AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 6.1.1.3

Energy changes in systems

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**6**
Available paper years	**2019–2025**

Using this booklet

1. Booklet answer numbers match the question booklet.
2. Use the original question number within marking tables.
3. Examiner comments are included where available.

Name: _____ **Date:** _____

Where a precise marking extract is unavailable, the full source document is included in an appendix. Any missing mark scheme is explicitly identified.

6.1.1.3 Energy changes in systems

Answer 01 · Mark scheme June 2019 | 8464/P/1H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.	ID
05.1	electrons collide with particles in the heating element which increases the (kinetic) energy of the particles (in the heating element)	allow there is a current in the heating element allow internal store of energy increases allow the particles (in the heating element) vibrate more rapidly	1 1	AO1.1 6.2.4.2 6.3.2.1 WS 1.2	E
05.2	the starting temperature of the water	allow the starting temperature of the kettle	1	AO3.3a 6.2.4.2 WS 2.2	E
05.3	(the heating element of) the kettle took time to heat up		1	AO3.1a 6.2.4.2 WS 3.7	E
05.4	the (rate of) energy transfer (per kg of water) to the surroundings decreases as the mass of water increases **or** the efficiency of the kettle increases as the mass of water increases	allow the (rate of) energy transfer (per kg of water) to the surroundings changes as the mass of water changes allow the efficiency of the kettle changes as the mass of water changes	1	AO3.1b 6.2.4.2 WS 3.7	E

6.1.1.3 Energy changes in systems

Answer 01 · Mark scheme

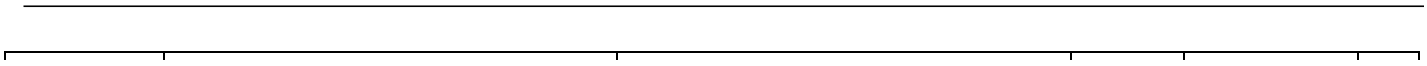
June 2019 | 8464/P/1H | Original Q5

05.5		an answer of 4800 (J/kg °C) scores **6** marks a correct answer given to more than 2 s.f. scores **5** marks		AO2.1 6.3.2.2 6.1.1.3 6.1.1.4 WS 3.3	E
	E = 2600 × 120	allow a correct substitution of an incorrectly/not converted value of P and/or t.	1		
	E = 312 000 (J)	this answer only the equation E=Pt must have been used to score subsequent marks.	1		
	312 000 = 0.80 × c × (100-18) **or** 312 000 = 0.80 × c × (82)	allow use of their value of E calculated using E =Pt for this and subsequent steps	1		
	$c = \frac{312\,000}{0.80 \times 82}$		1		
	c = 4 756		1		
	c = 4 800 (J/kg °C) (2 s.f.)	this mark can only be scored for a correct rounding of a value of c calculated using correct equations	1		
Total			**11**		

6.1.1.3 Energy changes in systems

Answer 01 · Mark scheme

June 2019 | 8464/P/1H | Original Q5



6.1.1.3 Energy changes in systems

Answer 02 · Mark scheme

November 2020 | 8464/P/1H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	they vibrate about fixed positions.		1	AO1 6.3.1.1
05.2	kinetic energy decreases potential energy decreases		1	AO1 6.3.2.1
05.3	metal: has a high thermal conductivity which increases the rate of energy transfer from the mixture plastic: has a low thermal conductivity which reduces the rate of energy transfer from the surroundings (to the liquid coolant at –20°C)	allow ice cream for mixture ignore references to insulation throughout	1 1 1 1	AO2 6.1.2.1
05.4	a high specific heat capacity so it can absorb a large amount of energy with only a small temperature change		1 1	AO2 6.3.2.2

