AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 6.3.1.2

Changes of state

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.

6.3.1.2 Changes of state

Answer 01 · Mark scheme June 2019 | 8464/P/1H | Original Q2

02.1	pressure decreased because molecules have less (kinetic) energy so fewer collisions (with the wall/container each second)	 allow less speed/velocity allow collide with less force allow less force on the walls	1 1 1	AO2.1 6.3.3.1	E
02.2	$0.70 = m \times 330$ **or** $700 = m \times 330\,000$ $m = \frac{0.70}{330}$ **or** $m = \frac{700}{330\,000}$ m = 0.0021 (kg)	an answer of 0.0021(212121…) scores **3** marks allow correct rearrangement using converted value(s) of E to J and/or L to J/kg allow 0.0021(212121…) allow correct calculation using converted value(s) of E and/or L 3 marks can only be awarded for m = 0.0021(212121…) (kg)	 1 1 1	AO2.1 6.3.2.2 6.1.1.3	E
02.3	<table><tr><th>Substance</th><th>Solid</th><th>Liquid</th><th>Gas</th></tr><tr><td>Oxygen</td><td></td><td>✓</td><td></td></tr><tr><td>Nitrogen</td><td></td><td></td><td>✓</td></tr><tr><td>Carbon dioxide</td><td>✓</td><td></td><td></td></tr></table> 2 correct answers scores **1** mark. if more than one tick in a row, neither tick can score a mark		2	AO3/2b 6.3.1.1	E

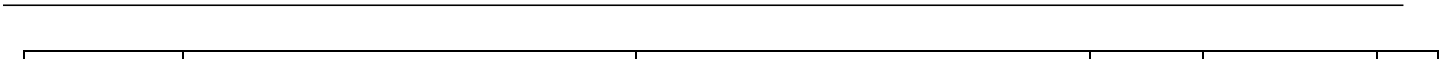
02.4	**Level 3:** Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account.	5–6	AO1.1 6.3.1.2	E
	Level 2: Relevant points (reasons/causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.	3–4		
	Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.	1–2		
	No relevant content	0		
	Indicative content cooling • as the argon cools the particles slow down • particles in a liquid move slower than particles in a gas • particles in a solid move slower than particles in a liquid • as the liquid/solid cools the particles get closer together • as the liquid/solid cools the density increases gas to liquid • particles change from being spread apart to touching each other • particles will (collide with other particles more often and) change direction more often liquid to solid • particles change from a random arrangement to a regular pattern • particles change from moving freely to fixed positions • particles change from moving freely/randomly to vibrating explanation • (internal) energy (of the argon) decreases • (kinetic) energy (of the particles) decreases with temperature • (potential) energy (of the particles) changes with change of state (of the argon) • forces between particles in a gas are negligible/zero • attractive forces act between atoms when they are close to each other • attractive forces between particles are stronger in a solid than in a liquid to access level 3 there must be an explanation of changes to arrangement and movement of particles during either cooling or a change of state			

