

Mixed physics exam skills diagnostic

AQA GCSE Combined Science Trilogy 8464 and Separate Physics 8463 | Both tiers | Papers 1 and 2

29 parts / 46 marks | Both tiers | Timing estimated/untrialled

Specification points covered

8463 4.1.1.2, 4.1.1.3 / 8464 6.1.1.2, 6.1.1.3: kinetic, gravitational and thermal energy

8463 4.2.1.3, 4.3.1.1 / 8464 6.2.1.3, 6.3.1.1: current, resistance and density

8463 4.4.2.1, 4.5.6.1.5 / 8464 6.4.2.1, 6.5.4.1.5: nuclear radiation and acceleration

8463 4.5.6.2.2, 4.6.1.2 / 8464 6.5.4.2.2, 6.6.1.2: resultant force and wave properties

A temporary field-science station is preparing to open. Check its sample heater, electrical indicators, material records, radiation demonstration, transport cart and ripple display. Each test is independent unless a question refers back to it.

Original PhysicsUK diagnostic, not official AQA. All parts are shared both-tier content. Allow valid alternatives and consistent follow-through; do not award the same step twice. Use mistakes to select follow-up work, not to predict grades. No required-practical completion claim.

1 Checking heat and energy

The heater warms small solid samples without changing their state. Use $g = 10 \text{ N kg}^{-1}$ for the lifting test. The cart energy test here is separate from its later graph test.

1(a) Define specific heat capacity. (E) **[1 mark]**

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

1(b) A 0.25 kg reference sample receives 6000 J and warms from 20 °C to 40 °C. Assume all this energy heats the sample. Calculate its specific heat capacity. (C) **[2 marks]**

Answer / mark points: $\Delta\theta = 40 - 20 = 20 \text{ °C}$ and $c = \Delta E / (m\Delta\theta) = 6000 / (0.25 \times 20)$. [1 for correct setup using the change] $c = 1200 \text{ J kg}^{-1} \text{ °C}^{-1}$. [1] Do not use 40 °C as the temperature rise.

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1 Checking heat and energy continued

1(c) The opening test warms a 0.40 kg sample from 22 °C to 52 °C. Its specific heat capacity is 900 J kg⁻¹ °C⁻¹. Calculate the energy transferred to the sample. (C) **[2 marks]**

Answer / mark points: $\Delta\theta = 52 - 22 = 30$ °C. [1] $\Delta E = mc\Delta\theta = 0.40 \times 900 \times 30 = 10\,800$ J (10.8 kJ). [1] This is the sample's energy increase.

1(d) In a different, uninsulated test some heater energy warms the surroundings. A trainee uses all the measured heater energy in $c = \Delta E / (m\Delta\theta)$. Explain how this affects the calculated c. (E) **[2 marks]**

Answer / mark points: The energy used in the calculation exceeds the energy transferred to the sample. [1] With the measured m and $\Delta\theta$ unchanged, this makes the calculated c too large. [1] Say what is overestimated and why, not just "energy is lost".

1(e) A hoist raises a 12 kg instrument through a vertical height of 3.0 m. Calculate its gain in gravitational potential energy. (C) **[1 mark]**

Answer / mark points: $\Delta E_p = mgh = 12 \times 10 \times 3.0 = 360$ J. [1] Use vertical height gained, not the length of an inclined route.

1(f) In the opening energy test, the 80 kg loaded cart travels at 3.0 m s⁻¹. Calculate its kinetic energy. (C) **[1 mark]**

Answer / mark points: $E_k = 0.5mv^2 = 0.5 \times 80 \times 3.0^2 = 360$ J. [1] Square the speed only, not the mass.

1(g) The loaded cart's speed doubles with no change of mass. State the factor by which its kinetic energy changes and explain why. (E) **[2 marks]**

Answer / mark points: Its kinetic energy becomes four times as large. [1] At constant mass E_k is proportional to v^2 , and $2^2 = 4$. [1] It does not merely double.

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2 Checking the electrical indicators

Each resistor is tested separately with 12 V across it. Treat its resistance as constant during each test. A maximum-current criterion is used later to select an indicator.

2(a) A test resistor carries 0.30 A. Calculate its resistance. (C) **[1 mark]**

Answer / mark points: $R = V / I = 12 / 0.30 = 40 \, \Omega$. [1] Use the potential difference across this resistor.

