AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 6.3.3.1

Particle motion in gases

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**4**
Available paper years	**2018–2024**

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.

6.3.3.1 Particle motion in gases

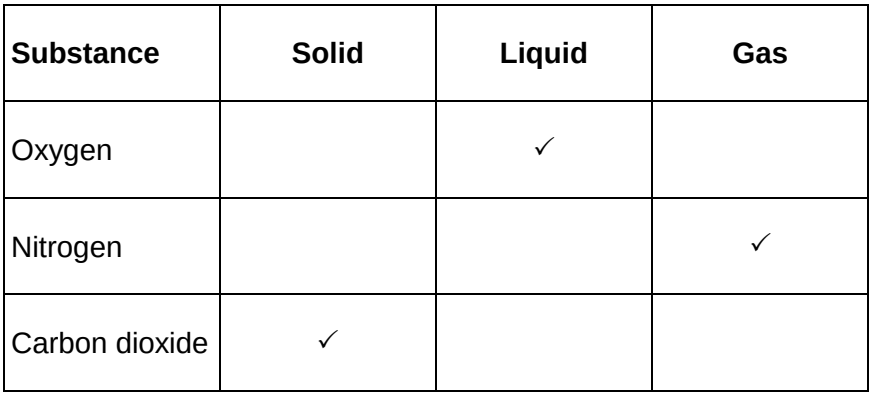
Answer 01 · Mark scheme June 2018 | 8464/P/1H | Original Q3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	they move in random directions they move with a range of different speeds		1 1	AO1 6.3.3.1
03.2	the (mean) speed of the particles would increase	allow kinetic energy increases	1	AO1 6.3.3.1
03.3	(if the temperature increases) the pressure increases so it could explode	allow an explanation in terms of large pressure difference	1 1	AO1 6.3.3.1 AO2 6.3.3.1
03.4	p = 0.1 (MPa)		1	AO2 6.3.3.1
03.5	$p = 2.25 \times \left(\frac{25}{100}\right)$ p = 0.56 t = 27 (minutes)	an answer of 27 scores **3** marks allow any correct method of determining 25% of 2.25 allow use of 2.2–2.3 allow 0.55–0.575 allow 26–28 minutes allow correct value of t using their calculated value of p	 1 1 1	AO3 6.3.3.1
03.6	(the volume of the air) increases		1	AO1 6.3.3.1
Total			**10**	

6.3.3.1 Particle motion in gases

Answer 01 · Mark scheme June 2018 | 8464/P/1H | Original Q3

Answer 02 · 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	 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

Substance	**Solid**	**Liquid**	**Gas**
Oxygen		✓	
Nitrogen			✓
Carbon dioxide	✓		

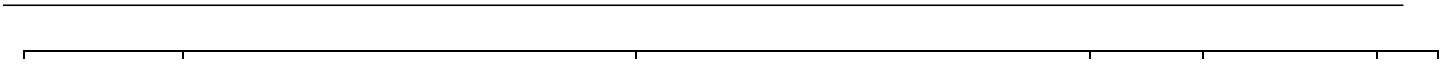
02.4	**Level 3:** Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account.	5–6	AO1.1 6.3.1.2	E
	Level 2: Relevant points (reasons/causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.	3–4		
	Level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

6.3.3.1 Particle motion in gases

Answer 02 · Mark scheme

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



6.3.3.1 Particle motion in gases

Answer 03 · Mark scheme

June 2022 | 8464/P/1H | Original Q4

Question 4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	100 (kPa)	allow 10^2 (kPa)	1	AO2 6.3.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.2	range = 0.006 (MPa) uncertainty = ± 0.003 (MPa)	allow mean = 0.118 an answer of uncertainty = 0.118 (MPa) scores **0** marks	1 1	AO2 6.3.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.3	the relationship is linear	allow the relationship obeys y = mx + c allow the gradient (of the graph) is constant do **not** accept (directly) proportional	1	AO2 6.3.3.1

6.3.3.1 Particle motion in gases

Answer 03 · Mark scheme

June 2022 | 8464/P/1H | Original Q4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.4		particles refers to particles in the steam throughout		AO2 6.3.3.1
	(as the amount of steam increases) the number of particles increases		1	
	and (as the temperature increases) particles move faster	allow (as the temperature increases) the (average) kinetic energy of the particles increases	1	
	particles collide with the wall of the cooker		1	
		if MP3 is not awarded no subsequent marks may be awarded		
	these collisions are more frequent		1	
	and each collision exerts more force		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.5	the particles spread out	do **not** allow particles expand	1	AO1 6.3.1.1
	so the steam / gas takes up a greater <u>volume</u>	allow there is less gas in the same <u>volume</u>	1	
	and $\text{density} = \frac{\text{mass}}{\text{volume}}$ so the density decreases	do **not** allow density of particles decreases	1	

Total Question 4		12

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

Answer 04 · Mark scheme

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
	mass = $48 \times 5.0 \times 10^5$		1	6.3.2.2 6.1.1.3
	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	allow named renewable resources	1	
	or			
	(most) renewable resources do not generate electricity all the time	allow renewable resources are unreliable		
	(so) efficient energy storage will help to meet the demand for energy / electricity		1	

Total Question 6	17

6.3.3.1 Particle motion in gases

Answer 01 · Examiner comments

June 2018 | 8464/P/1H | Original Q3

Question 3 (Standard and Standard/high demand)

03.1 Over 90% of students scored at least 1 mark and 73 % scored 2 marks.

03.2 69% of students answered correctly. Many students who weren't awarded the mark probably intended to say that the speed increased, but simply offered 'increased' as their response, which is ambiguous. Many incorrect responses referred to increased vibration or faster vibration in the air.

