PEARSON EDEXCEL GCSE CHEMISTRY · 1CH0

CHEMISTRY



MARK SCHEME

TOPIC 7: RATES OF REACTION AND ENERGY CHANGES

SCORE	PERCENTAGE
/168	%

STEMUP

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Q1.

The first question on this paper was answered well with the vast majority able to write the steps for the method of the experiment in the correct order to gain both marks.

Q2.

It was pleasing to see that most were able to score 1 mark for balancing the equation.

Candidates found it much more difficult to add the state symbols to the equation with many losing this mark. The most common error was to use aq for water rather than l.

Some wrote the complete word for the state of the substance rather than using the symbol. A few seemed not to have encountered state symbols and added the names or symbols of other elements into the brackets.

Complete the balanced equation for the reaction and fill in the two missing state symbols.
(2)

2 H_2O_2(aq) → 2H_2O(aq) + O_2(g)

Results Plus: Examiner Comments

This was a common error.

Complete the balanced equation for the reaction and fill in the two missing state symbols.
(2)

H_2O_2(aq) → 2H_2O(l) + O_2(g)

Results Plus: Examiner Comments

Where dotted lines are given, it is very likely that a repsonse will be required.

Q3.

Looking at the overall marks awarded for all the candidates, the majority candidates scored at least a Level 2 (3 or 4 marks). It is clear that many candidates have a good understanding of the effect of temperature and concentration on the rate of reaction and a good number scored highly on this item.

The typical Level 1 answer contained a simple application of the data such as increasing the temperature increased the rate of reaction. To get to Level 2, it was necessary for candidates to make direct reference to data given in the question and with some explanation in terms of particles and both the effects of concentration and temperature. A Level 3 answer needed an explanation of the connection between both temperature and concentration, shown by the data, and reaction rate together with explanations in terms of particles and collisions.

Some candidates gave very good explanations but failed to link their explanations to the data given in the table and were limited to Level 1. Also, candidates that talked about the effects of temperature and concentration on rates but did not explain them at all in terms of particles or collisions, were limited to Level 1. In general, many candidates have difficulty with giving sufficient detail in their explanations for the effects of changing different variables, so a reference to increased concentration was often characterised as just more particles rather than more particles per unit volume, higher collision frequency as just more collisions.

* Two substances, **A** and **B**, each form a colourless solution.
If the solutions are mixed in a beaker, **A** and **B** react to form a coloured product.
The rate of the reaction between **A** and **B** can be investigated by placing the beaker containing the mixture on a cross on a piece of paper and timing how long it takes for enough coloured product to be produced to make the cross invisible when viewed from above, through the solution.

	experiment 1	experiment 2	experiment 3
concentration of **A in solution** in g dm^{-3}	10	10	40
temperature in °C	20	40	40
time for cross to become invisible in s	320	80	20

Figure 13

Use the results of these experiments to explain, in terms of the behaviour of particles, the effect of changing temperature and the effect of changing the concentration of **A** in solution on the rate of this reaction.

(6)

Changing the concentration of A effects the time taken as it means that there are more particles in a smaller space, due to this the particles are going to bump into each other more often there for reacting more often which means the rate of reaction increases when concentration is increased.

Changing the temperature will increase the rate of reaction due to the particles having more energy so they move around at a greater speed meaning they will bump into other particles more often, therefor react more often and rate of reaction increases.

Results Plus: Examiner Comments

This response was awarded a Level 1, 2 marks.

The effects on the rate of reaction of changing temperature and concentration of **A** are discussed and are explained in terms of particles and collisions. However, the stem of this question very clearly instructs candidates to 'use the results of these experiments'. It is clear from the response that data from the table has not been used to compare the different conditions. Consequently, this response is limited to a Level 1.

Results Plus: Examiner Tip

Read the question carefully, especially when data is provided and the question instructs the candidate to use the data. Failing to use this information, as in this particular example, is likely to limit the Level that can be awarded.

* Two substances, **A** and **B**, each form a colourless solution.
If the solutions are mixed in a beaker, **A** and **B** react to form a coloured product.
The rate of the reaction between **A** and **B** can be investigated by placing the beaker containing the mixture on a cross on a piece of paper and timing how long it takes for enough coloured product to be produced to make the cross invisible when viewed from above, through the solution.

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Figure 13

Use the results of these experiments to explain, in terms of the behaviour of particles, the effect of changing temperature and the effect of changing the concentration of **A** in solution on the rate of this reaction.

(6)

In experiment 1, the temperature was relatively low and the concentration was too. This produced the longest time for the cross to become invisible at 320 seconds. This is because there is little energy to increase the frequency of collisions & which, & in effect would increase the rate of reaction. In experiment 2, the concentration was kept the same (at 10 g dm^{-3}) ~~same~~ but the temperature was doubled (increased to 40°c). This produced a time of 80 seconds (four times quicker than experiment 1). This is because there is more available energy for the frequency of collisions to increase, therefore for the rate of reaction to increase within the solution. In experiment 3, the temperature was kept the same at 40°c however the concentration was increased to 40 g dm^{-3} which produced a time of 20 seconds for the cross to disappear (four times quicker than in experiment 2) This is because there is ~~more of~~ because there is a higher concentration of A in the solution - it gives the reaction more energy to increase the rate at which it reacts.

Results Plus: Examiner Comments

This response was awarded a Level 2, 4 marks.

Data from the table is used and both the effects of temperature and concentration are discussed. Collisions are used in the explanations. However, particles or collisions are not used correctly in the explanation of concentration, therefore a Level 3 cannot be reached. Hence a Level 2 was awarded.

* Two substances, **A** and **B**, each form a colourless solution.
If the solutions are mixed in a beaker, **A** and **B** react to form a coloured product.
The rate of the reaction between **A** and **B** can be investigated by placing the beaker containing the mixture on a cross on a piece of paper and timing how long it takes for enough coloured product to be produced to make the cross invisible when viewed from above, through the solution.

	experiment 1	experiment 2	experiment 3
concentration of **A in solution** in g dm^{-3}	10	10	40
temperature in °C	20	40	40
time for cross to become invisible in s	320	80	20

use results!

Figure 13

thermal, kinetic → particles more, faster → more likely to collide, more successful collisions with activation energy — collision theory

Use the results of these experiments to explain, in terms of the behaviour of particles, the effect of changing temperature and the effect of changing the concentration of **A** in solution on the rate of this reaction.

increase amount of particles, more likely to collide, more likely to collide successfully with enough activation energy

(6)

Changing the temperature of 'A' in solution affects the rate of reaction, because thermal energy is transfered to kinetic energy. This then allows the particles to move faster, which means that they are more likely to collide. More collisions means more successful collisions with enough activation energy. For example, the temperature in experiment 1 was 20°c, and the time taken for the cross to become visible was 320 seconds. However, when the temperature was increased to 40°c in experiment 3, the time taken was only 20 seconds. This shows that as you increase the temperature, the

rate of reaction also increases.
Changing the concentration of 'A' in solution affects the rate of reaction, because it increases the concentration of particles in a given volume. Increasing the concentration of particles means that they are more likely to collide successfully with enough activation energy. For example, the concentration in experiment 2 was $10 g dm^{-3}$ and the time taken was 80 seconds. However, when the concentration was increased at $40 g dm^{-3}$, the time taken was only 20 seconds, which was 60 seconds faster than experiment 2. This shows that if you increase the concentration, the rate of reaction also increases.

Overall, if you increase the temperature and concentration of the solution, the rate will increase at the best rate, ~~for~~ for example in experiment 3.

Results Plus: Examiner Comments

This response was awarded a Level 3, 6 marks.

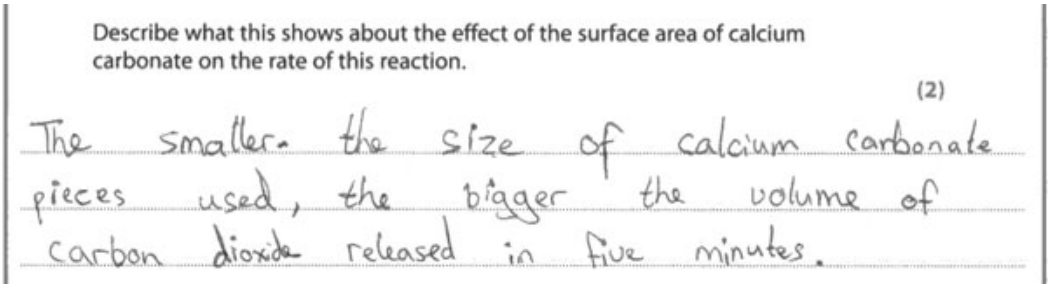
Data from the table is used and all three experiments in relation to the effects of both temperature and concentration are discussed. Both temperature and concentration are explained in terms of particles and collisions. There is a slip in experiment numbers on the first page but it is clear what experiments are being considered. Hence a Level 3 is scored. There is also a good conclusion at the end.

Even if the answer space had been blank, some credit could have been awarded for the annotation or plan by the table.

Q4. No Examiner's Report available for this question

Q5.

There was much confusion over size of calcium carbonate pieces and its surface area; many stated that large had a large surface area, small pieces a small surface area. The majority of the candidates repeated the data in the question and consequently narrowed down their possible score to one by stating that 'the smaller the pieces the faster the reaction'. There were some really elegant one sentence responses scoring both marks, but they were sadly, few and far between.

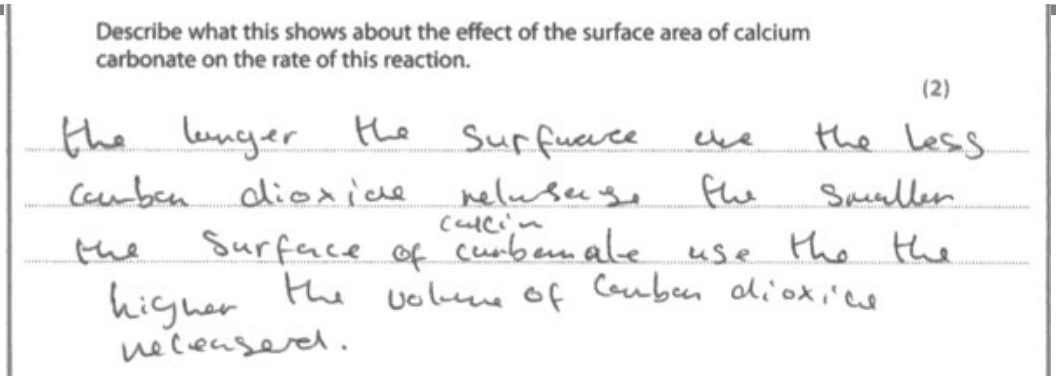

Describe what this shows about the effect of the surface area of calcium carbonate on the rate of this reaction.