2(b) The candidate indicator uses a 200 Ω resistor. Calculate its current in amperes. (C) **[1 mark]**

Answer / mark points: $I = V / R = 12 / 200 = 0.060 \, \text{A}$ (60 mA). [1] This is the candidate used in the final decision.

2(c) Another resistor carries 60 mA at 12 V. A trainee records $R = 12 / 60 = 0.20 \, \Omega$. Correct the calculation, showing the current in amperes. (C/U) **[2 marks]**

Answer / mark points: 60 mA = 0.060 A. [1] $R = 12 / 0.060 = 200 \, \Omega$. [1] The trainee's arithmetic used milliamperes as if they were amperes.

2(d) The indicator resistor is replaced by one with twice the resistance. The potential difference stays at 12 V. State what happens to the current. (E) **[1 mark]**

Answer / mark points: The current halves. [1] $I = V / R$ at constant V. Do not claim that the supply automatically doubles the potential difference.

3 Checking the material records

All samples are non-porous. In the displacement test the sample is completely submerged and does not dissolve. The measuring cylinder is large enough to hold it.

3(a) A reference block has mass 270 g and volume 100 cm³. Calculate its density in g cm⁻³. (C) **[1 mark]**

Answer / mark points: $\rho = m / V = 270 / 100 = 2.7 \, \text{g cm}^{-3}$. [1] Do not mix grams with a final kg m⁻³ label.

3(b) An irregular sample has mass 156 g. The cylinder reading changes from 48 cm³ to 68 cm³ when the sample is submerged. Calculate its density in g cm⁻³. (C) **[2 marks]**

Answer / mark points: Sample volume = 68 – 48 = 20 cm³. [1] $\rho = 156 / 20 = 7.8 \, \text{g cm}^{-3}$. [1] The 68 cm³ reading includes the original water.



3 Checking the material records continued

3(c) A large air bubble is trapped against an irregular sample during a repeat displacement test. Explain how this affects the density calculated from the measured mass and displacement. (E) **[2 marks]**

Answer / mark points: The bubble adds to the displaced volume, so the recorded sample volume is too large. [1] The measured sample mass is unchanged, so m/V and the calculated density are too small. [1] "A bubble causes error" is not enough.

3(d) A block can be logged as material A only if its density is between 2.6 and 2.8 g cm^{-3} , inclusive. Does the reference block in 3(a) meet this criterion? Justify your answer. (D) **[1 mark]**

Answer / mark points: Yes: 2.7 g cm^{-3} is within $2.6\text{--}2.8 \text{ g cm}^{-3}$. [1 for decision with value/range]
This meets the supplied criterion; density alone need not uniquely identify a real material.

4 Checking radiation demonstration records

Use supplied records only; pupils do not handle radioactive sources. The equipment detects the radiation types under discussion. The supplied background count rate is the detector reading with the source removed.

4(a) Which type of nuclear radiation is an electromagnetic wave emitted from the nucleus? (E) **[1 mark]**

Answer / mark points: Gamma radiation. [1] Alpha and beta radiation are particles.

4(b) A demonstration source emits just one of alpha, beta or gamma radiation. At a short source–detector gap it is detected, but a thin paper sheet reduces the repeated mean reading to background. Identify the radiation and explain the paper result. (E) **[2 marks]**

Answer / mark points: Alpha radiation. [1] Alpha particles are absorbed/stopped by thin paper, so no source contribution is detected through it under these conditions. [1] Background-only detection does not mean the source stopped decaying.

4(c) In a different fixed setup the detector records 360 counts in 60 s with the source present. The supplied background count rate is $2.0 \text{ counts s}^{-1}$. Calculate the net count rate due to the source. (C/U) **[2 marks]**

Answer / mark points: Total count rate = $360 / 60 = 6.0 \text{ counts s}^{-1}$. [1] Net source count rate = $6.0 - 2.0 = 4.0 \text{ counts s}^{-1}$. [1] Accept subtracting 120 background counts first, then $240 / 60$. Do not subtract 2 counts from 360 counts.

4(d) A trainee sets the source activity in becquerels equal to the net count rate found in 4(c). Explain why the detector reading alone does not justify this. (E) **[2 marks]**

Answer / mark points: The detector does not necessarily detect all emissions/decays; some radiation misses it or is absorbed. [1] Activity is the total decay rate of the source, so a $4.0 \text{ counts s}^{-1}$ detected rate alone is insufficient to assign 4.0 Bq . [1] Do not claim a source's activity depends on detector distance.



