AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 6.3.2.1

Internal energy

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**4**
Available paper years	**2019–2023**

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.

6.3.2.1 Internal energy

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

6.3.2.1 Internal energy

Answer 01 · Mark scheme

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

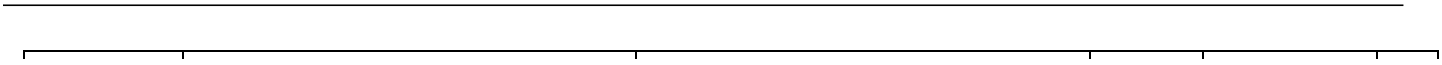
02.4	**Level 3:** Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account.	5–6	AO1.1 6.3.1.2	E
	Level 2: Relevant points (reasons/causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.	3–4		
	Level 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**

6.3.2.1 Internal energy

Answer 01 · Mark scheme

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



6.3.2.1 Internal energy

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

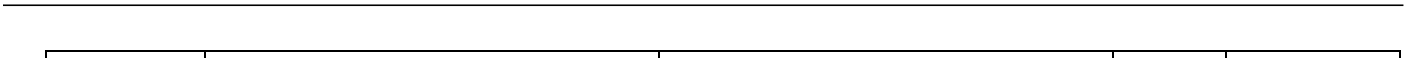
05.5	165 kJ = 165000 J		1	AO2 6.3.2.2
	ΔE = m × 3500 × 21.5 **and** ΔE = m × 255000		1	6.3.2.3 6.1.1.3
	165000 = 75250 m + 255000 m **or** 165000 = 330250 m	this mark may be awarded if E is incorrectly/not converted	1	
	$m = \frac{165000}{75250 + 255000}$ **or** $m = \frac{165000}{330250}$	this mark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

6.3.2.1 Internal energy

Answer 02 · Mark scheme

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



6.3.2.1 Internal energy

Answer 03 · 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

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	
	$c = 1.04 \times 10^3$ (J/kg °C)	this mark can only be awarded for a calculation using the correct equations	1	

6.3.2.1 Internal energy

Answer 03 · 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**	

6.3.2.1 Internal energy

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

6.3.2.1 Internal energy

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

6.3.2.1 Internal energy

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.

6.3.2.1 Internal energy

Answer 03 · 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.

6.3.2.1 Internal energy

Answer 03 · 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.

6.3.2.1 Internal energy

Answer 03 · 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.

6.3.2.1 Internal energy

Answer 04 · Examiner comments

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.

6.3.2.1 Internal energy

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.