

Thermistors, LDRs and sensor circuits

AQA GCSE Combined Science Trilogy 8464 and Separate Physics 8463 | Paper 1 | Both tiers

Suggested: 35–40 minutes + 15–20 minutes review | 28 parts | 50 marks

Specification points covered

8463 4.2.1.3 / 8464 6.2.1.3: potential difference, current and resistance ($V = IR$)

8463 4.2.1.4 / 8464 6.2.1.4: thermistors, LDRs and resistance changes

8463 4.2.2 / 8464 6.2.2: current, potential difference and resistance in series/parallel circuits

A seed bank is testing a storage cabinet. One sensor circuit warns when it becomes too warm; another detects light when the lid opens. Use the measurements to decide whether the warnings will work.

Use a calculator and equations sheet; show working and units. Supplies stay at 6.0 V. Assume ideal meters, negligible monitor-input current and negligible sensor self-heating.

1 Choosing and checking the sensors

T is an NTC thermistor. The other sensor is a light-dependent resistor (LDR). Table 1 gives calibration data for T.

1(a) As the cabinet warms, what happens to the resistance of T? Compare this with a metal filament lamp as its filament warms. **[2 marks]**

1(b) As more light reaches the lid sensor, what happens to the resistance of the LDR? **[1 mark]**

Table 1

Temperature / °C	Resistance of T / Ω
10	5000
20	3000
30	2000
40	1000
50	500

1(c) Use two changes from Table 1 to show that resistance does not decrease linearly with temperature. **[2 marks]**

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1(d) In a separate calibration test, T has 4.5 V across it and carries 1.5 mA. Calculate its resistance and identify the matching temperature in Table 1. **[2 marks]**

2 Building the temperature circuit

Figure 1 shows T in series with a fixed $1000\ \Omega$ resistor. The voltmeter measures the potential difference across the fixed resistor only. For this section, T is at $30\ ^\circ\text{C}$; use Table 1.

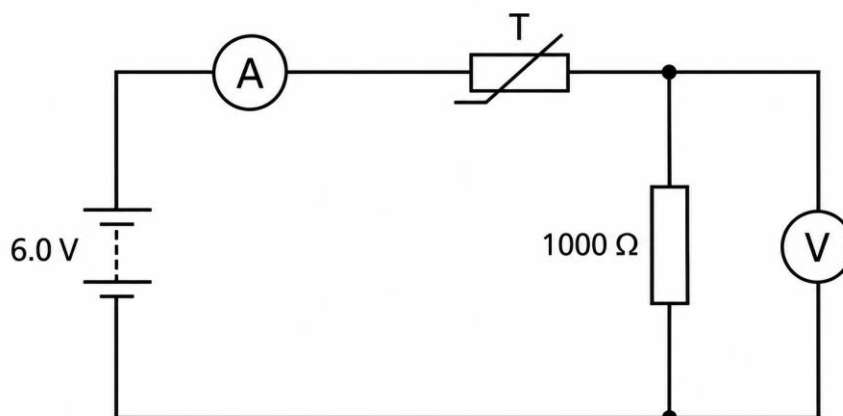


Figure 1

2(a) Calculate the total resistance of the main series circuit at $30\ ^\circ\text{C}$. **[1 mark]**

2(b) Calculate the ammeter reading at $30\ ^\circ\text{C}$. Give your answer in mA. **[2 marks]**

2(c) Calculate the voltage across the fixed $1000\ \Omega$ resistor at $30\ ^\circ\text{C}$. **[1 mark]**

2(d) Calculate the voltage across T at $30\ ^\circ\text{C}$. **[1 mark]**

2(e) A trainee says the fixed resistor carries less current than T because T uses some current up. Correct this claim. **[1 mark]**

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3 Will the temperature warning work

The temperature warning activates when the voltage across the fixed $1000\ \Omega$ resistor in Figure 1 is 2.5 V or greater. Keep the same circuit and use Table 1 unless a fault is stated.

3(a) T warms to $40\ ^\circ\text{C}$. Calculate the main circuit current in mA and the voltage across the fixed resistor. **[2 marks]**

3(b) Will the temperature warning be active at $40\ ^\circ\text{C}$? Use your result from 3(a). **[1 mark]**

3(c) Explain why warming T increases the voltage across the fixed resistor. Link resistance, current and potential difference. **[3 marks]**

3(d) A trainee says the warning must first activate at exactly $35\ ^\circ\text{C}$ because this is halfway between $30\ ^\circ\text{C}$ and $40\ ^\circ\text{C}$. Explain why the measurements do not establish this. **[2 marks]**

3(e) A lead breaks and disconnects T. Predict the main circuit current and the fixed-resistor voltage, then state whether a hot cabinet would still trigger the warning. **[2 marks]**

3(f) A wire accidentally bridges T, giving a zero-resistance path around it. Calculate the fixed-resistor voltage and decide whether a warning now proves that the cabinet is hot. **[2 marks]**

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4 Detecting an open lid

Figure 2 has a fixed $2000\ \Omega$ resistor in series with an LDR. Unlike Figure 1, its voltmeter measures across the sensor itself. The lid alarm activates when this LDR voltage is $2.5\ \text{V}$ or less. Table 2 gives LDR readings; assume constant temperature.