Total			**14**

6.3.1.2 Changes of state

Answer 01 · Mark scheme

June 2019 | 8464/P/1H | Original Q2



6.3.1.2 Changes of state

Answer 02 · 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

6.3.1.2 Changes of state

Answer 02 · Mark scheme

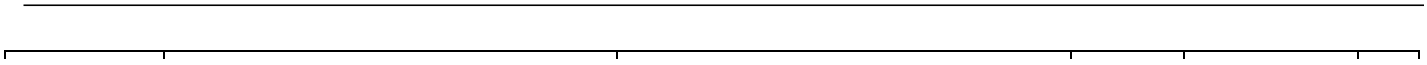
June 2019 | 8464/P/1H | Original Q5

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

6.3.1.2 Changes of state

Answer 02 · Mark scheme

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



6.3.1.2 Changes of state

Answer 03 · 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

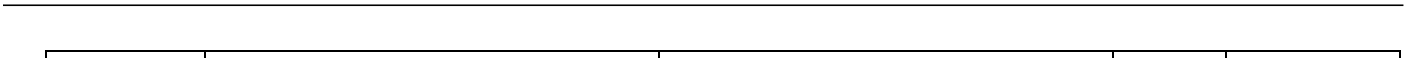
05.5	165 kJ = 165000 J		1	AO2 6.3.2.2
	ΔE = m × 3500 × 21.5 **and** ΔE = m × 255000		1	6.3.2.3 6.1.1.3
	165000 = 75250 m + 255000 m **or** 165000 = 330250 m	this mark may be awarded if E is incorrectly/not converted	1	
	$m = \frac{165000}{75250 + 255000}$ **or** $m = \frac{165000}{330250}$	this mark 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**	

6.3.1.2 Changes of state

Answer 03 · Mark scheme

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



6.3.1.2 Changes of state

Answer 04 · Mark scheme November 2021 | 8464/P/1H | Original Q6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	the kinetic energy (and the potential energy) of the particles increases so the internal energy increases because it is the sum of kinetic and potential energy (of the particles)	allow the speed of the particles increases	1 1	AO1 6.3.2.1 6.3.2.3
06.2	latent heat (of vaporisation)	allow specific latent heat (of vaporisation)	1	AO1 6.3.2.3
06.3	stays the same		1	AO1 6.3.1.2
06.4	more collisions per second a greater force per collision		1 1	AO1 6.3.3.1

6.3.1.2 Changes of state

Answer 04 · Mark scheme

06.5	0.875 = $\frac{\text{useful output energy transfer}}{1\ 560\ 000}$	allow a correct substitution using incorrectly/not converted values of efficiency and/or energy	1	AO2 6.1.2.2 6.1.1.3 6.3.2.2
	useful output energy transfer = 1 365 000(J)	this answer only	1	
		the equation efficiency = $\frac{\text{useful output energy transfer}}{\text{total input energy transfer}}$ must have been used to score subsequent marks		
	1 365 000 = 125 × c × (22.1–11.6)	allow a correct substitution using their calculated value of useful output energy	1	
	$c = \frac{1\ 365\ 000}{125 \times 10.5}$	allow a correct re-arrangement using their value of useful output energy	1	
	c = 1040 (J/kg °C)	allow a correct calculation using with their value of useful output energy	1	
	c = 1.04 × 10^3 (J/kg °C)	this mark can only be awarded for a calculation using the correct equations	1	

6.3.1.2 Changes of state

Answer 04 · Mark scheme

November 2021 | 8464/P/1H | Original Q6

06.6	the advertisement has ignored the energy input from the surrounding air so the total energy input is greater than the energy supplied from the electricity the efficiency must be less than 100%	an answer that the total energy input comes from the electricity supply and the air outside the building gains the first two marking points	1 1 1	AO3 AO2 AO1 6.1.2.2
Total			**15**	

6.3.1.2 Changes of state

Answer 05 · Mark scheme

November 2021 | 8464/P/2H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	different temperatures emit different intensities of infrared which are represented (on the infrared camera) as different shades / colours	 allow wavelength / frequency / amount for intensity throughout	1 1	AO1 AO3 6.6.2.4
05.2	visible light		1	AO3 6.6.2.1
05.3	both ionising radiation so some risk of cancer the whole body is irradiated by gamma rays when an X-ray is taken only part of the body is exposed exposure time for gamma rays is longer		1 1 1 1	AO1 AO3 AO3 AO3 6.6.2.3
05.4	$1.2 \times 10^{-13} = F \times 0.015$ $F = \frac{1.2 \times 10^{-13}}{0.015}$ $F = 8.0 \times 10^{-12}$ N	 allow a correct rearrangement using an incorrectly / not converted value of s allow 8×10^{-12} allow a correct calculation using an incorrectly / not converted value of s	1 1 1	AO2 6.5.2