(2)

The smaller the size of calcium carbonate pieces used, the bigger the volume of carbon dioxide released in five minutes.

Results Plus: Examiner Comments

This answer merely summarised the table of information in the question and scored 0 marks.


Describe what this shows about the effect of the surface area of calcium carbonate on the rate of this reaction.

(2)

the longer the surfuace are the less carbon dioxide relaesge the smaller the surface of calcium carbonate use the the higher the volume of carbon dioxide released.

Results Plus: Examiner Comments

This is where a candidate has confused particle size with its surface area. In addition, the second half of this answer is the reverse argument of the first half. Many candidates fell into this situation of incorrectly linking large particle size with large surface as well as repeated their answer with the reverse argument as demonstrated here.

Results Plus: Examiner Tip

If you take a large lump of solid and start to break it up into smaller pieces, the total surface of the smaller pieces is greater than that of the large lump. This means there is more surface over which reactions can occur and so the reaction is faster.

Remember: the smaller the pieces - the larger the surface area - the faster the reaction.

Q6. No Examiner's Report available for this question

Q7.

This question was well answered; most candidates calculated 300s, with only a few missing the need to convert from minutes to seconds. It was widely known that to find the rate the volume is divided by time.

Q8. No Examiner's Report available for this question

Q9.

This part was generally well done, and the examiners were pleased to see answers clearly laid out with the energy to break bonds and the energy released making bonds evaluated with working. The most common cause of loss of a mark being an answer of 730 instead of -730. A few candidates showed that they had no understanding and simply juggled the figures they were given. A similar minority seemed unable to transfer data from their calculator to the exam paper (or vice versa) accurately and so lost marks.

Q10.

This was found to be more difficult than expected. It was thought that the third line might be more tricky but this did not prove to be so; errors were randomly scattered. Most candidates scored 1 mark.

Q11. No Examiner's Report available for this question

Q12.

Diagram drawing seems to be quite challenging for several candidates. Although there was some degree of latitude shown for what could be described as a gas syringe, probably fewer than half the candidates attempted to draw one as a means of collecting and measuring the volume of gas. The use of a stopper and delivery tube was widespread but some candidates didn't see the need to have a sealed system.

Q13.

(i)

The majority of candidates gave an appropriate means of measuring the volume of gas more accurately and of those the overwhelming majority gave 'gas syringe' as their answer.

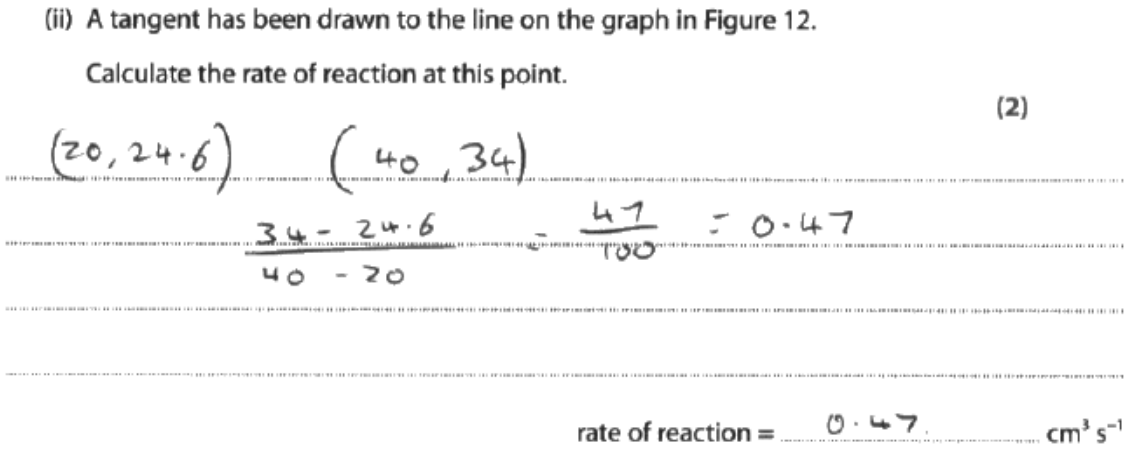
The most common error gave an answer that involved measuring the mass rather than the volume.

(ii)

The majority of responses scored both of the 2 marks available.

Most candidates made an attempt at calculating the gradient at the point shown by using the tangent line. An answer of 0.5 was as common as the best answer of 0.47.

Some made errors in reading the graph to calculate the gradient. The most obvious error seen was where candidates calculated the average gradient by dividing the volume at that point (29 cm^3) by the time (30 s), scoring 1 mark for an incorrect fraction correctly evaluated.


(ii) A tangent has been drawn to the line on the graph in Figure 12.

Calculate the rate of reaction at this point.

(2)

(20, 24·6) (40, 34)

$\frac{34 - 24.6}{40 - 20} = \frac{47}{100} = 0.47$

rate of reaction = 0·47 $cm^3 s^{-1}$

Results Plus: Examiner Comments

This response scored the 2 marks available, for a calculated value for the rate of reaction within the accepted range. Although the final answer alone scores full marks, from the working shown, it is clear how the candidate has used the tangent to the graph to calculate the gradient.

(iii)

This was not well answered on the whole, with less than half responses scoring the 1 mark available for sketching an appropriate graph showing the behaviour of an equal mass of powdered magnesium.

Many candidates omitted this question. Is it possible that they simply did not recognise that there was a question there to be answered.

The most common error was where no line was shown, other errors included a straight line going through the origin diagonally across the grid, where the line levelled off either above or below 40 cm^3.

The graph in Figure 12 shows the results of this experiment.

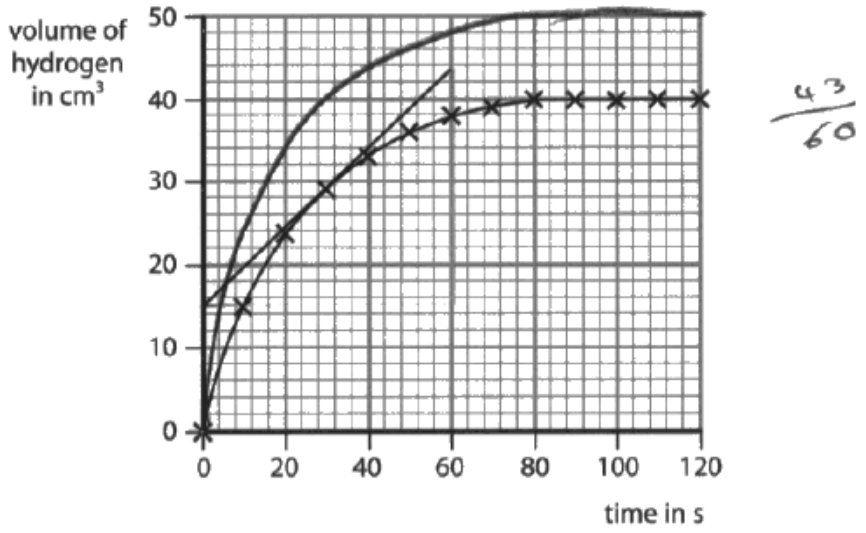


Figure 12

(iii) On the graph in Figure 12, draw the line you would expect to obtain if the magnesium ribbon in this experiment was replaced with an equal mass of powdered magnesium. All other conditions are kept the same.

(1)

Results Plus: Examiner Comments

This response did not score the 1 mark available.

Although the curve is steeper and correctly drawn to the left of the printed curve, it is incorrectly drawn above 40cm^3, so the mark is not scored.

The graph in Figure 12 shows the results of this experiment.

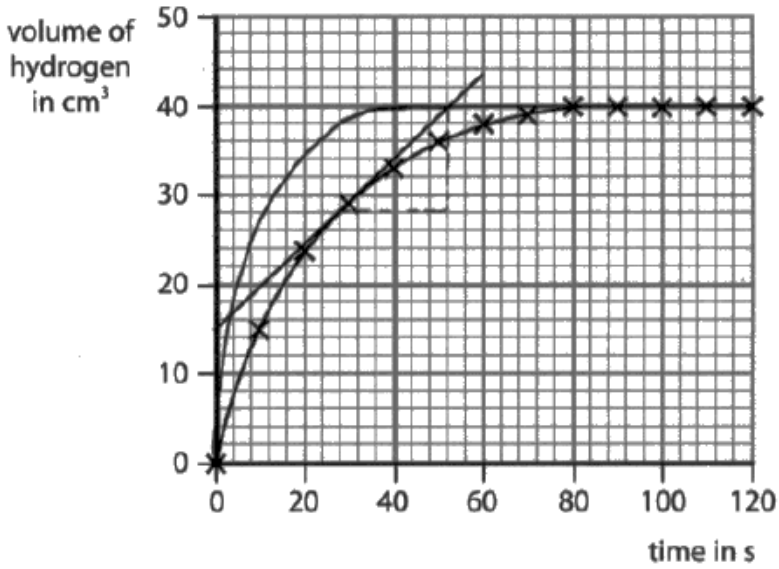


Figure 12

(iii) On the graph in Figure 12, draw the line you would expect to obtain if the magnesium ribbon in this experiment was replaced with an equal mass of powdered magnesium. All other conditions are kept the same.

(1)

Results Plus: Examiner Comments

This response scored the 1 mark available.

The line drawn is a curve to the left of the printed curve and also reaches the same final volume, 40 cm^3.

Q14.

(i)

Generally well answered on the whole, with the majority of the candidates identifying 'fuel oil' as the fraction that was most likely to be cracked. Nearly all the incorrect responses, indicating a misunderstanding of the question, referred to petrol.

(ii)

Most candidates were able to score 2 of the 3 marks available.

The endothermic reaction profile was known only to about half the candidates. Most candidates

managed to label the positions of reactants and products correctly. Only a small number could show the activation energy correctly on an endothermic reaction profile to score all the marks available.