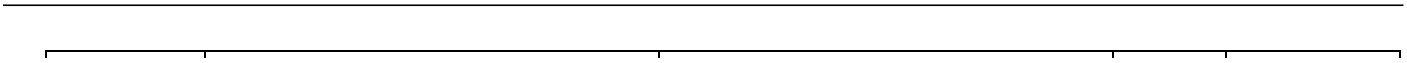
05.5	165 kJ = 165000 J		1	AO2 6.3.2.2
	ΔE = m × 3500 × 21.5 **and** ΔE = m × 255000		1	6.3.2.3 6.1.1.3
	165000 = 75250 m + 255000 m **or** 165000 = 330250 m	this mark may be awarded if E is incorrectly/not converted	1	
	$m = \frac{165000}{75250 + 255000}$ **or** $m = \frac{165000}{330250}$	this mark may be awarded if E is incorrectly/not converted allow an answer consistent with their value of E	1	
	m = 0.499621 (kg)		1	
	m = 0.50 (kg)	this answer only If no marks awarded other than the first marking point: **either** 165 000 = m × 3500 × 21.5 scores **1** mark m = 2.192… scores **1** mark m = 2.2 (kg) scores **1** mark. these marks may be awarded if E is incorrectly/not converted **or** 165 000 = m × 255 000 scores **1** mark m = 0.647 scores **1** mark m = 0.65kg scores **1** mark. these marks may be awarded if E is incorrectly/not converted	1	

Total			**14**

6.1.1.3 Energy changes in systems

Answer 02 · Mark scheme

November 2020 | 8464/P/1H | Original Q5



6.1.1.3 Energy changes in systems

Answer 03 · Mark scheme

June 2022 | 8464/P/1H | Original Q2

Question 2

Question	Answers	Mark	AO / Spec. Ref.
02.1	**Level 3:** The method would lead to the production of a valid outcome. All key steps are identified and logically sequenced.	5–6	AO1 6.1.1.3 6.3.2.2 RPA14
	Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the plan is not fully logically sequenced.	3–4	
	Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.	1–2	
	No relevant content	0	
	Indicative content • measure mass of oil using the top pan balance • measure start temperature of oil using the thermometer • place beaker of oil on heater • switch on heater to heat oil • measure final temperature of oil using the thermometer • measure energy transferred using joulemeter • calculate increase in temperature ($\Delta\theta$) • use the equation $E = mc\Delta\theta$ to determine c		

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.2	burns / scalds	allow cuts from broken glass ignore the heater / oil is hot	1	AO1 6.1.1.3 RPA14

6.1.1.3 Energy changes in systems

Answer 03 · Mark scheme

June 2022 | 8464/P/1H | Original Q2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.3	power = $\frac{\text{energy transferred}}{\text{time}}$ **or** $P = \frac{E}{t}$		1	AO1 6.1.1.4 6.2.4.2 RPA14

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.4	$50 = \frac{4750}{t}$ **or** $4750 = 50 \times t$ $t = \frac{4750}{50}$ t = 95 (s)		1 1 1	AO2 6.1.1.4 6.2.4.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.5	thermistor		1	AO1 6.2.1.4

6.1.1.3 Energy changes in systems

Answer 03 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.6	250 (Ω)	allow an answer in the range 240 (Ω) to 260 (Ω) allow **1** mark for temperature = 160 (°C)	2	AO3 6.2.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.7	the water will recover its original properties if the steam is cooled		1	AO1 6.3.1.2

Total Question 2		**15**

6.1.1.3 Energy changes in systems

Answer 04 · Mark scheme

June 2023 | 8464/P/1H | Original Q6

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	(air) particles move faster **or** (air) particles have increased kinetic energy		1	AO1 6.3.3.1
	(so air) particles collide more frequently with the wall / chamber **or** (so air) particles collide with more force with the wall / chamber		1	
	(so) the pressure increases	dependent on MP1 or MP2	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.2	(metals) have a high(er) thermal conductivity	allow metals are good/better (thermal) conductors	1	AO1 6.1.2.1
	which allows a greater rate of (thermal) energy transfer	allow (thermal) energy is transferred more quickly	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.3	(a low) specific heat capacity		1	AO1 6.1.1.3 6.3.2.2

