I-V characteristics

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

GCSE science required practicals

This practical online

Answers

1 In Hana's experiment, what was:

a. the independent variable

b. the dependent variable?

(2 marks)

a) The potential difference across the lamp.

b) The current through the lamp.

Marking points

- Potential difference across the lamp
- Current through the lamp

2 Describe how Hana could:

a. change the potential difference across the lamp

b. get the readings with negative values.

(2 marks)

a) Adjust a variable resistor in series with the lamp, or change the setting on a variable power supply.

b) Swap over the two wires connected to the lamp (or to the supply) so the current flows through it in the opposite direction, then take the readings again.

Marking points

- Variable resistor or variable supply
- Reverse the connections (supply or component) so current flows the other way

3 Hana also tested a fixed resistor. She switched off between readings so that one variable stayed the same. Name this variable and explain why it matters.

(2 marks)

The temperature of the resistor. If the resistor heated up its resistance would increase, so the graph would no longer be a straight line and would not show the true behaviour at constant temperature.

Marking points

- Temperature of the resistor
- A rise in temperature would change (increase) the resistance and spoil the straight-line result

4 Give one hazard when testing the filament lamp and say how Hana can reduce the risk.

(2 marks)

The lamp gets hot and could burn her. She should not touch it while it is on and should let it cool before taking it out of the holder.

Marking points

- Hazard: hot lamp (burns) or lamp breaking from too high a p.d.
- Matching control: do not touch until cool, do not go over the rated 6 V

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5 Describe how the current through the lamp changes as the potential difference increases from 0 V to 6.0 V. (2 marks)

The current increases as the potential difference increases, but each step in potential difference gives a smaller increase in current: from 0 to 2.0 V it rises by 0.16 A, but from 4.0 to 6.0 V it rises by only 0.05 A. So the graph is a curve that gets less steep.

Marking points

- Current increases with potential difference
- Not proportional: increases by less each time (curve gets less steep), with data

6 Calculate the resistance of the lamp when the potential difference is 2.0 V. (2 marks)

Resistance = 2.0 ÷ 0.16 = 12.5 Ω.

$R = V \div I$

$R = 2.0 \div 0.16$

$R = 12.5\ \Omega$

Marking points

- Resistance = 2.0 ÷ 0.16
- 12.5 Ω

7 Calculate the resistance of the lamp when the potential difference is 6.0 V, and use your answer and the previous question to say what happens to the resistance of the lamp as the potential difference increases. Show your working. (3 marks)

Resistance = 6.0 ÷ 0.30 = 20 Ω.

At 2.0 V the resistance was 12.5 Ω, so the resistance of the lamp increases as the potential difference increases.

$R = V \div I$

$R = 6.0 \div 0.30$

$R = 20\ \Omega$

20 Ω is more than 12.5 Ω, so resistance increases

Marking points

- Resistance = 6.0 ÷ 0.30
- 20 Ω
- Resistance increases with potential difference (12.5 Ω to 20 Ω)

8 **Higher tier**

Explain why the resistance of the filament lamp increases as the current through it increases. (3 marks)

A bigger current transfers more energy to the filament, so it gets hotter. In a hotter metal the ions vibrate more. The electrons flowing through the filament collide with the vibrating ions more often, which makes it harder for them to pass, so the resistance goes up.

Marking points

- Larger current makes the filament hotter
- Ions (atoms) in the metal vibrate more
- Electrons collide with the ions more often, so resistance increases

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9 Hana's results for the fixed resistor were:

-3.0 V, -0.15 A; 1.0 V, 0.05 A; 2.0 V, 0.10 A; 3.0 V, 0.15 A.

Describe the relationship between current and potential difference for the resistor, using her results. (2 marks)

The current is directly proportional to the potential difference: doubling the potential difference from 1.0 V to 2.0 V doubles the current from 0.05 A to 0.10 A. The graph would be a straight line through the origin, and the resistance stays the same (20 Ω) at every reading, including the negative one.

Marking points

- Current directly proportional to potential difference (straight line through the origin)
- Supported with data, e.g. double the p.d. gives double the current, or V ÷ I = 20 Ω each time

10 Hana's results for the diode were:

-2.0 V, 0 mA; -1.0 V, 0 mA; 0.2 V, 0 mA; 0.4 V, 1 mA; 0.6 V, 12 mA; 0.7 V, 24 mA; 0.8 V, 60 mA.

Describe what these results show about the diode. (3 marks)

When the potential difference is negative, no current flows, so the diode has a very high resistance in the reverse direction. In the forward direction almost no current flows until about 0.4 V to 0.6 V. Above this, the current increases very steeply for small increases in potential difference, so the resistance becomes low.

Marking points

- No current in the reverse (negative) direction: very high resistance
- Very little current at small forward potential differences
- Current rises steeply above about 0.6 V (low resistance)

11 Calculate the resistance of the diode when the potential difference across it is 0.7 V and the current is 24 mA.

Give your answer to 2 significant figures. Show your working. (3 marks)

Current = 24 ÷ 1000 = 0.024 A.

Resistance = 0.7 ÷ 0.024 = 29.2 Ω, which is 29 Ω to 2 significant figures.

$I = 24 \div 1000$

$I = 0.024\ A$

$R = V \div I$

$R = 0.7 \div 0.024$

$R = 29.17\ \Omega$

$R = 29\ \Omega$ (2 s.f.)