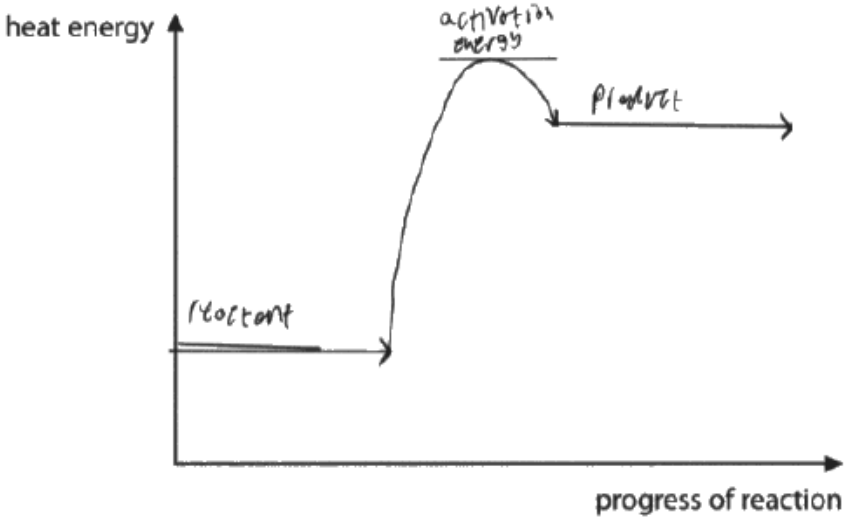
Consequential marking was in place for those who drew an exothermic reaction profile.

Incorrect diagrams included random straight lines starting from the origin, others drew a line similar to that produced from a rates of reaction curve and a few candidates drew curves to show what happened to the amount reactant and to the amount of product formed during a reaction.

(ii) In a cracking reaction, reactants are heated to form products.
This reaction is endothermic.

On the axes provided, draw the reaction profile of this reaction.
Label the energy of the reactants, the energy of the products and the activation energy of the reaction.

(3)



Results Plus: Examiner Comments

This response scored 2 of the 3 marks available.

A profile has been drawn for an endothermic reaction, with the relative positions of the reactants and products labelled and shown correctly. However, the activation energy is not labelled correctly, so limiting this response to 2 marks.

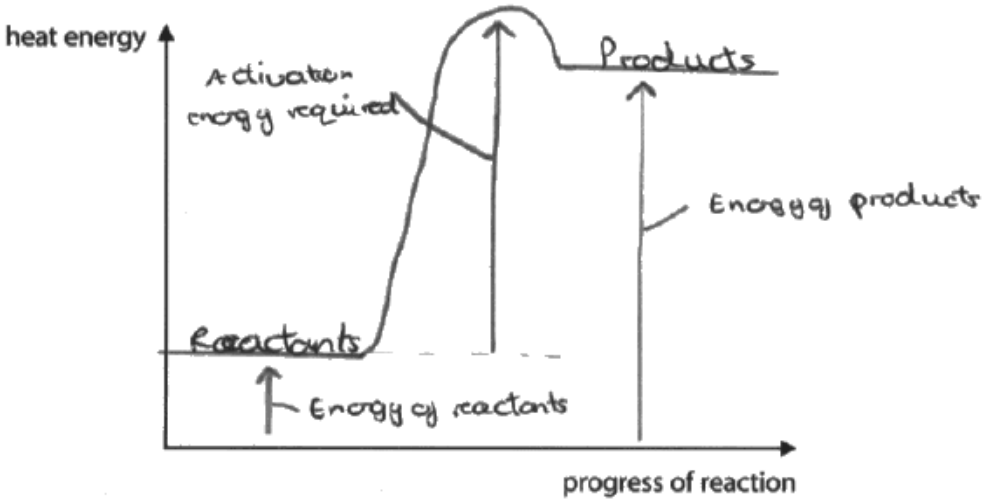
Results Plus: Examiner Tip

Make sure that not only can you draw the reaction profiles for both endothermic and exothermic reactions that you can label the activation energy on the profiles for both these types of reaction.

(ii) In a cracking reaction, reactants are heated to form products.
This reaction is endothermic.

On the axes provided, draw the reaction profile of this reaction.
Label the energy of the reactants, the energy of the products and the activation energy of the reaction.

(3)



Results Plus: Examiner Comments

An example of a fully correct response which scored 3 marks.

A profile has been drawn for an endothermic reaction, with the correct relative positions of the reactants and products labelled, with the activation energy also labelled correctly.

(iii)

Most candidates were able to work out the formula of the single product needed to balance the equation for the cracking of dodecane by writing C_6H_{14}. A common incorrect response seen here was to give $2C_3H_7$ as the answer, despite the question stating that the formula of a single molecule was needed to balance the equation.

Q15.

Of the candidates who scored a mark on this question, the overwhelming majority was for stating that a catalyst speeds up a reaction. However the second point about it not being used up or changed during the reaction was only scored by a minority of the candidates. Many candidates made at an attempt at the second point but stated something similar to 'not involved/does not take part' in the reaction, despite saying it speeded up the reaction. A few of the most able on this paper did write about lowering activation energy, which gained credit, but is not a requirement of this specification.

The weaker candidates where they did attempt this question were making reference to catalytic

convertors on vehicles.

(b) A catalyst is added to some reactions.

Explain the meaning of **catalyst**.

(2)

A catalyst is a substance that either slows down or speeds up the reaction.

Results Plus: Examiner Comments

At this level we consider catalysts as increasing the speed of a reaction. This answer contradicts itself, perhaps by the candidate not being completely sure, so does not score the mark.

(b) A catalyst is added to some reactions.

Explain the meaning of **catalyst**.

(2)

This speeds up a chemical reaction, so if you react two chemicals and the reaction is slow you add a ~~catalyst~~ catayst to speed it up.

Results Plus: Examiner Comments

The same point is being made twice here, so only 1 mark was awarded.

(b) A catalyst is added to some reactions.

Explain the meaning of **catalyst**.

(2)

A catalyst is something thats added to a chemical reaction to speed it up. But it doesn't take place in the reaction.

Results Plus: Examiner Comments

This was given 1 mark for the first sentence in the answer; however, the second sentence was frequently seen and gained no credit.

Results Plus: Examiner Tip

Know the factors that can increase the rate of a chemical reaction and be able to explain how

changing that factor causes the increase in the reaction rate.

Q16. No Examiner's Report available for this question

Q17.

Generally well answered on the whole with the majority of candidates able to score 3 or 4 of 4 marks available.

Most candidates understood the need to sum bond energies of reactants and products and subtract the two results. Thus, they often scored some marks for correctly carrying forward incorrect number(s). It was noted by examiners that it was sometimes difficult to establish from a poorly laid out response what the candidate was doing.

Hydrogen reacts with oxygen to form steam.

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$$

Bond energies are shown in Figure 14.

bond	bond energy in kJ mol^{-1}
H—H	435
O═O	500
O—H	460

Figure 14

Calculate the energy change for the reaction of 2 mol of hydrogen gas, H_2, with 1 mol of oxygen gas, O_2, to give 2 mol of steam, H_2O.

(4)

2 H–H + O=O → 2 H–H–O

2 (435) + 500 → 2 (435 + 460)

1370 → 1790

1370 – 1790 = –420

energy change = –420 kJ mol^{-1}

Results Plus: Examiner Comments

This response scored 3 of the 4 marks available.

The energy needed to break bonds (1370) is correctly evaluated, so the first marking point is

scored. The energy released (1790) is incorrectly evaluated (one 0-H and one H-H), so the second marking point is not scored.
The difference between the two energies is correctly evaluated (1370 - 1790 = -420), so the third marking point is scored by error carried forward. The energy change is correctly shown with negative sign, so the fourth marking point is also scored.

Hydrogen reacts with oxygen to form steam.

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$$

Bond energies are shown in Figure 14.

bond	bond energy in kJ mol^{-1}
H—H	435
O=O	500
O—H	460

Figure 14

Calculate the energy change for the reaction of 2 mol of hydrogen gas, H_2, with 1 mol of oxygen gas, O_2, to give 2 mol of steam, H_2O.

(4)

$2H_2 + O_2 \rightarrow 2H_2O$

$(435 \times 2)\ (500 \times 2)\ (460 \times 2)$

$870 + 1000 \rightarrow 920$

$1870 - 920 = 950$

energy change = 950 kJ mol^{-1}

Results Plus: Examiner Comments

This response scored 1 of the 4 marks available.

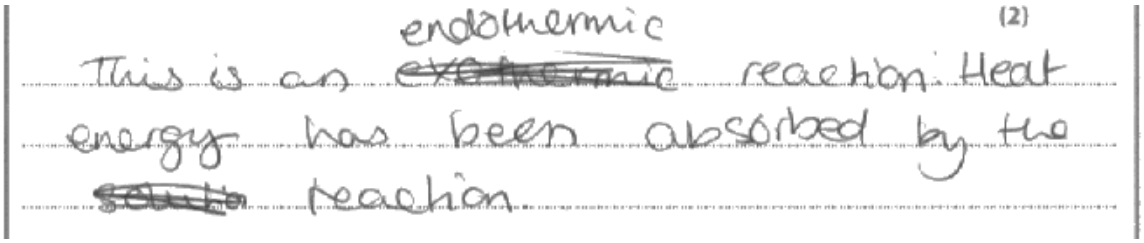
Both sets of bond calculations, namely to calculate the energies needed to break and make bonds, are incorrect so neither of the first two marking points are scored. The difference between the two energies is correctly calculated so the third marking point is scored by error carried forward. As calculated from the incorrect answers to first two marking points, the energy change should be positive showing energy absorbed. To score this mark by error carried forward, the candidates must show a + sign or say 'energy absorbed', which is not shown in this particular response, so the fourth marking point cannot be scored.

Q18.

(a)(i)

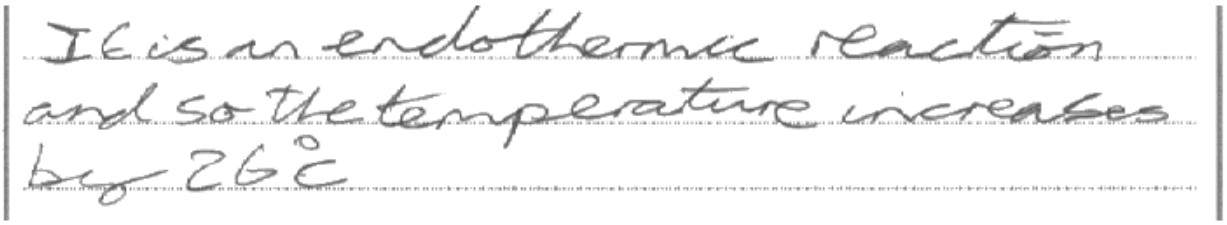
Many candidates stated that the temperature increased, although quite a few skipped that statement and stated that heat is released. Some candidates did not then link that to an exothermic reaction.

