

Paper 1: explanations and practical methods

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

20 parts / 42 marks per route | Both tiers | Timing estimated/untrialled

Specification points covered

8463 4.1.1.3 / 8464 6.1.1.3: specific heat capacity and a valid heating investigation
8463 4.1.3 / 8464 6.1.3: renewable resources, reliability and environmental comparisons
8463 4.2.1.3–4.2.1.4 / 8464 6.2.1.3–6.2.1.4: resistance, meters and component behaviour
8463 4.3.1.1 / 8464 6.3.1.1: density and displacement measurements
8463 4.4.2.1, 4.4.2.4 / 8464 6.4.2.1, 6.4.2.4: radiation properties; irradiation versus contamination

A food-inspection laboratory audits a heated processing line, its electrical sensors and radiation-monitoring records. Use the evidence to repair weak scientific explanations and design valid tests.

Original PhysicsUK practice, not official AQA. Complete Sections 1–6 plus ONE final alternative: 20 parts/42 marks. Both qualifications and tiers. Selected practical skills only, not full RP completion. Radiation case is a supplied record, not a pupil source-handling experiment.

1 Case A: heating the processing line

The laboratory tests two heater inserts of equal mass. Each receives the same increase in thermal energy. Neither changes state.

1(a) State what is meant by the specific heat capacity of the insert material. **[1 mark]**

Answer / mark points: The energy required to raise the temperature of 1 kg of the substance by 1 °C. [1] Both the mass and temperature interval are essential.

1(b) Insert A has a lower specific heat capacity than insert B. Explain why A has the larger temperature rise in this test. **[2 marks]**

Answer / mark points: A needs less energy per kilogram for each 1 °C rise. [1] The same energy shared by the same mass therefore produces a greater temperature rise. [1] Do not confuse temperature rise with total energy transferred.

1(c) A 0.80 kg insert warms from 20 °C to 35 °C when it receives 6000 J of thermal energy. Calculate its specific heat capacity. **[2 marks]**

Answer / mark points: $\Delta\theta = 35 - 20 = 15\text{ °C}$. [1] $c = 6000 / (0.80 \times 15) = 500\text{ J kg}^{-1}\text{ °C}^{-1}$. [1] The temperature change is not 35 °C.

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1 Case A: heating the processing line continued

1(d) A different test uses the total electrical energy input to calculate specific heat capacity, but some energy heats the surroundings. Explain why this makes the calculated value too high. **[2 marks]**

Answer / mark points: The electrical energy input is greater than the energy that increases the block's thermal store. [1] Using that larger input with the measured mass and temperature rise makes $c = E/(m\Delta\theta)$ too large. [1] Insulation reduces this bias; repeating alone does not remove it.

2 Case A: an energy-supply decision

The line must operate after sunset. Table 1 is the laboratory's simplified evidence for two energy resources; there is no battery storage.

Table 1

Resource	Availability	Carbon dioxide during operation
Solar electricity	Varies with sunlight; zero after sunset	No fuel burning in generation
Natural gas heating	On demand while fuel is supplied	Carbon dioxide released when burned

2(a) Identify the renewable resource in Table 1 and state what renewable means. **[1 mark]**

Answer / mark points: Solar/the Sun: it is replenished as it is used. [1 for identification and meaning] "It lasts longer" alone is insufficient.

2(b) Compare the two resources for the laboratory's evening operation and its aim to reduce carbon dioxide emissions. Use the evidence to recommend a supply arrangement. **[3 marks]**

Answer / mark points: Solar alone cannot run the line after sunset without storage. [1] Gas can supply it on demand, but burning it releases carbon dioxide whereas solar generates without burning fuel. [1] A justified arrangement is solar when available with gas/another dispatchable supply for evening demand, reducing gas use but not eliminating emissions. [1] Accept a valid alternative consistent with the stated no-storage case.