Answer 04 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.4	any **one** from: • lubrication • use hotter coffee • decrease the temperature of the surroundings	allow oil the device/wheel	1	AO3 6.1.2.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.5	$1.1 \times 10^3 = \frac{\text{mass}}{1.9 \times 10^{-4}}$		1	AO2 6.1.1.3 6.3.2.2 6.3.1.1
	mass = 0.209 (kg)	allow m = $1.9 \times 10^{-4} \times 1.1 \times 10^3$ the equation density = $\frac{\text{mass}}{\text{volume}}$ must have been used to score subsequent marks	1	
	15 000 = 0.209 × 4200 × Δθ	allow a correct substitution using their calculated value of mass	1	
	$\Delta\theta = \frac{15\,000}{0.209 \times 4200}$	allow a correct re-arrangement using their value of mass and/or an incorrectly / not converted energy value	1	
	Δθ = 17(.088…)	allow a correct calculation using their value of mass and / or an incorrectly / not converted energy value	1	
	final temperature (= 76 – 17.088) = 59 (°C)	allow 58.9… (°C) allow an answer consistent with their value of mass and / or an incorrectly / not converted energy value	1	

Total Question 6	13

6.1.1.3 Energy changes in systems

Answer 05 · Mark scheme

June 2024 | 8464/P/1H | Original Q6

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	efficiency = 0.72 × 0.86 efficiency = 0.61(92) 0.62	allow use of percentages if % is seen	 1 1 1	AO2 6.1.2.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.2	(at higher temperatures) the (average) speed of the particles is greater so the frequency of collisions (between particles and the turbine) increases and the force of each collision (between a particle and the turbine) is greater so more energy transferred (each second)	allow the (average) kinetic energy of the particles is greater do **not** accept vibrations dependent on MP2 or MP3 ignore increases the power	1 1 1 1	AO3 6.1.1.1 6.1.1.4 6.3.2.1 6.3.3.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.3	$48 = \frac{\text{mass}}{5.0 \times 10^5}$		1	AO2 6.3.1.1 6.3.2.2 6.1.1.3
	mass = $48 \times 5.0 \times 10^5$		1	
	mass = 24 000 000		1	
		the equation density = $\frac{\text{mass}}{\text{volume}}$ must have been used to score subsequent marks		
	E = 24 000 000 × 1100 × 15	allow a correct substitution using their calculated value for mass	1	
	E = 396 000 000 000	allow an answer consistent with their calculated value for mass	1	
	$E = 3.96 \times 10^{11}$(J)	allow a correctly converted answer consistent with their calculated value for energy using the equation $\Delta E = m\, c\, \Delta\theta$	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.4	(efficient energy storage means) less energy is wasted		1	AO1 6.1.3
	(to reduce carbon dioxide emissions) less fossil fuel used / burned	allow named fossil fuel	1	
	the amount of energy generated from renewable resources will need to increase **or** (most) renewable resources do not generate electricity all the time	allow named renewable resources allow renewable resources are unreliable	1	
	(so) efficient energy storage will help to meet the demand for energy / electricity		1	

Total Question 6	17

6.1.1.3 Energy changes in systems

Answer 06 · Mark scheme June 2025 | 8464/P/1H | Original Q2

Question 2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.1	$13\,800 = 0.75 \times c \times 20$		1	AO2 6.1.1.3 RPA14
	$c = \dfrac{13\,800}{0.75 \times 20}$		1	
	$c = 920$ (J/kg °C)		1	

6.1.1.3 Energy changes in systems

Answer 06 · Mark scheme

June 2025 | 8464/P/1H | Original Q2

Question	Answers	Mark	AO / Spec. Ref.
02.2	**Level 3:** The method would lead to the production of a valid outcome. The key steps are identified and logically sequenced.	5–6	AO1 6.1.1.3 RPA14
	Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced.	3–4	
	Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.	1–2	
	No relevant content	0	
	Indicative content **Mass** • use a top pan balance to measure mass of block **Energy transfer** • use a joulemeter to measure energy • connect heater to a joulemeter • measure initial energy and switch on • switch off and measure final energy • calculate the difference between initial and final energy • use an ammeter, voltmeter and stopwatch • calculate energy transferred **Temperature change** • use a thermometer to measure temperature • measure the initial temperature • measure the final temperature • calculate the difference between initial and final temperature for **Level 3** answers must describe all three measurements		

6.1.1.3 Energy changes in systems

Answer 06 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.3	the amount of wasted energy is less the temperature increase of the aluminium block is greater		1 1	AO3 6.1.1.3 6.1.2.1 RPA14

Total Question 2	11

6.1.1.3 Energy changes in systems

Answer 01 · Examiner comments — June 2019 | 8464/P/1H | Original Q5

Question 5 (High demand)

05.1 Just over 40% of students scored at least 1 mark on this question and just below 5% of students gained both marks. Of those gaining no marks, some stated that the hot water in the kettle increased the temperature of the heating element. Many students wrote about friction in the circuit causing heating, although some of these answers gained one mark by also mentioning that a current was involved.