There was quite a lot of confusion between exothermic and endothermic reactions when the temperature rises and many contradictory statements were seen, for example 'the temperature increased so the reaction takes in heat'. Many candidates are unclear about the difference between heat and temperature and it was not unusual to see statements such as 'the heat increased by 26°C'.



Results Plus: Examiner Comments

This candidate knows the meaning of endothermic but unfortunately this is the wrong answer to this question so no mark was scored.



Results Plus: Examiner Comments

This candidate has stated that the temperature has increased, so scores 1 mark. Unfortunately they have mixed up the meaning of exothermic and endothermic.

Results Plus: Examiner Tip

Learn the difference between exothermic and endothermic reactions.

(2)

The temperature has risen from 20°C to 46°C showing this is a exothermic reaction which means heat is released into the atmosphere which is why it gets hotter.

Results Plus: Examiner Comments

This is a very good answer that scored 2 marks. The candidate has written about the temperature change and linked this to an exothermic reaction.

(a)(ii)

Many candidates were able to complete the equation for the reaction with the correct formulae. Some candidates completed the equation as a word equation and received no credit.

Some candidates would benefit from more practice in writing balanced equations.

$Zn + CuSO_4 \rightarrow$ zinc sulfate + copper

Results Plus: Examiner Comments

This candidate has written the names of the substances formed and scored no marks. If a question asks for formulae, you will not receive any marks for a word equation.

Results Plus: Examiner Tip

Practise writing balanced equations.

$Zn + CuSO_4 \rightarrow$ ZnCu + $ZnSO_4$

Results Plus: Examiner Comments

This candidate has scored 1 mark for the correct formula for zinc sulfate. ZnCu is incorrect. Look

at the information given in the question. The start of this question states that zinc sulfate and copper are formed.

$Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$

Results Plus: Examiner Comments

This is an example of a correct equation that scored 2 marks.

(b)

There were some excellent answers to this question. However, some candidates are confused between rate and time and wrote about time getting quicker rather than shorter. Some candidates just described the pattern in the graph and they scored 1 mark. Other candidates knew that the rate increases as the concentration increases and they also scored a mark. A common incorrect answer was that the rate decreases as the concentration increases as they had not realised that the graph was a plot of time against concentration.

The more concentration of hydrochloric acid increased the less time taken for the magnesium to react.

Results Plus: Examiner Comments

This answer scored 1 mark as it gives a clear description of the pattern shown in the graph.

Results Plus: Examiner Tip

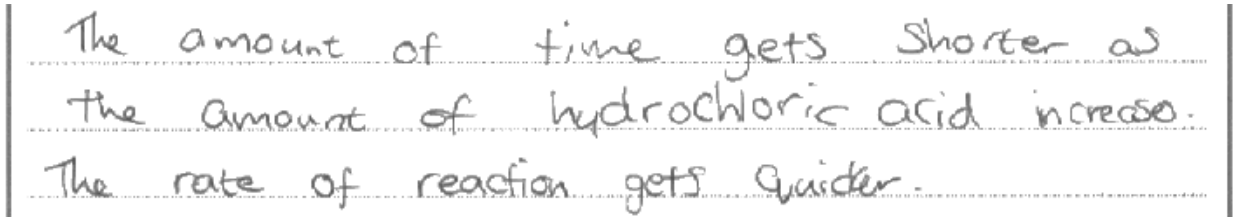
Use the labels on the axes of the graph to help you to describe the pattern shown.

As ~~more~~ the concentration of hydrochloric acid increases, the time taken for the magnesium to react gets quicker.

Results Plus: Examiner Comments

This candidate has confused rate and time so has not scored a mark.

Try to understand the difference between rate and time. As the time taken for a reaction to take place decreases, the rate of reaction increases.

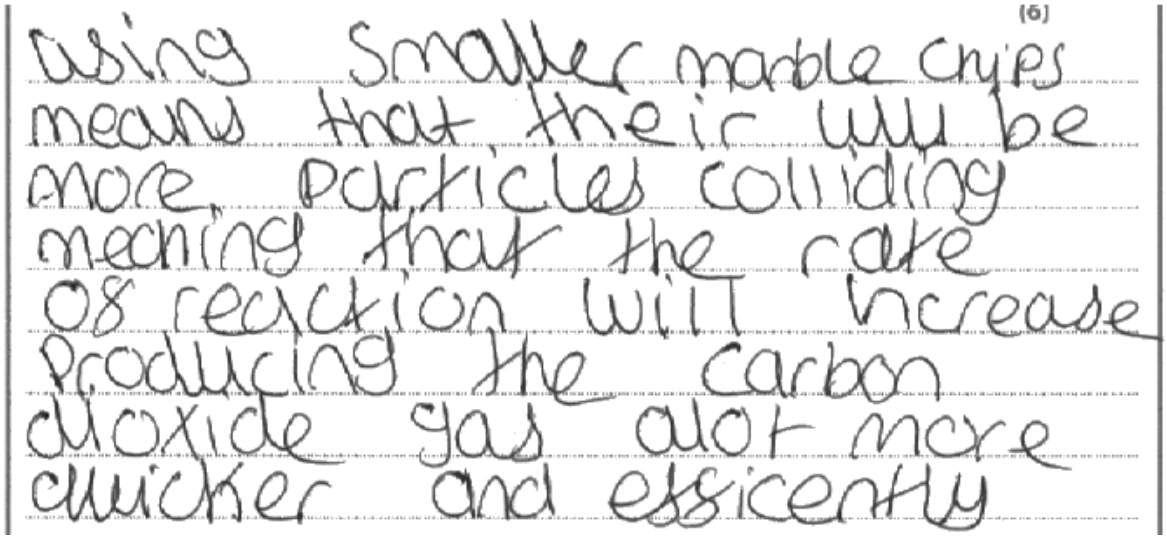

The amount of time gets shorter as the amount of hydrochloric acid increase. The rate of reaction gets quicker.

Results Plus: Examiner Comments

This is a correct answer and scored 2 marks.

(c)

Some candidates gave excellent experimental details of how to investigate the effect of using different size marble chips on the rate of reaction, showing that they had carried out these experiments. Some candidates tried to describe an experiment of adding the marble chips to a beaker of hydrochloric acid but they gave no indication of how they could measure the volume of gas produced, the mass loss or time for limewater to go milky. Some candidates seemed unfamiliar with this type of experiment but they gave good descriptions of the results they would expect and they received some credit for this. Some candidates were unfamiliar with the idea of a fair test and thought that they could investigate the rate by comparing one large chip and one small chip or use different masses of marble chips. A common misunderstanding was that smaller marble chips have a smaller surface area so they react faster. A few candidates thought that the marble chips were acting as a catalyst. Some candidates spent time writing about other factors that affect the rate of reaction but that was not needed in this question.

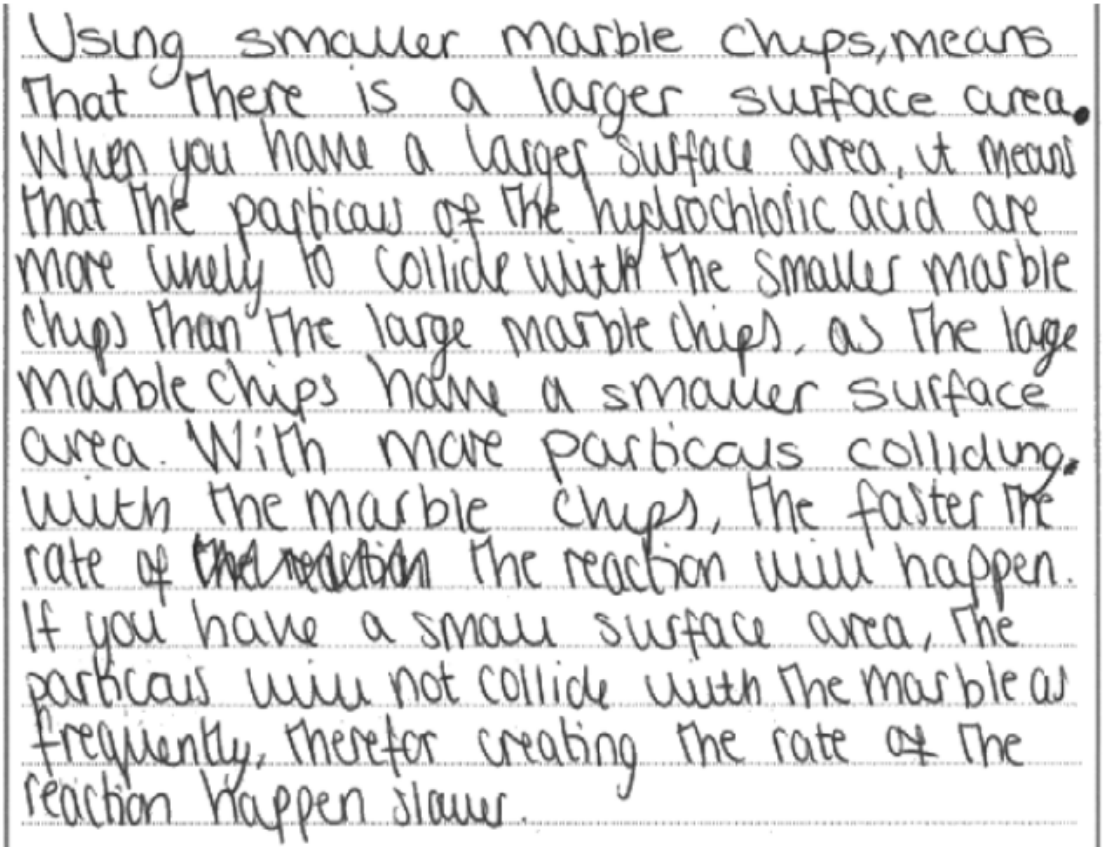

(6)
using smaller marble chips means that their will be more particles colliding meaning that the rate of reaction will increase producing the carbon dioxide gas alot more quicker and essicently

Results Plus: Examiner Comments

This is an example of a level 1 answer that scored 2 marks. The candidate has not described the experiments but does know that smaller marble chips will increase the rate of reaction.