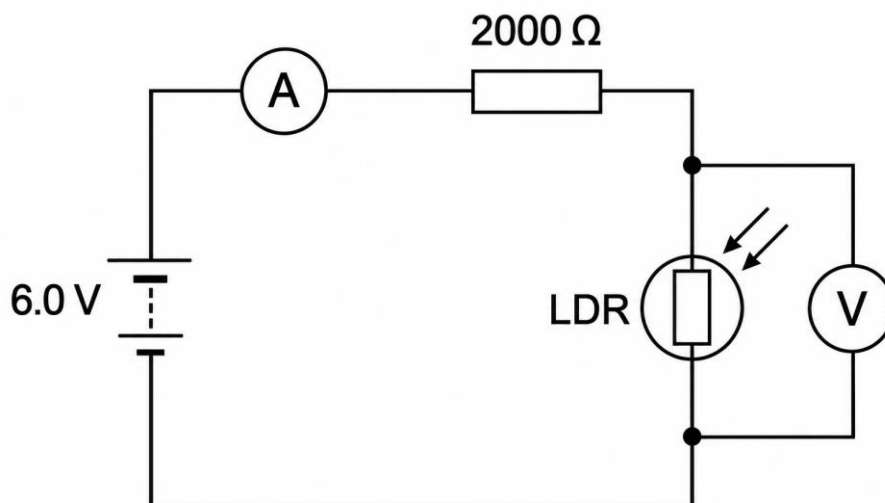


Figure 2

Table 2

Cabinet condition	Light at LDR	LDR resistance / Ω
Lid closed	Dark	6000
Lid partly open	Shaded	2000
Lid fully open	Bright	1000

- 4(a) The lid is fully open in bright light. Calculate the main circuit's total resistance. [1 mark]
- 4(b) Calculate the ammeter reading with the lid fully open in bright light. Give your answer in mA. [2 marks]
- 4(c) Calculate the voltage across the LDR with the lid fully open in bright light. [1 mark]
- 4(d) Does the alarm activate with the lid fully open in bright light? Justify your answer using the voltage. [1 mark]
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4 Detecting an open lid continued

4(e) The lid is closed and the LDR is dark. Calculate the current in the main circuit in amperes. [2 marks]

4(f) Calculate the voltage across the dark LDR. [1 mark]

5 Checking the alarm design

Use the Figure 2 circuit and Table 2. The alarm activates at an LDR voltage of 2.5 V or less. Keep the fixed resistor at $2000\ \Omega$ except where a change is explicitly stated.

5(a) The lid is partly open but the sensor is shaded. Calculate the LDR voltage and decide whether the alarm activates. Show your steps. [3 marks]

5(b) Compare the closed-dark and open-bright results. Explain how the LDR voltage can decrease even though the current increases. Refer to both components. [3 marks]

5(c) Dust covers the LDR, so it remains dark when the lid opens. Explain why the absence of an alarm is not reliable evidence that the lid is closed. [2 marks]



5 Checking the alarm design continued

5(d) The fixed resistor in Figure 2 is replaced by a $1000\ \Omega$ resistor. In bright light the LDR is still $1000\ \Omega$. Calculate the LDR voltage and decide whether this change improves detection of the open lid. **[3 marks]**

6 An alternative board: parallel branches

A technician rewires the temperature board. T is connected directly across the $6.0\ \text{V}$ supply in one branch. The fixed $1000\ \Omega$ resistor is connected directly across the same supply in a separate parallel branch. This is NOT the Figure 1 series circuit. The supply stays at $6.0\ \text{V}$.

6(a) Calculate the current through the fixed $1000\ \Omega$ resistor on this parallel board. **[1 mark]**

6(b) T is at $10\ ^\circ\text{C}$ on the parallel board. Calculate its branch current and the total current from the supply. Give both in mA. **[2 marks]**

6(c) T warms to $40\ ^\circ\text{C}$ on the parallel board. Calculate the new total supply current. Explain why the fixed-resistor current stays unchanged, unlike in Figure 1. **[3 marks]**

Review: check that each voltage explanation names the component being measured, not just “the voltage”.

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