out how the length of a wire affects its resistance, and how the total resistance of two resistors in series compares with two in parallel.

Equipment

- Metre rule
- Length of thin resistance wire (for example constantan) taped along the metre rule
- Two crocodile clips
- Low voltage power supply or battery
- Variable resistor
- Ammeter
- Voltmeter
- Connecting leads
- Switch
- Two fixed resistors (for example 22 Ω and 33 Ω)

Free for classroom and home use: print, photocopy and share. Not for resale or re-hosting.

Method

1. Tape the wire straight along the metre rule so it lies next to the scale.
2. Connect the power supply, switch, variable resistor and ammeter in series with the wire, using a crocodile clip at the 0 cm mark and a second crocodile clip that can slide along the wire.
3. Connect the voltmeter in parallel across the part of the wire between the two clips.
4. Put the sliding clip at 20 cm, close the switch, and read the ammeter and voltmeter.
5. Open the switch straight after taking the readings so the wire does not heat up.
6. Move the clip to 40, 60, 80 and 100 cm and take readings at each length.
7. Repeat the readings for each length and calculate a mean resistance using resistance = potential difference ÷ current.
8. Plot a graph of resistance against length and draw a line of best fit.
9. Next, connect the two fixed resistors in series with the supply and ammeter, with the voltmeter across both, and calculate their total resistance.
10. Then connect the two resistors in parallel, read the ammeter and voltmeter again, and calculate the total resistance.

Variables

- **Independent:** The length of wire between the crocodile clips (or the way the resistors are connected).
- **Dependent:** The resistance, calculated from the voltmeter and ammeter readings.
- **Control:** Material of the wire; Thickness (diameter) of the wire; Temperature of the wire (keep the current small and switch off between readings); A small current (set with the variable resistor) and the same meters for every reading

Hazards

Hazard	What could happen	How to reduce the risk
The wire gets hot when a current flows	Burns to fingers, or the wire could scorch the bench	Use a low potential difference, open the switch between readings and do not touch the wire while the current is on.
A short circuit if the clips touch or the wire is very short	Large current overheats the leads or the supply	Do not take readings at very short lengths and keep the clips apart; switch off at once if anything gets hot.

Key points

- Resistance = potential difference ÷ current, so you need both meters: ammeter in series, voltmeter in parallel across the wire.
- A longer wire has a bigger resistance; the graph is a straight line.
- The line may not go through zero because the clips and their contact with the wire add a little resistance (a systematic error).
- Keep the current small and switch off between readings: a hot wire has a higher resistance.
- Resistors in series: total resistance is the sum of the resistances.
- Resistors in parallel: total resistance is less than the smallest single resistor.

Free for classroom and home use: print, photocopy and share. Not for resale or re-hosting.