2(c) A manager claims: "Renewable means reliable at every time, so solar alone will always power the line." Evaluate the claim. **[2 marks]**

Answer / mark points: Renewable concerns replenishment, not whether output matches demand at every time. [1] Solar output depends on sunlight and is zero after sunset, so this no-storage arrangement cannot guarantee the required supply. [1] Do not credit a bare "unreliable" without the case link.



3 Case A: identifying a loose insert

An irregular, non-porous insert sinks in water and does not react with it. Its mass is 156 g. Water in a measuring cylinder rises from 40 cm³ to 60 cm³ when it is fully submerged.

3(a) Calculate the insert's density in g cm⁻³. The replacement specification accepts densities from 7.5 to 8.0 g cm⁻³ inclusive. Decide whether this result meets it. **[2 marks]**

Answer / mark points: Volume = 60 – 40 = 20 cm³; density = 156/20 = 7.8 g cm⁻³. [1 for correct density using displaced volume] It meets the density criterion because 7.8 lies within 7.5–8.0. [1] Density alone does not certify every property of the part.

3(b) Describe how to obtain the mass and displaced volume for another irregular insert. Include a reading precaution and explain how to avoid counting air as part of its volume. **[3 marks]**

Answer / mark points: Zero/tare a balance and measure the dry insert's mass. [1] Record the initial cylinder reading and the reading with the insert fully submerged; subtract initial from final. [1] Read the bottom of the meniscus at eye level and ensure no trapped air bubbles on the insert. [1 for both precautions] Accept a valid displacement-can method collecting all displaced water with equivalent volume-reading care.

3(c) A bubble remains attached to the submerged insert. Explain how this affects the measured volume and calculated density. **[2 marks]**

Answer / mark points: The bubble also displaces water, so the measured volume is too large. [1] The measured mass is unchanged, so dividing it by this larger volume makes the calculated density too small. [1] Do not say the actual material density has changed.



4 Case B: testing the indicator circuit

Figure 1 shows a low-voltage test circuit for a filament lamp. P and Q are meter positions. Table 2 gives steady readings from two separate component tests. The fixed resistor is kept at constant temperature.

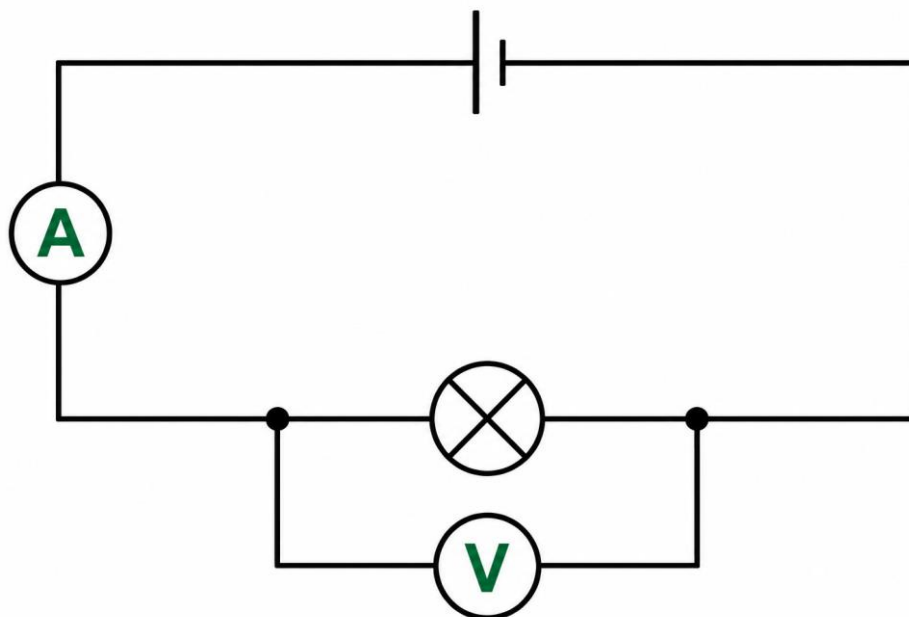


Figure 1

4(a) Name the meters required at P and Q, and state why each connection is suitable. [2 marks]

Answer / mark points: P is an ammeter in series, so it measures current through the lamp. [1] Q is a voltmeter connected in parallel across the lamp, so it measures the potential difference across it. [1] Name and linked connection/function required for each mark.