Results Plus: Examiner Tip

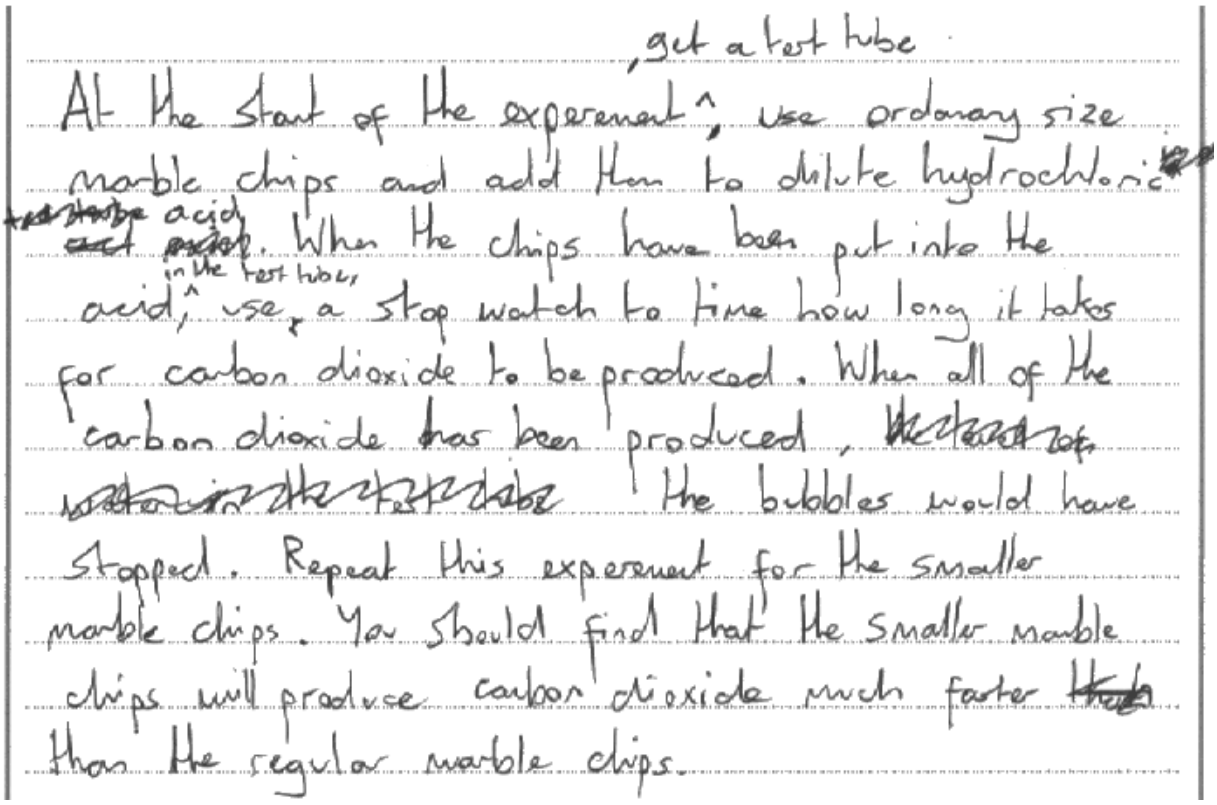
Revise the experiments that you have carried out or seen demonstrated to you so that you can describe them.


Using smaller marble chips, means that there is a larger surface area. When you have a larger surface area, it means that the particles of the hydrochloric acid are more likely to collide with the smaller marble chips than the large marble chips, as the large marble chips have a smaller surface area. With more particles colliding with the marble chips, the faster the rate of ~~the reaction~~ the reaction will happen. If you have a small surface area, the particles will not collide with the marble as frequently, therefor creating the rate of the reaction happen slower.

Results Plus: Examiner Comments

This is an example of a level 2 answer that scored 4 marks. The candidate has explained that the smaller marble chips have a larger surface area so the reaction will be faster. However, they have not described an experiment so they cannot achieve level 3.

You will only achieve the highest level if you answer the question and include a description of the experiments.


, get a test tube
At the start of the experiment, use ordinary size marble chips and add them to dilute hydrochloric acid in the test tube. When the chips have been put into the acid, use a stop watch to time how long it takes for carbon dioxide to be produced. When all of the carbon dioxide has been produced, the bubbles would have stopped. Repeat this experiment for the smaller marble chips. You should find that the smaller marble chips will produce carbon dioxide much faster than the regular marble chips.

Results Plus: Examiner Comments

This is an example of a level 3 answer that scored 6 marks. The answer gives a description of two experiments and the results that would be expected.

Q19. No Examiner's Report available for this question

Q20.

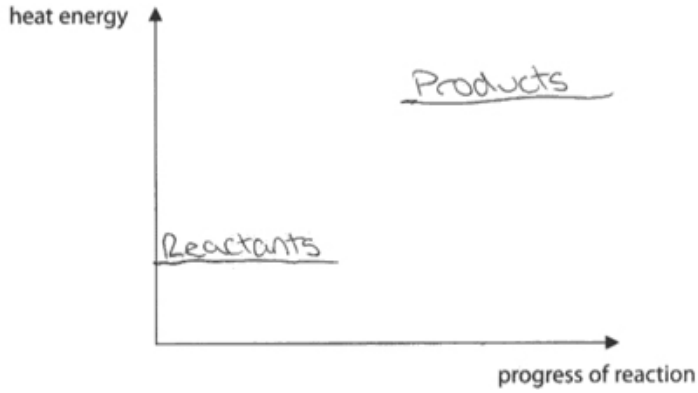
(ii)

Many candidates scored both marks but some lost a mark by either labelling the lines incorrectly or not labelling them at all. Many candidates drew a reaction profile diagram and put in the activation energy "hump" which was obviously acceptable. Some thought the products would be at a higher level than the reactants but others did not draw any horizontal lines and seemingly tried to plot some sort of graph.

(ii) This reaction is exothermic.

On the diagram below draw labelled lines to show the relative energies of the reactants and products in this reaction.

(2)



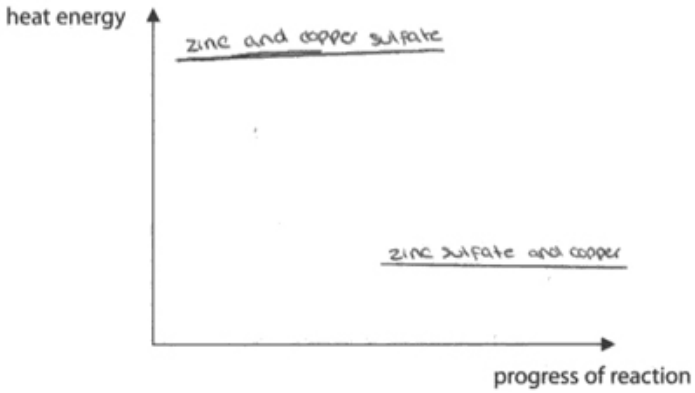
Results Plus: Examiner Comments

This is worth one mark as the products line is to the right of the reactants but does not gain the second mark as it shows an endothermic reaction.

(ii) This reaction is exothermic.

On the diagram below draw labelled lines to show the relative energies of the reactants and products in this reaction.

(2)



Results Plus: Examiner Comments

A good answer giving the names of the reactants and products (although just "reactants" and "products" was also acceptable) in their correct relative positions.

Q21. No Examiner's Report available for this question

Q22.

(i) Candidates should read the question carefully before they start on their answer. Several candidates wrote about bond breaking and bond making which did not score as the question was about how the energy level diagram showed that dissolving ammonium chloride in water was endothermic. However, many candidates produced a well-constructed answer worthy of both marks.

(ii) Although the majority could draw the correct curve with the peak above the energy level of ammonium chloride solution, many candidates showed the activation energy as the difference between the ammonium chloride solution energy level and the peak of the curve. A few candidates drew a straight line from reactants to products which left them with an impossible task of scoring a mark for the activation energy.

Q23.

There were several good answers that scored both marks with the idea of the increased surface area and a greater rate of reaction, but there were those who limited their answers to the nanoparticles being very small without further development and again these did not score.

Q24.

This question was the first of the two 6 mark levelled response questions based on the effect of changing the concentration of hydrochloric acid and changing the size of lumps of calcium carbonate on the rate of a reaction.

It was pleasing to see that candidates found this question accessible with very few blank responses seen. A good range of marks were seen with the majority scoring marks in level 3. In general, the best answers were often concise with excellent, succinct explanations, using the correct scientific terminology. It was clear that teachers have focused on teaching candidates to use clear terminology with many using the correct scientific terms throughout their answers with many candidates answering using the idea of frequency of collisions to explain their answer. Weaker candidates were confused between the increased frequency of collisions and increased energy of collisions, in these cases the lower mark in the level was awarded.

Those that scored a mark in level 2 rather than level 3, often did so as they only explained one of the factors, albeit it in good detail or if they did not relate their answer to the context of the question and referred to the amount of gas produced in the reactions. In other examples, candidates were able to give a weak explanation of both the effect of the size of the lumps and the concentration of the acid but not in detail which scored them a mark in level 2.

An investigation was carried out into the rate of reaction of calcium carbonate with dilute hydrochloric acid.

5.0g of small lumps of calcium carbonate were reacted with 50 cm^3 of 0.50 mol dm^{-3} hydrochloric acid.
Another 5.0g of the same sized lumps of calcium carbonate were reacted with 50 cm^3 of 1.0 mol dm^{-3} hydrochloric acid.
The volume of gas collected in two minutes was recorded for each experiment.

The two experiments were then repeated, each using 5.0g of large lumps of calcium carbonate.

Figure 5 shows the results.

concentration of hydrochloric acid in mol dm^{-3}	volume of gas collected in cm^3	
	small lumps of calcium carbonate	large lumps of calcium carbonate
0.50	17.2	3.1
1.0	35.1	5.6

Figure 5

Explain, in terms of collision of particles, how these results show the effect of the size of the lumps of calcium carbonate and the effect of the concentration of the acid on the rate of this reaction.

(6)

- When small lumps were used a higher volume of gas is produced because there is a larger surface area in direct contact with the HCl, meaning more collisions occur, meaning more gas is produced.
- When 1.0 concentration is used, there are more H^+ ions which can dissociate. Because there is a higher frequency, more collisions with the $CaCO_3$ occur, meaning higher rate of reaction, meaning more gas is produced.

→ The most reactive of the 4 tests was 1.0 HCl and small lumps of HCl because there was both a high concentration of H^+ ions, meaning the likelihood of collision increases, and small lumps, meaning the surface area on which to collide was larger meaning a fast rate of reaction, meaning more gas produced.

→ The next most reactive was the test will small bits and low HCl concentration. This is because the surface area is so ~~too~~ increased that it is the largest effector, and so the lower concentration decreases collisions slightly, but the rate of reaction still remains high.