5 Checking the transport cart graph

Figure 1 records one straight-line test of an 80 kg loaded cart. Positive velocity is towards the sample store. All values refer to this test, not the 3.0 m s⁻¹ energy test in Section 1.

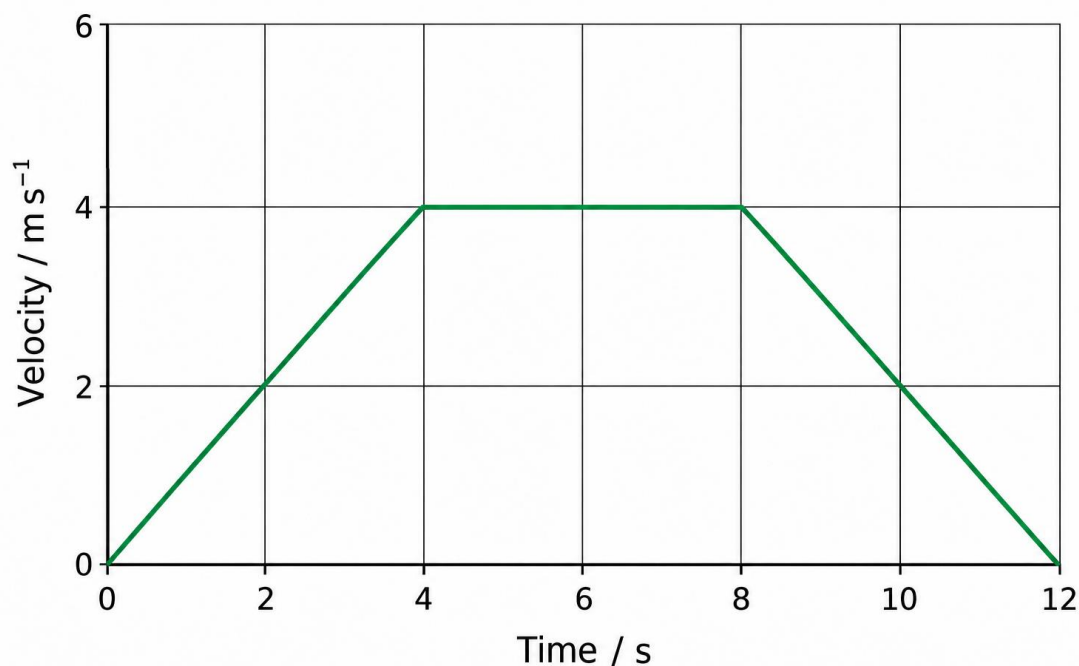


Figure 1

5(a) State the maximum speed reached in Figure 1. (G) [1 mark]

Answer / mark points: 4.0 m s⁻¹. [1] The vertical axis is velocity; it is non-negative throughout this straight-line test.

5(b) Determine the cart's speed at 2.0 s. (G) [1 mark]

Answer / mark points: 2.0 m s⁻¹. [1] Read the sloping data line, not the plateau or the nearest time label.

5(c) Calculate the acceleration from 0 s to 4.0 s. (G/C) [2 marks]

Answer / mark points: $a = \Delta v / \Delta t = (4.0 - 0) / (4.0 - 0)$. [1] $a = +1.0 \text{ m s}^{-2}$. [1] Gradient uses a change in velocity and elapsed time.

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5 Checking the transport cart graph continued

5(d) Describe how velocity changes between 8.0 s and 12 s. Include whether the change is linear. (G/E) [2 marks]

Answer / mark points: Velocity decreases. [1] It decreases linearly/at a constant rate (to zero). [1] The cart decelerates uniformly. Do not write “the velocity is decelerating”: the quantity decreases; the cart decelerates.

5(e) Calculate the acceleration between 8.0 s and 12 s. Include its sign. (G/C) [2 marks]

Answer / mark points: $a = (0 - 4.0) / (12 - 8.0)$. [1] $a = -1.0 \text{ m s}^{-2}$. [1] A deceleration magnitude of 1.0 m s^{-2} alone omits the requested signed acceleration. Negative acceleration here reduces the positive velocity.

5(f) Using the acceleration from 5(c), calculate the resultant horizontal force on the loaded cart from 0 s to 4.0 s. (C) [1 mark]

Answer / mark points: $F = ma = 80 \times 1.0 = 80 \text{ N}$ towards the sample store. [1] Accept consistent follow-through from 5(c). This is resultant force, not an unspecified motor pulling force.