05.2 Slightly more than 15% of students identified that the starting temperature of the kettle, water, or heating element needed to be controlled. A small proportion of students suggested that the kettle itself was a control variable, but this was not allowed as if this had been changed, the investigation would not then have been about a particular electric kettle.

05.3 Around 1 in 10 students gained this mark for either suggesting that the kettle or element took time to heat up, or for suggesting that the kettle took time to detect that there was no

Answer 01 · Examiner comments — June 2019 | 8464/P/1H | Original Q5

water in the kettle. The data for this question was taken from a real kettle. Many students stated that the kettle took time to switch off when it was empty, which is effectively saying the same as the line does not go through the origin, so and gained no credit. A large number of students stated that it is not possible to put no water in a kettle, and again this scored no marks.

05.4 Only a very small proportion of students gained this mark. Most students did not appear to realise that they had to suggest what caused the curve to be non-linear, and instead described what was meant by a non-linear trend or pointed out that the graph was not directly proportional.

05.5 Just over 60% of students scored 0 marks on this level 8-9 calculation question. However, the students who did manage to access the question generally scored rather well, with more than 25% of all students gaining 5 or 6 marks.

Answer 03 · Examiner comments

June 2022 | 8464/P/1H | Original Q2

Question 02 (Standard demand)

02.1 Almost all students gained some marks on this question, with about half of students accessing level 2 of the mark scheme and gaining 3 or 4 marks. Just over 15% of students gave answers which scored in level 3.

It was clear that a lot of students were not aware of what a top pan balance is, with many thinking that it is a device to help prevent things from falling over, or that the pan of the top pan balance was to be used for heating the oil. As a consequence of this misunderstanding, many students placed the top pan balance on the heater. Of the students who did know what a top pan balance is, a sizeable minority thought that it is used to find the weight of oil, rather than the mass of oil.

While most students realised that the thermometer should be used to measure temperature, some students measured the heat with the thermometer, which was worth no credit.

The joulemeter was often confused with a voltmeter, or students did not appreciate the function of a joulemeter. Common suggestions included setting the joulemeter to 10 and leaving it for a fixed time, for example.

A lot of students did not mention the measuring equipment at all, and simply stated that they would weigh the oil and measure its temperature. Students who did this were unable to access level 3 on the mark scheme, but could gain some credit for these statements.

Some students described the use of a voltmeter, ammeter, and stopclock to determine the energy supplied to the heater. Although a method determining specific heat capacity of oil using this equipment would lead to a valid outcome, this did not use the equipment given in the question, so would not be able to score all 6 marks.

Many students described the wrong experiment, either finding the boiling point of the oil, carrying out a cooling-curve experiment, or describing how to use an immersion heater to find the specific heat capacity of a block of metal. These responses could still gain some credit, for example by correctly stating how to use the thermometer.

02.2 Approximately 60% of students could identify the risk when using the given equipment.

It was clear that many students were unable to distinguish between risks, hazards, and precautions. Some students did not talk about safety at all, instead suggesting that a risk might be inaccurate results, for example.

02.3 As students were given an equation sheet for this exam, almost 100% of students gave the correct equation.

02.4 Nearly 90% of students gained full marks on this question, with just over 5% of students scoring 0 marks.

6.1.1.3 Energy changes in systems

Answer 03 · Examiner comments June 2022 | 8464/P/1H | Original Q2

02.5 Only about a fifth of students recognised that the electrical component whose resistance decreases as temperature increases is a thermistor.