03.3 A little over 70% of students recognised that the canister was in danger of exploding/bursting. 33% went on to say that the increase in pressure was the cause. Of the students that failed to score any marks, most just made simple statements such as 'the diver will not be able to breathe'.

03.4 Only 31% of students deduced that the pressure would stop dropping when the pressure inside the can was the same as the atmospheric pressure.

03.5 32% of students scored all three marks on the question. 27% were able to calculate the final pressure but then read the value from the graph incorrectly.

A number of students incorrectly calculated 75% of the initial pressure and then read the value off the graph correctly as t = 6, and scored one mark.

6.3.3.1 Particle motion in gases

Answer 02 · 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.

6.3.3.1 Particle motion in gases

Answer 03 · Examiner comments

June 2022 | 8464/P/1H | Original Q4

Question 04 (Standard, standard/high and high demand)

04.1 Just over half the students could convert this correctly.

04.2 Very few students were able to calculate the uncertainty, with just over 15% gaining both marks.

Many students simply calculated the mean, but if they then demonstrated that they thought the mean is the same as the uncertainty by writing this value on the answer line, they gained no credit. Some students gave the uncertainty as 3, rather than 0.003, but could still gain 1 mark if relevant working had been shown. Some students mixed up the two possible methods and calculated mean divided by two, rather than range divided by two.

04.3 Almost no students were able to identify that the graph shows a linear relationship. A lot of answers described the trend as directly proportional, and there were also many qualitative descriptions such as pressure increases evenly with temperature, which were insufficient to gain the mark. Some students gave an explanation of the relationship, which did not answer the question.

04.4 Slightly more than 55% of students gained some credit on this question, but it was uncommon for students to gain 4 or 5 marks.

A lot of answers did not refer to particles at all, and therefore gained no marks, but students who referred to atoms or molecules instead of particles could still gain full marks. Many answers wrote about successful collisions, which did not prevent them from gaining marks, but demonstrated a misunderstanding of the cause of pressure in gases. A large number of students did not state what collisions were between, or stated that the collisions were between particles in the steam.

6.3.3.1 Particle motion in gases

Answer 03 · Examiner comments

June 2022 | 8464/P/1H | Original Q4

Some students referred to an increased number of collisions, but did not indicate that this was in a fixed time period, or did not mention frequency of collisions, so did not gain marking point 4.

Few students identified that collisions at higher temperatures would cause a greater force, or that the number of particles in the steam would increase as the water boiled.

04.5 Only about a third of students gained any marks on this question, with most of these only gaining one mark.

The most commonly awarded mark was for the idea of particles spreading out. Most students gave vague descriptions of particles moving into a larger space or larger area, where they needed to be describing a volume to give an explanation of the density change. Some students stated that the steam would cool and condense, so the particles would move closer together, but the question clearly stated that the steam would expand as it moved into the atmosphere so this gained no credit. A few students stated that particles were less likely to collide, demonstrating a confusion between density and pressure.

Some students described a change in density of the gas remaining in the pressure cooker. This did give the opportunity to describe the correct physics involved, and could lead to full credit being awarded.

Answer 04 · Examiner comments

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

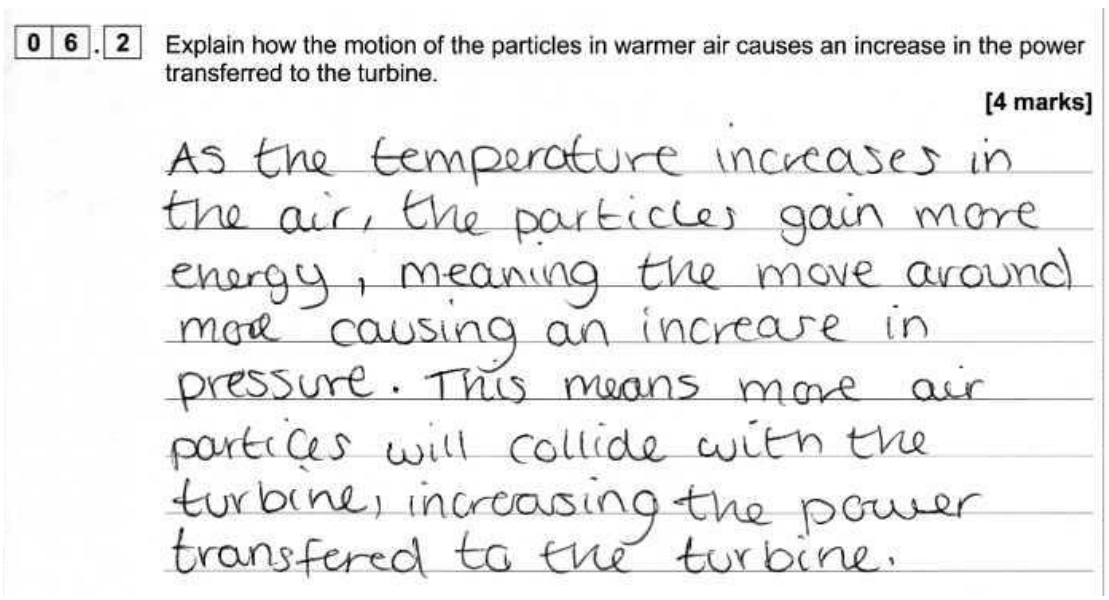
Question 6 (standard/high & high demand)

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.

© 2024 AQA and its licensors. All rights reserved.

6.3.3.1 Particle motion in gases

Answer 04 · 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.

© 2024 AQA and its licensors. All rights reserved.

6.3.3.1 Particle motion in gases

Contact us

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

Tel: 01483 477756
Email: gcsescience@aqa.org.uk

aqa.org.uk

© 2024 AQA and its licensors. All rights reserved.