→ The 3rd most reactive was the test with 1.0 conc and ~~large~~ small surface area. The 1.0 conc means high frequency of collisions, but the smaller surface area means the likelihood of collisions is decreased.

→ The least reactive was the test with large bits and 0.5 conc because there is a smaller surface area in direct contact with the HCl, which contains less H^+ ions, meaning there is a low frequency of collisions, meaning low rate of reaction, meaning small volume of gas produced.

Results Plus: Examiner Comments

In this example, the candidate has fully explained the results in the table explaining the effect of increasing concentration and changing the size of the lumps of calcium carbonate on the amount of gas produced and rate of reaction, giving more than necessary to gain the full 6 marks available in level 3.

In terms of the size of the lumps they affect the rate of reaction because smaller lumps have a larger surface area this will increase the rate of successful collisions because the particles are more likely to collide which increases rate of reaction. ~~In terms of concentration~~ if the lumps are larger the chance of successful collisions is lower because the surface area will be smaller. In ~~to~~ terms of concentration, if the concentration is higher it means there are more particles in the same ~~volume~~ volume, this increased chances of successful collisions because of the increased number of particles meaning they're more likely to collide this increases rate of reaction. The small lumps and higher concentration would have largest results but smallest rate of reaction because there are two factors which speed up rate of reaction.

Results Plus: Examiner Comments

In this example, the candidate has discussed the concentration of the hydrochloric acid and the size of the lumps of calcium carbonate but they have not related this to the results in the table and the amount of gas produced and a mark of 4 in level 2 was awarded.

The small lumps of calcium carbonate meant there was a larger surface area and that means more hydrochloric acid will be in contact with the calcium carbonate giving off more bubbles and a greater reaction. The larger [redacted] lumps have a much smaller surface area because there will be less of them meaning a smaller surface area so less of a reaction.

Results Plus: Examiner Comments

In this example, the candidate has only focused on the size of the lumps of calcium carbonate. The explanation is simple and sufficient for level 1–2 marks only.

The candidate has given the explanation for the small lumps of calcium carbonate followed by the reverse argument for large lumps. The explanation for the small lumps only was sufficient for the 2 marks and the reverse argument adds no more to the answer.

Q25.

This question was not answered well on the whole, with only half of responses scoring typically 1 out of the 2 marks available.

Most responses scored 1 mark for recognising that there is a rise in temperature or equivalent. Fewer candidates were able to score on the second marking point for recognising this an exothermic process.

It was noted by examiners that candidates used the terms endothermic and exothermic but often confused these processes. In some responses, candidates thought that stirring was the cause of the temperature rise.

The main misconception was that many candidates thought that energy was being taken in to result in a temperature rise and said this was exothermic. Some candidates clearly had not read the question since they decided that the temperature had decreased.

The student's results were

temperature of water at start	= 21 °C
temperature of mixture after stirring	= 32 °C

Explain, using these results, the type of heat energy change that occurs when calcium chloride dissolves in water.

(2)

when adding calcium chloride the temperature increases. Creating an exothermic reaction.

Results Plus: Examiner Comments

This response scored on both marking points.

There are correct references made to both 'temperature increases' and 'exothermic'.

when calcium chloride dissolves in water when stirring it rises in temperature.

Results Plus: Examiner Comments

This response scored 1 mark only.

While the rise in temperature has been stated, there is no reference made to this being an exothermic process.

Q26.

Candidates still find the concept of bond making or bond breaking very challenging and bringing the two together to explain an overall change could only be achieved by the best candidates. Marking point 3 was often not attempted or contradicted what has been written elsewhere. Some candidates talked more about the number of bonds breaking rather than comparing the amount of energy taken in or given out. Lack of the correct terminology often let candidates down in this question.

The reaction between calcium carbonate and dilute hydrochloric acid is exothermic.

Explain, in terms of bond breaking and bond making, why some reactions are exothermic.

(3)

When bonds are broken, some of the energy is released into its surroundings, making it exothermic. However, bond making uses some energy from its surroundings to form the bonds, making it endothermic.

Results Plus: Examiner Comments

A common incorrect answer that gained no credit.

Q27.

(i) Most candidates linked the cloudiness to a precipitate, slightly fewer to sulfur (even though the equation gave it as a solid product). Others identified NaCl as a solid precipitate (even though the equation gave it as aqueous), whilst others thought that the cloudiness was caused

by effervescence.

(ii) It was clear that the majority of candidates had either carried out this investigation or seen it done. A pleasing majority were able to locate a black cross correctly and knew that it would disappear. However, some were confused into discussing the effect of different concentrations of HCl, but omitted to discuss the process for measuring the rate.

Q28.

This question was poorly answered, with only around a third of the responses scoring any of 3 marks available.

In the responses that scored, mostly for 1 mark only, candidates correctly identified that there was less magnesium or reactant as the reaction takes place. Very few responses scored all three marking points.

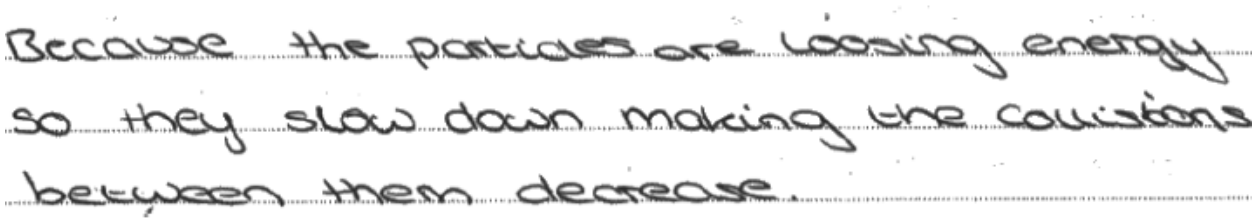
Examiners noted that very few candidates actually referred specifically to 'particles' in their responses and rarely referred to the 'frequency of particle collisions'.

In many incorrect responses, candidates misinterpreted what was required and simply listed factors affecting the rate of a reaction.

The graph shows that the rate of reaction slows as the reaction takes place.

Explain, in terms of particles, why the rate of reaction between magnesium ribbon and dilute hydrochloric acid slows as the reaction takes place.

(3)



Results Plus: Examiner Comments

This response scored 1 mark.

Although the first part of response is incorrect and was ignored, the correct idea of fewer collisions was credit worthy.

Because at first there are a lot of particles meaning that there are frequent collisions, however, as the reaction goes on more particles have already reacted so there are less particles in the same given volume so there are less frequent collisions, meaning slower rate of reaction.

Results Plus: Examiner Comments

This is a very good example of a fully correct response.

The correct ideas of fewer reaction particles and less frequent collisions scored all the available marks.

Results Plus: Examiner Tip

Remember when explaining the rate of a chemical reaction, always refer to **collision frequency** of particles.

Q29.

This question was poorly answered with only a third of responses scoring 1 or 2 of the 2 marks available.

Few candidates were able to explain mass loss in terms of a gas being formed and escaping from the flask via the loose plug to gain full credit.

Most responses scored by reference to a gas escaping. However, many did not specify that the gas had been formed or incorrectly discussed air escaping or incorrectly discussed the solution evaporating.

Common misconceptions included: dissolving magnesium means loss of mass; cotton wool soaks up the acid; energy being lost which means mass is lost; or in some cases, that gaseous magnesium escaped.

Explain why there is a loss in mass of the flask and contents.

(2)

Hydrochloric acid reacts with magnesium to form a gas - (hydrogen.) Therefore there will be a loss in mass.

Results Plus: Examiner Comments

This response scored 1 mark only.

The formation of a gas, namely hydrogen, has been correctly mentioned. However, there is no mention of the gas escaping from the flask causing the mass loss.

Results Plus: Examiner Tip

Always check the number of marks available for a question since this will indicate the number of points needed in your answer.

Because hydrogen was a product, so the gas could've escaped through the cotton wool through diffusion.

Results Plus: Examiner Comments

This response scored the 2 marks available. The fact that hydrogen is a product and also that this escapes are both credited.

Q30.

It is pleasing to note that a good number of candidates were able to discuss their response in

terms of kinetic energy, some even mentioning the change from thermal to kinetic energy. This was often linked to a higher frequency of collision (although some candidates failed to score by referring to 'more collisions', not 'more frequent collisions'). The frequency of collision and success rate of collision were confused by some candidates who are advised to refer to these aspects separately.

Q31. No Examiner's Report available for this question

Q32.

This question was well answered with most candidates gaining the 1 mark available.

The majority of responses correctly referred to 'balance' or 'scales' as the correct piece of apparatus needed to measure the mass of the solid. The inclusion of the term 'scale' alone in the mark scheme allowed many candidates to score.

Commonly seen errors in incorrect responses included the use of a: measuring cylinder; burette; pipette.

Q33. No Examiner's Report available for this question

Q34.

As with the other 6-mark question, the response to this was equally disappointing. The weakest candidates largely left this unanswered. About a quarter of the candidates achieved a level 1 answer by a very simple description of adding pieces of magnesium to different concentrations of hydrochloric acid in a suitable container. Some candidates developed this idea to describe how to make or record observations or what conclusions could be drawn. However, few candidates secured level 3, due to the absence of a solid description of a workable method.

Often where no marks were scored the response was couched in general terms and collision theory, not addressing the point of 'tell me how you would do it'. Many candidates wasted lots of lines by repeating the question. Where candidates were more successful, many different methods used to collect the hydrogen gas were seen – some mentioned filling inverted test tubes in water, others mentioned collecting it in a balloon.

*(d) Hydrochloric acid reacts with magnesium metal to produce hydrogen gas.

magnesium + hydrochloric acid → magnesium chloride + hydrogen

Describe how you could use magnesium ribbon and a solution of hydrochloric acid to show that decreasing the concentration of the hydrochloric acid changes the rate of this reaction.

(6)

The higher the concentration of acid, the quicker the rate of the reaction will be. If you have 5 test tubes all with a piece of magnesium ribbon in and put the same amount of hydrochloric acid in each test tube, however each test tube has a different amount of concentration. For example 0m, 0.25m, 0.5m, 0.75m and 1m then you could witness the speed in which it takes, using a stopwatch, for the reaction between hydrochloric acid and magnesium metal to produce hydrogen gas. Also conecting the test tubes using a delivery tube to the gas cyclinder measuring how much hydrogen gas is produced in a set amount of time.