Marking points

- Converts 24 mA to 0.024 A
- Resistance = 0.7 ÷ 0.024
- 29 Ω

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12 **Higher tier**

Ifeoma tested a different fixed resistor. Her graph of current (y-axis) against potential difference (x-axis) was a straight line through the origin. It passed through the point 5.0 V, 0.040 A.

Calculate the gradient of her graph and use it to find the resistance of the resistor. (2 marks)

Gradient = 0.040 ÷ 5.0 = 0.0080 A/V. The gradient is current ÷ potential difference, which is 1 ÷ resistance, so resistance = 1 ÷ 0.0080 = 125 Ω.

$\text{gradient} = \Delta I \div \Delta V$

$\text{gradient} = 0.040 \div 5.0$

$\text{gradient} = 0.0080 \text{ A/V}$

$R = 1 \div \text{gradient}$

$R = 1 \div 0.0080$

$R = 125 \Omega$

Marking points

- Gradient = 0.040 ÷ 5.0 = 0.0080 A/V
- Resistance = 1 ÷ gradient = 125 Ω

13 Hana's lamp curve changes shape most quickly between 0 V and 2.0 V, but she has only one reading in between. Suggest an improvement to her method and explain how it helps. (2 marks)

Take readings in smaller steps, such as every 0.5 V, between 0 V and 2.0 V. More points where the curve bends most means she can draw the shape of the curve more accurately.

Marking points

- Take more readings (smaller steps) between 0 and 2.0 V
- So the shape of the curve where it changes most can be drawn more accurately

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14 Plan an investigation to find the current-potential difference graph of a diode, including negative values. Include how you would protect the diode from damage. (6 marks)

Set up a series circuit with a variable power supply, a switch, a protective resistor of about 100 Ω, a milliammeter and the diode. Connect a voltmeter in parallel across the diode only. The protective resistor limits the current so the diode does not overheat. Start with the supply at 0 V, close the switch and read the voltmeter and milliammeter. Increase the potential difference across the diode in steps of 0.1 V up to about 0.8 V, recording both readings each time, and use small steps near 0.6 V where the current starts to rise quickly. Open the switch between readings. Then reverse the connections to the diode and take readings from 0 V down to about -2 V in steps of 0.5 V. Repeat the set of readings and check they agree. Plot current on the y-axis against potential difference on the x-axis, with both axes going through negative values. Do not let the current go above the diode's maximum, and do not touch components while the current is on.

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

- Series circuit: supply, diode, ammeter (milliammeter)
- Voltmeter in parallel across the diode only
- Protective resistor in series to limit the current
- Change the potential difference with a variable supply or variable resistor
- Small steps (about 0.1 V), especially near 0.6 V
- Reverse the connections to get negative values
- Record current and potential difference at each step and repeat
- Plot current against potential difference through all four quadrants
- Switch off between readings or other safety point

How it is marked

- 5-6 marks: a clear plan with the meters placed correctly, the protective resistor explained, small forward steps, reversed connections for negative values, and the graph described.
- 3-4 marks: a workable circuit and readings are described, but one key part is missing, such as the protective resistor or how to get negative values.
- 1-2 marks: a few correct points about equipment or measuring current, but no clear sequence and the circuit would not give the full graph.

Revision notes: the method

Aim: To find how the current through a fixed resistor, a filament lamp and a diode changes with the potential difference across it, and to draw their current-potential difference graphs.

Equipment

- Variable d.c. power supply (or a battery with a variable resistor)
- Fixed resistor (for example 20 Ω)
- Filament lamp (for example 6 V, 0.3 A) in a holder
- Diode with a protective resistor of about 100 Ω
- Ammeter (or milliammeter for the diode)
- Voltmeter
- Switch
- Connecting leads

Method

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1. Build a series circuit of the power supply, switch, variable resistor, ammeter and the component being tested.
2. Connect the voltmeter in parallel across the component only.
3. Set the supply or variable resistor so the potential difference across the component is small, close the switch, and read the voltmeter and ammeter.
4. Increase the potential difference in equal steps, for example 1.0 V at a time, and record both readings each time, opening the switch between readings.
5. Swap the connections to the component (or reverse the supply) so the current flows the other way, and repeat to get negative values of potential difference and current.
6. Repeat the whole set of readings to check they are repeatable.
7. Do the same for the filament lamp and for the diode (with its protective resistor in series and a milliammeter, using small steps of 0.1 V near 0.6 V).
8. Plot current on the y-axis against potential difference on the x-axis for each component, with both axes running through negative values.

Variables

- **Independent:** The potential difference across the component, read on the voltmeter.
- **Dependent:** The current through the component, read on the ammeter.
- **Control:** The component being tested in each set of readings; Temperature of the fixed resistor (keep the current small and switch off between readings); The same meters for every reading

Hazards

Hazard	What could happen	How to reduce the risk
The filament lamp and the resistor get hot	Burns to the fingers	Do not touch the lamp or resistor while the current is on, and let them cool before changing the circuit.
Too big a current through the diode or lamp	The component overheats or breaks, and could crack the glass of the lamp	Keep the diode's protective resistor in series and do not go above the lamp's rated potential difference.

Key points

- Ammeter in series with the component, voltmeter in parallel across the component only.
- Reverse the connections to get the negative half of the graph.
- Fixed resistor at constant temperature: straight line through the origin, so current is directly proportional to potential difference.
- Filament lamp: a curve that flattens, because the filament gets hotter and its resistance increases.
- Diode: current flows in one direction only; almost no current until about 0.6 V, then it rises steeply.
- Resistance at a point = potential difference ÷ current at that point, not the slope of a curve.

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