6.3.1.2 Changes of state

Answer 05 · Mark scheme

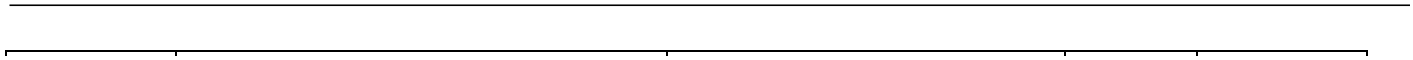
November 2021 | 8464/P/2H | Original Q5

05.5	some of the energy of the electrons causes heating (therefore) increasing the temperature (so using tungsten) allows more electrons to be collided per second than using any other metal	 allow (so using tungsten) enables more energy per second to be transferred than using any other metal	1 1 1	AO1 AO3 AO3 6.5.2
Total			**13**	

6.3.1.2 Changes of state

Answer 05 · Mark scheme

November 2021 | 8464/P/2H | Original Q5



6.3.1.2 Changes of state

Answer 06 · Mark scheme

June 2025 | 8464/P/2H | Original Q5

Question 5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	random		1	AO3 6.6.2.2 RPA 21

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.2	range = 0.5 – (–0.5) **or** range = 1 **or** uncertainty = $\frac{0.5 - (-0.5)}{2}$	allow $0.5-\left(\frac{0.5+0.2-0.3+0.5+0.1}{5}\right)$ allow $\left(\frac{0.5+0.2-0.3+0.5+0.1}{5}\right)-0.5$	1	AO3 6.6.2.2 RPA 21
	uncertainty = (±) 0.5 (°C)		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3	*y*-axis scale of 10 °C per cm		1	AO2
	all points plotted correctly	allow **1** mark for 3 or 4 points plotted correctly allow a tolerance of ± ½ small square'	2	AO2
	curved line of best fit ignoring anomalous point at 8 minutes		1	AO3 6.6.2.2 RPA 21

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.4	2 minutes = 120 seconds	subsequent marks may be awarded if time is incorrectly / not converted	1	AO2 6.6.2.2 RPA21
	rate = $\frac{63 - 18}{120}$		1	
	rate = 0.375 (°C/s)	allow 0.38 (°C/s)	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.5		ignore references to heat throughout		AO1 6.6.2.2 RPA21
	black surfaces are good absorbers (and emitters of infrared / radiation)		1	
	white surfaces are poor absorbers (and emitters of infrared / radiation)		1	
	as the temperature of the cubes increases the cubes emit infrared / radiation at a greater rate		1	
	at maximum / constant temperature, each cube emits infrared /radiation at the same rate that it absorbs infrared / radiation		1	

Total Question 5	**14**

6.3.1.2 Changes of state

Answer 01 · Examiner comments — June 2019 | 8464/P/1H | Original Q2

Question 2 (Standard demand)

02.1 Around 30% of students gained 3 marks on this question, with just under a third of students gaining 2 marks and approximately a fifth of students gaining just 1 mark. Many students wrote about successful collisions, which was condoned here. However, writing about particles moving less was not seen as equivalent to writing about particles moving more slowly. The most common reason for gaining 2 marks, rather than three, was the omission of any mention of collisions.

One common misconception observed was that, as the particles cool down, the number of particles increases. There were also a number of students who did not mention pressure in their answer, instead discussing how the movement of particles changed as they cooled and how this linked with temperature.

02.2 Just over half of the students gained full marks on this question, with a little under 15% gaining 2 marks. Those students who scored 2 marks had usually made an erroneous conversion of either kJ to J or kg to g. Many students tried to answer the question using the equation $E = mc\Delta\theta$, using 20 °C as their change in temperature, and gaining 0 marks.

02.3 Slightly less than a third of students gained 2 marks on this question, with around 20% of students gaining 1 mark for correctly identifying two states. A small but significant number of students chose to fill the boxes with numbers representing temperatures, rather than ticking one box for each row of the table.

02.4 This 6-mark question enabled almost all students to write something relevant, and as a consequence only a very low proportion of students failed to score any marks. Around 60% of students gained marks in level 2 of the mark scheme for describing changes to arrangement and/or motion of the particles, but not giving any explanation for these in terms of either the energy of the particles or the forces between them. Students who drew diagrams to aid their descriptions and explanations tended to score well on the question. Many of the students who gained 0 marks on this question failed to talk about particles, instead naming and describing changes of state.