Table 2

Component	Potential difference / V	Current / A
Fixed resistor	2.0	0.20
Fixed resistor	4.0	0.40
Filament lamp	2.0	0.25
Filament lamp	4.0	0.40

4(b) Use both readings in Table 2 to compare how the resistance of the fixed resistor and the lamp changes. Support your comparison with calculated values. [2 marks]

Answer / mark points: Fixed resistor: $2.0/0.20 = 10\ \Omega$ and $4.0/0.40 = 10\ \Omega$, unchanged. [1] Lamp: $2.0/0.25 = 8.0\ \Omega$ and $4.0/0.40 = 10\ \Omega$, increased. [1] Use operating-point V/I , not a graph tangent.

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4 Case B: testing the indicator circuit continued

4(c) The trainee writes: "The lamp current doubles when the potential difference doubles." Correct this statement using Table 2 and explain the lamp's behaviour. **[2 marks]**

Answer / mark points: Current rises from 0.25 A to 0.40 A, not to 0.50 A; it increases by less than a factor of two. [1] The filament becomes hotter, increasing its resistance and limiting the increase in current. [1] Both temperature and resistance must be linked.

4(d) In a separate sensor-wire test, the technician changes the length of one wire. Explain why using a low current and disconnecting between readings makes the length comparison more valid. **[2 marks]**

Answer / mark points: These steps limit heating/allow the wire to cool, helping keep its temperature constant. [1] Resistance depends on temperature as well as length, so the changes can then be attributed to length rather than a temperature change. [1] Same wire also keeps material and diameter unchanged.

5 Case C: checking the irradiation record

A sealed source exposes packaged food to gamma radiation in a controlled industrial facility. No radioactive material is transferred to the food. These are supplied records, not instructions to carry out a radiation experiment.

5(a) A trainee says the food must be radioactively contaminated because it was irradiated. Explain why this conclusion is wrong in the stated case. **[2 marks]**

Answer / mark points: Irradiation is exposure to nuclear radiation. [1] Contamination requires unwanted radioactive material on or in the food; none was transferred, so irradiation does not make it radioactive in this case. [1] Radiation passing through is not the same as radioactive atoms being deposited.

5(b) The radiation must reach food inside thick packaging. Explain why gamma is more suitable than alpha radiation for this requirement. **[2 marks]**

Answer / mark points: Gamma is much more penetrating and can pass through the packaging. [1] Alpha is stopped by thin material/the outer packaging and would not reach the food inside. [1] This is a penetration comparison, not an assertion that gamma is always more hazardous.

5(c) In another incident, radioactive powder actually lands on an item. Explain why moving the item away from the external source does not remove this hazard. **[2 marks]**

Answer / mark points: Radioactive atoms remain on/in the item: it is contaminated. [1] Those atoms continue to decay and emit ionising radiation after the external source is removed. [1] Time, distance or turning off a detector does not remove the contaminating material.

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6 Checking the quality of the writing

Use the laboratory cases to distinguish a practical method from an explanation and an evaluation.

6(a) A draft method says only: “The lamp gets hotter, so its resistance increases.” State what is missing if this is meant to describe how to collect I–V data. **[1 mark]**

Answer / mark points: Practical measurement steps: e.g. vary the supply potential difference and record paired potential-difference and current readings with correctly connected meters. [1] A causal explanation alone is not a usable method.

6(b) A draft evaluation says: “Repeating an uninsulated heating test removes its heat-loss error.” Correct this claim. **[1 mark]**

Answer / mark points: Repeating/averaging can reduce random variation but does not remove the systematic bias caused by energy heating the surroundings. [1] The heat-loss mechanism remains unless the method is improved.