02.6 Just over 40% of students gained both marks, with around a quarter gaining one mark on this question.

Some students misread the temperature scale, deciding that the maximum temperature reached was 152 °C or 170 °C, for example. Some students thought that the relevant temperature was the change in temperature of 140 °C. Of those students who correctly read 160 °C from figure 4, but did not then use figure 3, many decided to divide the temperature by a time read from the graph, or tried to use the equation $R = V / I$ or $P = I^2 R$. Some students used their temperature with the maximum resistance of 1000 Ω shown on figure 3.

Students who read 160 °C on figure 3 and decided that this was the resistance of the resistor by writing 160 on the answer line gained no marks.

02.7 Just under 40% of students chose the correct answer to why this was a physical change.

6.1.1.3 Energy changes in systems

Answer 04 · Examiner comments

June 2023 | 8464/P/1H | Original Q6

Question 06 (Standard, standard/high and high demand)

06.1 Approximately 35% of students scored 2 or 3 marks for their explanation. Explanations of gas pressure need to mention the idea of particles, and those who did not mention particles (or atoms, molecules etc.) scored no marks. Those who did mention the idea of particles often mentioned collisions but did not state that the collisions were between particles and the wall of the container. It was also common for students to say that the number of collisions increased, but not include any reference to rate of collisions or to a time period.

06.2 Slightly more than half the students scored at least 1 mark, although only the best students gained both marks on this question. It was quite common for students to refer to plastic having a lower melting point than metal, which was ignored. A fair number of students contradicted themselves by stating that metal is a good thermal conductor and a good insulator so that it keeps the coffee hot, which gained no credit.

06.3 Only a very small proportion of students identified that the property is (a low) specific heat capacity.

06.4 A little less than 50% of students suggested a valid way to increase the speed.

06.5 Roughly 30% of students scored 2 marks, and just under 25% scored all 6 marks on this extended calculation. About 20% of students gained no marks at all. Most students got as far as calculating the mass of 0.209 kg. The majority of students did not convert 15kJ to J, and many then incorrectly re-arranged the specific heat capacity equation.

6.1.1.3 Energy changes in systems

Answer 04 · Examiner comments

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results Statistics page of the AQA Website.

Answer 05 · Examiner comments

June 2024 | 8464/P/1H | Original Q6

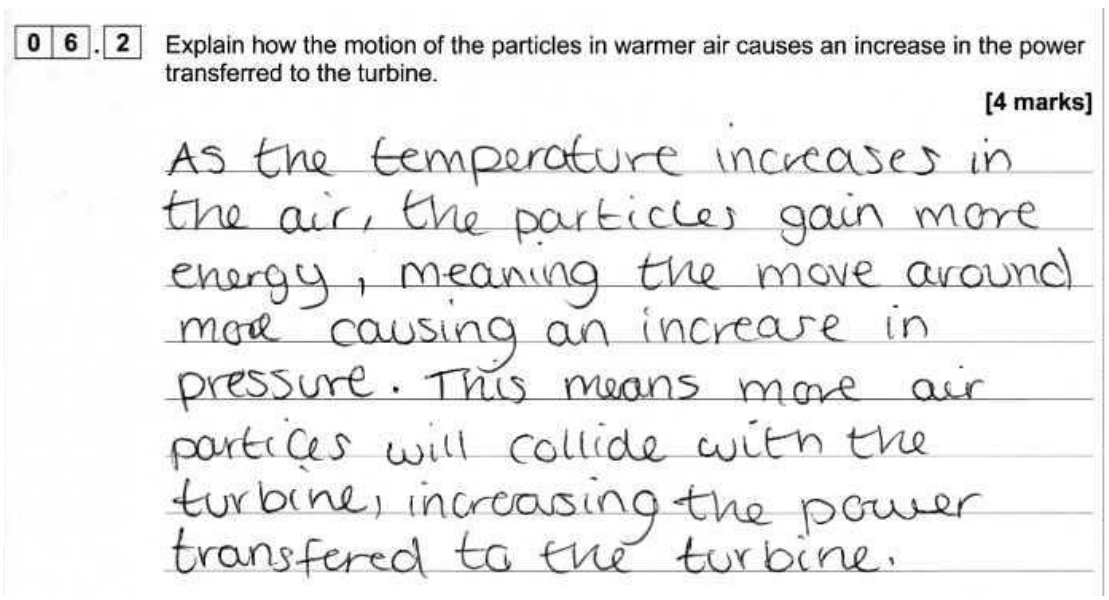
Question 6 (standard/high & high demand)

06.1 Most students struggled to appreciate that the process of compressing the air would reduce the useful energy, and that releasing the air would then reduce this energy further. This lack of understanding of the physics involved meant that a very small proportion of students were able to carry out the correct calculation. Most students who correctly multiplied the two efficiency values tended to also round their answer correctly.