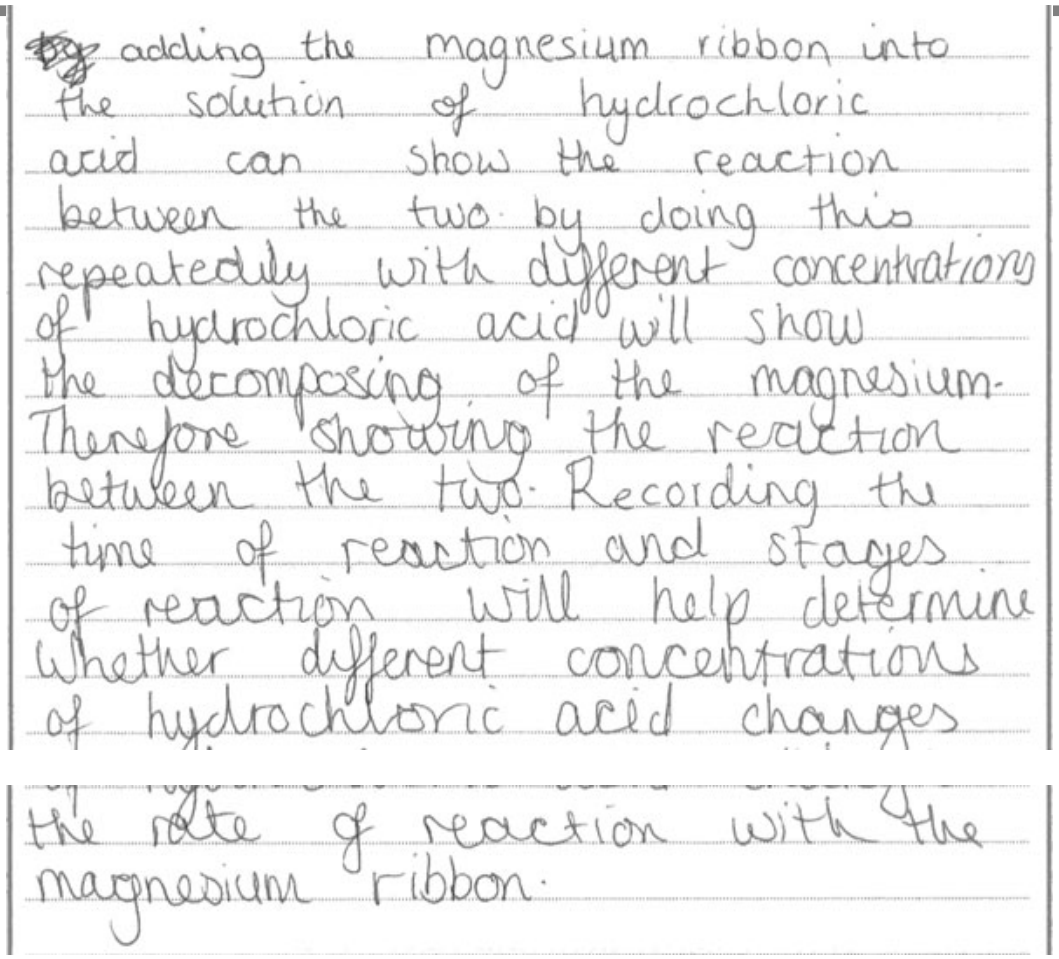
Results Plus: Examiner Comments

This was judged to be a level 3 answer. This answer could be read and understood as to how to go about finding out how decreasing the concentration of hydrochloric acid changes the rate of reaction. However, there were several spelling and grammar errors which meant that this answer scored 5 marks.

- As you change the concentration of acid the rate of reaction will change due to the collision theory.
- The higher the concentration the quicker the reaction as there will be more collisions meaning the magnesium and hydrochloric acid will react together quicker.
- The magnesium ribbon could be used as a way of identifying the rate this reaction has taken place.

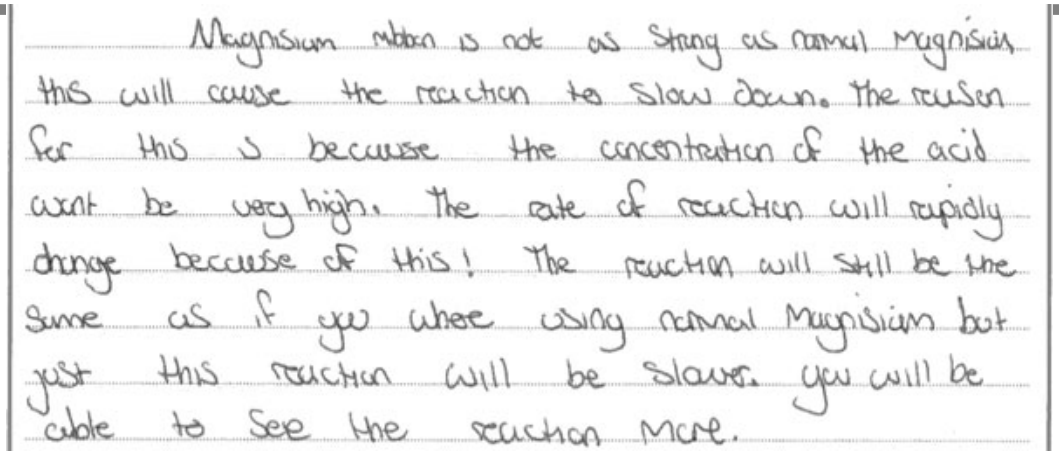
Results Plus: Examiner Comments

Many candidates did not answer the question of how this reaction could be carried out to show that decreasing the concentration changed the rate of reaction. This candidate did give a valid conclusion which was judged to be a level 1 answer with a mark of 1.


adding the magnesium ribbon into the solution of hydrochloric acid can show the reaction between the two by doing this repeatedly with different concentrations of hydrochloric acid will show the decomposing of the magnesium. Therefore showing the reaction between the two. Recording the time of reaction and stages of reaction will help determine whether different concentrations of hydrochloric acid changes the rate of reaction with the magnesium ribbon.

Results Plus: Examiner Comments

This answer was judged to be level 2. However it lacked the detail needed for level 3 and was awarded 4 marks.


Magnesium ribbon is not as strong as normal magnisium this will cause the reaction to slow down. The reason for this is because the concentration of the acid wont be very high. The rate of reaction will rapidly change because of this! The reaction will still be the same as if you where using normal Magnisium but just this reaction will be slower. you will be cable to see the reaction more.

Results Plus: Examiner Comments

Several candidates were well off the mark when it came to answering this question. This was an example of where a candidate was probably unsure as to what magnesium ribbon was. Another candidate could only give the response 'I don't know what magnesium ribbon is so I can't answer the question.' This answer really did not answer the question at all and was given 0 marks.

Results Plus: Examiner Tip

Practice answering the 6-mark questions. Read the question carefully and use the information to help you put together your ideas and then write out your answer.

Q35. No Examiner's Report available for this question

Q36. No Examiner's Report available for this question

Q37.

This question was very well answered with a significant majority of responses scoring the 1 mark available.

Most correct responses referred to the use of goggles or gloves. In many responses where glasses were referred to, candidates specified 'safety' glasses to score the mark. Reference to 'glasses' alone did not score.

Commonly seen incorrect answers included: wear an apron, tie long hair back, washing hands, use a blast shield, being careful or wearing a mask.

(ii) Give a safety precaution that the student should take during the experiment. (1)



Results Plus: Examiner Comments

This response was typically seen and not credit worthy.

The use of glasses alone in insufficient and to score would need to be qualified, i.e. safety glasses.

Q38. No Examiner's Report available for this question

Q39.

(i) Most candidates gave the answer of using a water bath to control the temperature. Incorrect suggestions included using a Bunsen burner or even a thermometer.

(ii) Many could draw a correct tangent and a calculated gradient that fell within an acceptable range. Although some did have a correct tangent, errors were when calculating the gradient such as diving the horizontal difference by the vertical difference or miscalculating one of those differences. Most of those scoring 0 marks were where the volume of gas produced at 100 seconds was divided by the time.

(iii) Most candidates could correctly identify another variable that needed to be controlled.

(iv) Most candidates scored at least two marks here for making the points that with a decreasing temperature the particles would have lower energy which results in a lower rate of reaction. Only the most able candidates correctly made the important point about fewer successful collisions on decreasing the temperature.

Q40. No Examiner's Report available for this question

Q41. No Examiner's Report available for this question

Q42. No Examiner's Report available for this question

Q43.

Stating 'gas syringe' as the piece of apparatus shown in the diagram proved quite difficult for candidates with many giving unsuitable alternatives or leaving a blank.

Q44. No Examiner's Report available for this question

Q45.

Most candidates identified a measuring cylinder as a more suitable measuring instrument.Some suggested pipette or burette, which wereallowed.

Answers that did not score included measuring jug, measuring cup, repeating the experiment or 'weigh the water'.

Q46.

This response was well answered on the whole with most responses scoring the 1 mark available.

The majority of responses correctly referred either to 'measuring cylinder' or occasionally a 'burette' or 'pipette' as the correct piece of apparatus needed to measure the dilute hydrochloric acid.

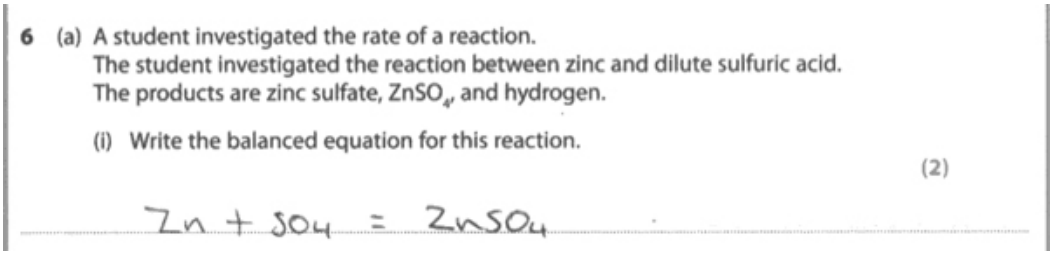
Commonly seen errors in incorrect responses included the use of a: measuring tube; measuring jug; beaker.

Q47. No Examiner's Report available for this question

Q48.

(i)

Very few candidates could write a correct formula for sulphuric acid. SO4 was often seen even though hydrogen still appeared on the right-hand side of the equation. More candidates gained the mark for correct products as the formula for zinc sulphate was given but some even lost this mark as they wrote hydrogen as H.



6 (a) A student investigated the rate of a reaction.
The student investigated the reaction between zinc and dilute sulfuric acid.
The products are zinc sulfate, $ZnSO_4$, and hydrogen.