7 Independent extended response: choose ONE

Your teacher assigns either 7(a) OR 7(b). Both are 6 marks and suitable for both tiers. Complete only the assigned alternative. Write a connected method, not just an apparatus list.

7(a) Alternative A — heating audit. Determine the specific heat capacity of a replacement solid block. You have the block (with heater and thermometer holes), balance, low-voltage heater and supply, joulemeter, thermometer, insulation and leads. Describe a method, including how to improve the measurement. Use $\Delta E = mc\Delta\theta$. Answer this OR 7(b), not both. **[6 marks]**

Answer / mark points: Original PhysicsUK best-fit rubric, not an official AQA mark scheme. Level 3 (5–6): a logically ordered, workable method obtains mass, electrical energy and temperature change, derives c correctly and includes a justified way to reduce energy-loss/measurement error. Award 6 for a clear complete method; 5 for a minor omission. Level 2 (3–4): most relevant measurements identified with some sequence/calculation, but an important link is missing or validity not secure. Level 1 (1–2): isolated relevant equipment or steps, insufficient for a valid result. 0: no relevant physics. Judge overall quality; no automatic six-keyword tally.
Example: measure the dry block’s mass on a zeroed balance. Insert the heater and thermometer with good thermal contact and insulate the block. Let the thermometer settle and record the initial temperature. Record the starting joulemeter reading, switch on the low-voltage heater, and record the energy supplied and final temperature over the same heating interval. Find the differences in energy and temperature, then calculate $c = \Delta E / (m\Delta\theta)$ with mass in kg and temperature change in °C. Insulation reduces energy transferred to the surroundings, making electrical input closer to the block’s thermal-energy increase. Repeat under comparable initial conditions and compare/average c values; do not claim this removes remaining heat loss. Follow school hot-block/electrical safety instructions. Accept valid equivalent energy measurement (e.g. measured VIt), and thermal-contact precautions; do not require every listed detail for the highest level.

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7 Independent extended response: choose ONE continued

Alternative B only. If you completed 7(a), do not answer this page.

7(b) Alternative B — indicator audit. The laboratory needs a full I–V characteristic for a replacement filament lamp, including both current directions. Available equipment includes the lamp, low-voltage variable supply, ammeter, voltmeter and leads. Describe a method to collect and present valid data, including suitable checks. Answer this OR 7(a), not both. **[6 marks]**

Answer / mark points: Original PhysicsUK best-fit rubric, not an official AQA mark scheme. Level 3 (5–6): a workable ordered method places meters correctly, obtains paired readings over a suitable range in both directions, and explains presentation and a meaningful validity/reliability check. Award 6 for a clear complete method; 5 for a minor omission. Level 2 (3–4): most key steps present but range/direction, connections or validation incomplete enough to weaken the outcome. Level 1 (1–2): isolated relevant steps that cannot produce a valid characteristic. 0: no relevant physics. Judge the whole response, not six keyword ticks.

Example: connect the ammeter in series with the lamp and the voltmeter in parallel across it. Start at low potential difference, increase it in steps within the lamp's rating and record paired V and I readings when steady. Reduce the supply to zero, switch off and reverse its connections, then repeat for the other direction, recording negative V and I relative to the original direction. Repeat selected settings and compare/average consistent readings, investigating rather than simply deleting anomalous results. Plot I vertically against V horizontally, label units and draw a smooth curve through the trend. Stay within ratings and avoid touching the hot lamp. Allow the filament to reach a steady temperature at each setting; do not try to keep its temperature fixed across the entire I–V test, because temperature change is part of the behaviour being investigated. Accept a variable-resistor method that safely varies lamp V.

Review and improve

Review the chosen final task only. Model links from cause to quantity to outcome. A method needs measurable steps; an explanation needs causal links; an evaluation needs evidence and a justified judgement. Reward equivalent valid methods, not a list of six magic words.

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