Roughly 20% of students scored 3 marks.

06.2 Many students demonstrated some understanding of how the temperature affects the rate of energy transfer to the turbine. However, many of these answers lacked crucial details. Statements such as 'the number of collisions between the particles and the turbine increases' were common, but without a reference to frequency, or to the collisions happening in a fixed time, marking point 2 was not scored. The proportion of students who referred to the force from each collision was very low.

About 70% of students gained some credit for their answers.



0 6 . 2 Explain how the motion of the particles in warmer air causes an increase in the power transferred to the turbine.

[4 marks]

As the temperature increases in the air, the particles gain more energy, meaning the move around more causing an increase in pressure. This means more air particles will collide with the turbine, increasing the power transfered to the turbine.

This answer demonstrates some understanding, but lacks the detail needed to gain any marks. The student refers to particles gaining more energy but needed to refer to kinetic energy to gain the point. If the particles 'move around more' it could mean that they move a greater distance, rather than moving at a greater speed, so again marking point 1 is not scored. Similarly, 'more particles will collide with the turbine' does not have a reference to frequency or to time, so is not sufficient to score the second marking point.

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6.1.1.3 Energy changes in systems

Answer 05 · Examiner comments June 2024 | 8464/P/1H | Original Q6

06.3 This question proved to be relatively straightforward for a high proportion of students, with over 60% gaining full marks. Having an equation sheet which included all of the physics equations was, no doubt, helpful to many students.

Common errors included spurious conversions of the calculated mass into grams. Some students calculated the correct answer, but then tried to apply the efficiency equation to their answer, often going back to question 06.2 to find an efficiency to use. These responses could still score the first 3 marking points for calculating the mass of air in the tank.

Some students used their calculator to obtain an answer in standard form, but then wrote the answer out in full on the answer line, demonstrating that they did not understand how to give their answer in standard form.

06.4 Many students scored marks for referring to a reduction in wasted energy, but very few discussed both a reduction in the use of fossil fuels and an increase in the use of renewables, so it was very rare for a student to score full marks on this question. Roughly two-fifths of students gained at least 1 mark.

A large number of students seemed confused about what was being asked. Some students wrote about the use of transformers in the National Grid. Some appear to have misread 'efficient energy storage' as 'renewable energy resources' and based their answers around the relative benefits of solar panels and wind turbines. It was common to read answers explaining the impact of carbon dioxide in the atmosphere, but not actually answering the question. Many students seemed to think that the compressed air energy storage system was part of a carbon-capture and storage system.

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6.1.1.3 Energy changes in systems

Contact us

Our friendly team will be happy to support you between 8am and 5pm, Monday to Friday.

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Answer 06 · Examiner comments

Question 2 (Standard demand)

02.1 This standard demand calculation was well answered with over 80% of students gaining full marks. Nearly all students that did a correct substitution were able to rearrange correctly and calculate the final answer.

02.2 Students found this question quite demanding. Over 20% of students did not attempt the question. 40% of students were able to write something creditworthy. 85% of students wrote a creditworthy response. Half of students that gained marks wrote Level 1 responses, the most common Level 1 response just suggested measuring temperature with a thermometer. The 40% of students that wrote Level 2 or 3 answers went on to describe measuring the energy transferred with either a joulemeter or other method and/or measuring mass using a top pan balance.

02.3 Over 95% of students were able to gain at least 1 mark on this question. The majority of students who gained one mark identified that the amount of wasted energy is less. 45% of students gained a second mark for also identifying that the temperature increase of the aluminium block is greater.

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