AQA GCSE Physics 8463 | Energy changes in systems solutions

Matching solutions and teaching prompts for the class review

Specification points covered

- 4.1.1.3 — calculate a thermal energy change using $\Delta E = mc\Delta\theta$ and define specific heat capacity.
- Required practical activity 1 — determine the specific heat capacity of one or more materials.
- 4.1.1.3 — link energy transferred by work to an increase in a thermal energy store.

Use these solutions for the 15-20 minute review: reveal enough working for pupils to diagnose errors, then model the clearest route to a full-mark answer.

1. Specific heat capacity
(a) State what is meant by the specific heat capacity of a substance. [2]
(b) Give its SI unit. [1]

Answer / mark points: (a) The energy required to raise the temperature of 1 kg of the substance by 1 °C (or 1 K). Award one mark for energy per unit mass and one for a 1 °C/1 K rise. (b) J kg^{-1} $°C^{-1}$ or J kg^{-1} K^{-1}.

Teacher prompt / common error: Common error: specific heat capacity is a material property, not the total energy stored by an object.

2. A factory heats a 2.5 kg aluminium thermal-store block from 18 °C to 65 °C. The specific heat capacity of aluminium is 900 J kg^{-1} $°C^{-1}$.
(a) Calculate the temperature change. [1]
(b) Calculate the energy transferred to the block. [4]

Answer / mark points: (a) $\Delta\theta = 65 - 18 = 47$ °C. (1) (b) $\Delta E = mc\Delta\theta$ (1); $= 2.5 \times 900 \times 47$ (1); = 105 750 J (1), with joule unit (1). Accept 1.06×10^5 J or 106 kJ with correct conversion.

Teacher prompt / common error: Common error: pupils substitute the final temperature, 65 °C, instead of the change, 47 °C.

3. A student is given a metal block with holes for an electric heater and a thermometer. Describe a method to determine the specific heat capacity of the metal. The heater power is known. [5]

Answer / mark points: Any five linked points: measure the block mass with a balance; insert heater and thermometer firmly (use thermal paste if available); measure initial temperature; wrap the block in insulation and place it on an insulating mat; switch on the heater and measure heating time; record the final temperature; calculate input energy using $E = Pt$; calculate $\Delta\theta$; calculate $c = E/(m\Delta\theta)$. Credit a safe, workable sequence. Do not credit measuring voltage/current unless the pupil explains how power is obtained.

Teacher prompt / common error: Probe whether pupils have measured every quantity in $c = E/(m\Delta\theta)$, rather than merely naming apparatus.

4. A 1.20 kg test block is heated by a 48 W heater for 300 s. Four measurements of its temperature change are shown in the table.
(a) Identify the anomalous result and suggest one plausible measurement problem. [2]
(b) Calculate the mean temperature change using only the valid results. [2]
(c) Calculate the electrical energy supplied by the heater. [2]

Trial	Temperature change / °C
1	14.8
2	15.1
3	4.2
4	15.0

Answer / mark points: (a) Trial 3, 4.2 °C (1); plausible reason such as poor heater contact, thermometer not inserted properly, heater switched off early or timing/recording error (1). (b) Mean = (14.8 + 15.1 + 15.0)/3 = 14.97 °C, accept 15.0 °C (2). (c) E = Pt = 48 × 300 = 14 400 J (2).

Teacher prompt / common error: Common error: including the 4.2 °C result in the mean even after identifying it as anomalous.

5. Use the valid data from Question 4 to calculate the specific heat capacity of the test block. Give your answer to three significant figures. [3]

Answer / mark points: c = 14 400/(1.20 × 14.97) (1) = 801.6 J kg^{-1} $°C^{-1}$ (1), so 802 J kg^{-1} $°C^{-1}$ to three significant figures (1). If 15.0 °C is used, accept 800 J kg^{-1} $°C^{-1}$. Allow ECF from Question 4.

Teacher prompt / common error: Ask pupils to check that a larger mass or larger temperature rise appears in the denominator after rearrangement.

6. The manufacturer states that the block has a specific heat capacity of 900 J kg^{-1} $°C^{-1}$, higher than the student's result. Suggest one measurement problem that could make the calculated value too low. Explain the direction of the effect. [3]

Answer / mark points: Example full answer: the thermometer is too close to the heater, so it records a temperature rise greater than the average rise of the whole block (1). Δθ is therefore overestimated (1). Since c = E/(mΔθ), the denominator is too large and calculated c is too low (1). Also accept an overestimated mass with the same correct direction. Do not accept heat loss alone: counting lost energy as block input normally makes calculated c too high.

Teacher prompt / common error: Diagnostic: heat loss does not explain a low c result in this calculation; it usually increases the calculated value.

7. A food company compares two 5.0 kg thermal-store blocks. Block A has c = 500 J kg^{-1} $°C^{-1}$ and block B has c = 1000 J kg^{-1} $°C^{-1}$. Each block receives 100 kJ.
(a) Calculate the temperature rise of each block. [4]
(b) The company wants the block whose temperature changes least while absorbing energy. Choose a block and justify your answer. [2]

Answer / mark points: 100 kJ = 100 000 J (1 across the calculation). (a) ΔθA = 100 000/(5.0 × 500) = 40 °C (2); ΔθB = 100 000/(5.0 × 1000) = 20 °C (2). Award each result with valid substitution. (b) Choose block B (1) because its larger specific heat capacity gives the smaller temperature rise for the same mass and energy input (1).

Teacher prompt / common error: Common error: saying the higher-c block becomes hotter. Higher c means more energy is needed for each degree of temperature rise.

8. A sealed mixer does 36 kJ of work on 2.0 kg of oil. The oil has c = 1800 J kg^{-1} $°C^{-1}$ and no energy leaves the system.
(a) Calculate the temperature rise of the oil. [3]
(b) Name the energy-transfer pathway and the store that increases. [1]

Answer / mark points: (a) 36 kJ = 36 000 J; Δθ = E/(mc) = 36 000/(2.0 × 1800) = 10 °C. Award conversion/equation (1), substitution (1), answer with unit (1). (b) Energy is transferred mechanically by work, increasing the oil's thermal energy store (1).

Teacher prompt / common error: Check that pupils do not invent a 'heat store'; the store is thermal and the transfer pathway here is mechanical work.