6 Checking the ripple display

A shallow-water wave display helps explain how signals transfer energy. A video records 18 complete oscillations at one fixed point in 6.0 s of real time. The wavelength is 4.0 cm.

6(a) Calculate the actual frequency of the ripple display. (C) [1 mark]

Answer / mark points: $f = 18 / 6.0 = 3.0 \text{ Hz}$. [1] Use the recording's real elapsed time, not slow-playback viewing time.

6(b) Calculate the wave speed in m s^{-1} . (C/U) [2 marks]

Answer / mark points: $\lambda = 4.0 \text{ cm} = 0.040 \text{ m}$. [1] $v = f\lambda = 3.0 \times 0.040 = 0.12 \text{ m s}^{-1}$. [1] Allow consistent follow-through for f .

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6 Checking the ripple display continued

6(c) A calibrated still image shows seven consecutive crests spanning 24 cm from the first to the last. A trainee divides 24 by 7 to check the wavelength. Explain the error and give the correct wavelength. (C/E) **[2 marks]**

Answer / mark points: Seven crests span six complete wavelength gaps, not seven. [1] $\lambda = 24 / 6 = 4.0$ cm (0.040 m). [1] Count the intervals between matching points.

7 Deciding whether the checks pass

Table 1 gives three simplified commissioning criteria for this training exercise. All three must be satisfied. These are not real safety standards or a complete safety assessment.

Table 1

Check	Required result	Use result from
Heated sample	Energy no greater than 12 kJ	1(c)
Indicator resistor	Current no greater than 70 mA	2(b)
Cart energy test	Kinetic energy no greater than 300 J	1(f)

7(a) Should the station open under the three criteria in Table 1? Justify your decision using your calculated result for each check. If you could not find an earlier result, state the comparison you would need. (D/U) **[3 marks]**

Answer / mark points: Do not open under these criteria. Heater: 10.8 kJ is at most 12 kJ, so it passes. [1] Indicator: 0.060 A = 60 mA is at most 70 mA, so it passes. [1] Cart: 360 J exceeds 300 J, so it fails and prevents opening until changed and rechecked. [1] The overall judgement is embedded in the cart comparison, not an extra mark. Accept physically consistent follow-through; a comparison described without a result cannot earn that numerical-evidence mark. These checks do not certify real safety.

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8 Choosing your next step

After marking, use the errors in your work, not just the total. Find the named PhysicsUK worksheets below; the numbers identify them in your teacher's set. Choose only one or two follow-ups, using the same qualification and correct tier route.

Table 2

If you missed	What to practise	Follow-up worksheet
1(a)–1(d)	Temperature change, energy input and c	1 Specific Heat Capacity Required Practical
1(e)–1(g)	Energy equations and squared speed	6 Paper 1 Multi Step Calculation Practice
2(a)–2(d)	$V = IR$, rearranging and mA to A	27 I V Graphs Resistance and Component Choice
3(a)–3(d)	Density, displacement and error direction	6 Paper 1 Multi Step Calculation Practice; 10 Practical Graphs Errors and Evidence
4(a)–4(d)	Radiation properties and detector evidence	15 Alpha Beta Gamma Penetration and Shielding
5(a)–5(e)	Read axes, use changes and explain gradients	30 Motion Graphs 2 Comparing Journeys — common parts and your teacher's tier route
5(f)	Resultant force, mass and acceleration	9 Force Mass and Acceleration Required Practical
6(a)–6(c)	Frequency, wavelength gaps and cm to m	13 Wave Speed Required Practical
7(a)	Match units and justify every comparison	6 Paper 1 Multi Step Calculation Practice; revisit 7(a) after corrections

If the topic is correct but your explanation is vague, try 38 Paper 1 Six Mark Explanations and Practical Methods or 39 Paper 2 Six Mark Explanations and Practical Methods. Follow the teacher-assigned alternative, not both final tasks.

Check the skill codes too. U: write conversions before substituting. C: choose a model, substitute and check units. G: read both axes and use differences. E: link a cause to an outcome. D: compare every result with its criterion.

Review and improve

Use the map to select one or two targeted follow-ups. Treat a unit conversion, wrong model, graph misreading and unsupported explanation as different needs. Recheck two questions after practice. Do not convert this small selected-content score into a predicted GCSE grade.

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