Answer 02 · 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 02 · 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 04 · Examiner comments November 2021 | 8464/P/1H | Original Q6

Question 6 (High demand)

06.1 The concept of internal energy is challenging to many students, and only around 15% of students gained any credit on this question.

06.2 Just over 10% of students answered this correctly.

06.3 This was correctly answered by just over a third of all students. Over half of all the students thought that the mass of the coolant decreases when it evaporates.

06.4 While many students realised that pressure was due to collisions between the particles and the pipe, it was uncommon for students to mention that the rate or frequency of those collisions would increase with temperature and density. Very few students recognised that with increased temperature each collision would exert a greater force on the pipe. Roughly 10% of students gained at least one mark on this question.

06.5 This question was targeted students working at grade 8-9. It required students to realise that the efficiency equation needed to be used before the equation for specific heat capacity could be applied. A fair proportion of students made errors in using the efficiency equation, ending up with an incorrect energy value. Of students who did this, the most common error was to calculate the useful energy, and then to subtract this from the total energy supplied, so that they ended up with 12.5% of 1560 kJ, rather than 87.5% of 1560 kJ. Although their incorrect use of the efficiency equation gained them no marks, these students were able to apply their calculated energy value to the specific heat capacity equation and still gain some credit on this question. Around 15% of students gained at least 4 marks.

6.3.1.2 Changes of state

Answer 04 · Examiner comments November 2021 | 8464/P/1H | Original Q6

06.6 Many students did not appear to have assimilated all of the information in the question, and used the information to incorrectly calculate that the efficiency of the heat pump was actually 25%, rather than the 400% advertised. A few students referred to the previous question and stated that the efficiency of the heat pump is 87.5%, which gained no credit. It was uncommon for students to realise that the energy transferred to the coolant comprised of energy transferred from the air outside the building in addition to the energy transferred from the mains electricity supply. The most common mark scored in this question was by those students who recognised that efficiency cannot exceed 100%. Nearly a fifth of all students made no attempt to answer the question.

6.3.1.2 Changes of state

Mark Ranges and Award of Grades

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

6.3.1.2 Changes of state

Answer 05 · Examiner comments — November 2021 | 8464/P/2H | Original Q5

Question 5 (standard/high demand and high demand)

05.1 Only 10% of students scored marks on this question. At high demand it is expected that where a question follows a figure, students should use information from the figure. Very few students linked the amount of infra-red radiation to temperature, or stated that different temperatures are displayed at different colours, despite that information being given in Figure 8.

05.2 This was a demanding question - students had to compare wavelengths given in nm and mm and in standard form. They then had to use their understanding of the electromagnetic spectrum. Less than 30% of students answered this question correctly.

05.3 The vast majority of the 40% of students that scored marks on this question only scored 1 mark, and that was mostly for saying that there is some risk of cancer with both.

05.4 This question performed as expected with 30% of students scoring 2 marks. Only 8% of students included the conversion to gain full marks.

Answer 05 · Examiner comments — November 2021 | 8464/P/2H | Original Q5

05.5 20% of students gained at least 1 mark. Most of those stated that the energy from the electrons would cause heating and increase the temperature. Some went on to say that tungsten could be heated to a higher temperature than any other metal. No student scored full marks for explaining this meant that more electrons could be collided.

Answer 06 · Examiner comments — June 2025 | 8464/P/2H | Original Q5

Question 5 (Standard, standard/high and high demand)

05.1 Only about 15% of students were able to correctly identify the random error in the results. This perhaps illustrates a misconception that many students perceive that digital devices give a definitive value for what they are measuring, and therefore cannot possibly show random errors.

05.2 This question was not well answered, with fewer that one in five students gaining any credit. Many students correctly calculated that the sum or mean of the numbers is zero, but this gained no credit. It was also common to see students calculate the size of the range, but to state that this was equal to the uncertainty, so gained no marks.