(i) Write the balanced equation for this reaction.

(2)

$Zn + SO_4 = ZnSO_4$

Results Plus: Examiner Comments

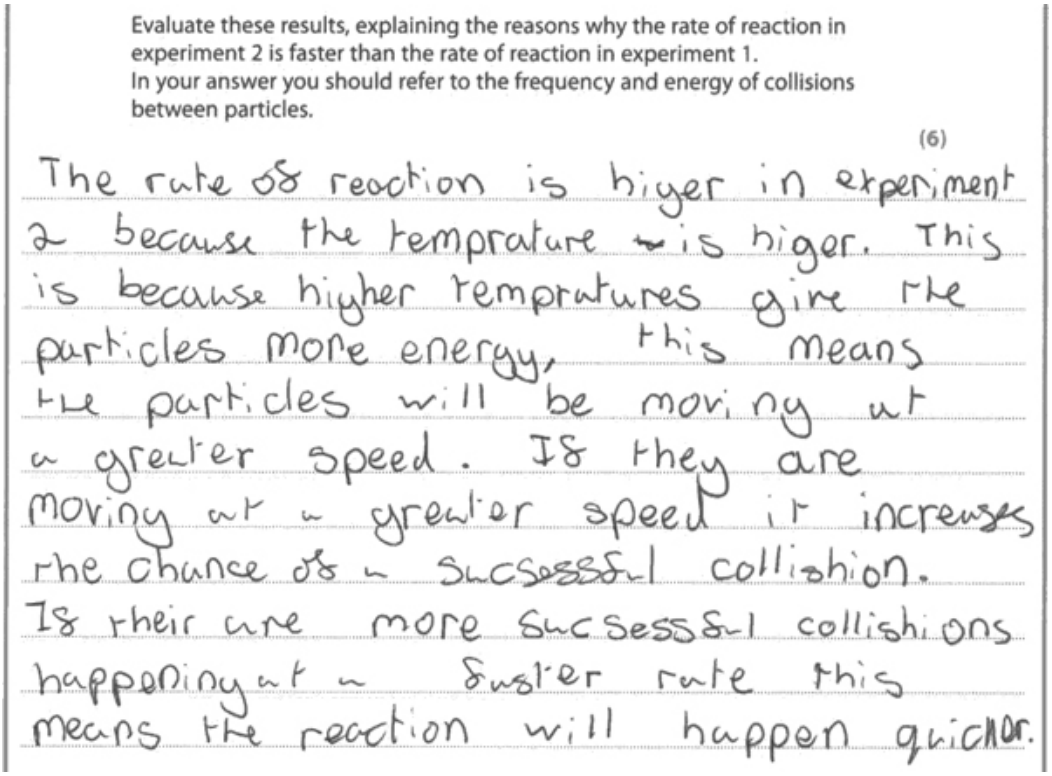
A common incorrect attempt for the formula of sulfuric acid.

(ii)

This proved to be a very accessible and hence well answered question, with the large majority of candidates producing a level 2 or 3 answer. Most candidates demonstrated a good understanding of the collision theory. The effect of the changed conditions was often well described, with the best answers containing separate considerations of the effect of concentration and temperature. However many candidates did not distinguish between their explanations for temperature and concentration and gave a combined answer rather than explaining each factor in turn. As a result these candidates often referred to an increase in concentration making the particles move faster or having more energy. Sometimes candidates lost marks because they only referred to concentration effects or temperature effects, rather than both. Many candidates omitted the need for successful collisions, simply stating that collision frequency would be increased.

Evaluate these results, explaining the reasons why the rate of reaction in experiment 2 is faster than the rate of reaction in experiment 1.
In your answer you should refer to the frequency and energy of collisions between particles.

(6)



Results Plus: Examiner Comments

This answer contains a good description of the effect of increasing temperature but does not mention concentration and so is unable to access level 3.

Evaluate these results, explaining the reasons why the rate of reaction in experiment 2 is faster than the rate of reaction in experiment 1.
In your answer you should refer to the frequency and energy of collisions between particles.

(6)

The rate of reaction was alot faster due to the difference between the tempurature that was use in experiment 1+2. In experiment 1 the temp was 20 and 2 the temp was 40. This praves that the higher the temp the quicker the reaction is. Also using different amounts of concemtrated Sulfuric acid helps to increase the rate of reaction. This is because the peiece of zinc would have more to react with making the reation stronger.

Results Plus: Examiner Comments

This answer just gives a limited description and so is a level 1 response.

Evaluate these results, explaining the reasons why the rate of reaction in experiment 2 is faster than the rate of reaction in experiment 1.
In your answer you should refer to the frequency and energy of collisions between particles.

(6)

As the concentration of sulfuric acid and the temperature increases, the rate of the reaction also increases. When the concentration increases, there are more particles per cm^3 which means there are more frequent collisions between the particles. More frequent collisions means more successful collisions. When the temperature is increased, the particles move a lot faster. When the particles move faster, they move with a lot more energy which means there are more frequent collisions. The more frequent the collisions are, the more successful the collisions are and therefore the rate of the reaction increases.

Results Plus: Examiner Comments

A detailed description of the effect of increasing the concentration and temperature and worthy of six marks.

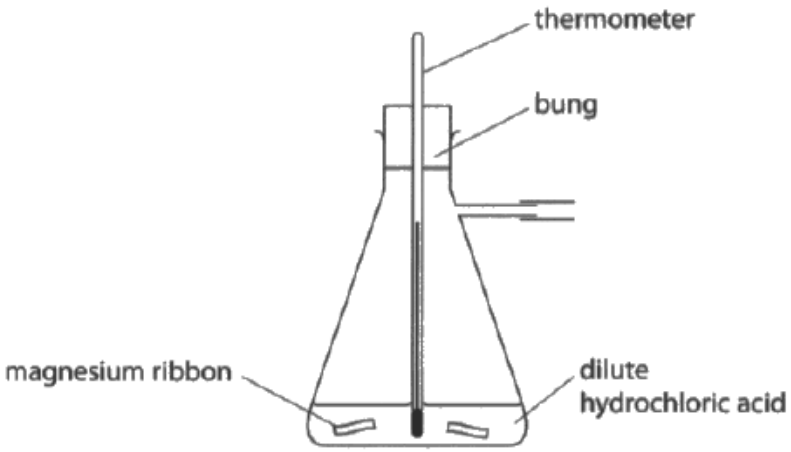
Q49.

(a)

There were many misconceptions and misunderstanding of the meanings of the state symbols. There were many who did not understand the meaning of (aq) and several different alternatives were suggested. Surprisingly, some who gave correct meanings of (aq) then proceeded to say (l) meant either a solid or a gas. It was not unusual to see statements such as 'aq is more reactive'.

Chemical reactions

4 The apparatus shown was used by a student to investigate the reaction between strips of magnesium ribbon and **excess** dilute hydrochloric acid.



The word equation for the reaction is

$$\text{magnesium(s)} + \underset{\text{acid}}{\text{hydrochloric}}\text{(aq)} \rightarrow \underset{\text{chloride}}{\text{magnesium}}\text{(aq)} + \text{hydrogen(g)}$$

(a) States of substances in reactions can be shown by state symbols.

Explain the difference between magnesium chloride(aq) and magnesium chloride(l).

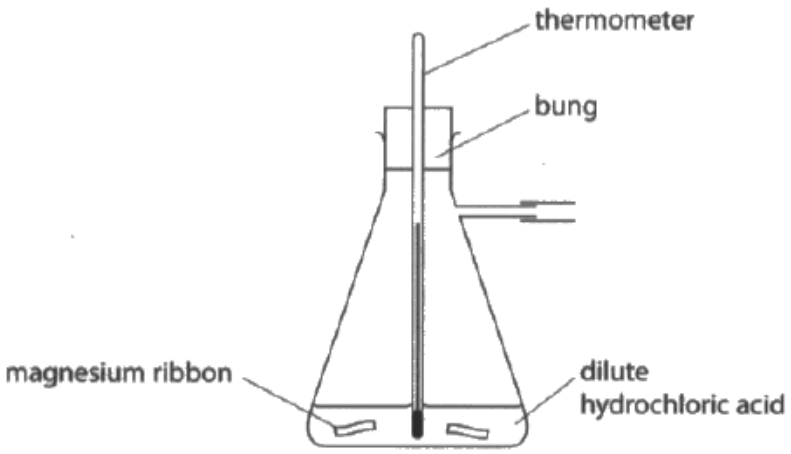
(2)

(aq) is a solid and magnesium chloride (l) is a liquid.

Results Plus: Examiner Comments

This type of response was surprisingly common.

4 The apparatus shown was used by a student to investigate the reaction between strips of magnesium ribbon and **excess** dilute hydrochloric acid.



The word equation for the reaction is

$$\text{magnesium(s)} + \underset{\text{acid}}{\text{hydrochloric}}\text{(aq)} \rightarrow \underset{\text{chloride}}{\text{magnesium}}\text{(aq)} + \text{hydrogen(g)}$$

(a) States of substances in reactions can be shown by state symbols.

Explain the difference between magnesium chloride(aq) and magnesium chloride(l).

(2)

Magnesium chloride (aq) is a gas and Magnesium chloride (l) is a Liquide

Results Plus: Examiner Comments

Another common incorrect explanation of (aq)

(b)

Many candidates correctly suggested fizzing or bubbling. Temperature rise was common too. This was an acceptable answer as a thermometer was shown in the diagram.
However, many candidates then lost the mark by also giving an incorrect observation such as a white flame or suggesting would be seen.

(b) Describe what you would **see** when magnesium ribbon reacts with dilute hydrochloric acid.

(1)

Bubbles, a gas is being released

Results Plus: Examiner Comments

The mark was awarded for reference to bubbles but other candidates simply gave the second

part of the response - "a gas/hydrogen being produced/released" which was not sufficient to gain a mark.

(b) Describe what you would **see** when magnesium ribbon reacts with dilute hydrochloric acid.

It sets on fire with a bright light. (1)

Results Plus: Examiner Comments

This candidate, like many others, incorrectly thought the magnesium would set alight.

(c) (i)

The mark was most frequently awarded for a gas syringe but a measuring cylinder was also commonly seen. A variety of incorrect responses were given, some quite surprising such as thermometer, stop watch and ruler.

(c) Every 20 seconds, the student recorded the total volume of hydrogen produced in the reaction.

(i) Name a piece of apparatus the student should use to measure the volume of hydrogen produced. (1)

a gas ~~Fire~~ syringe

Results Plus: Examiner Comments

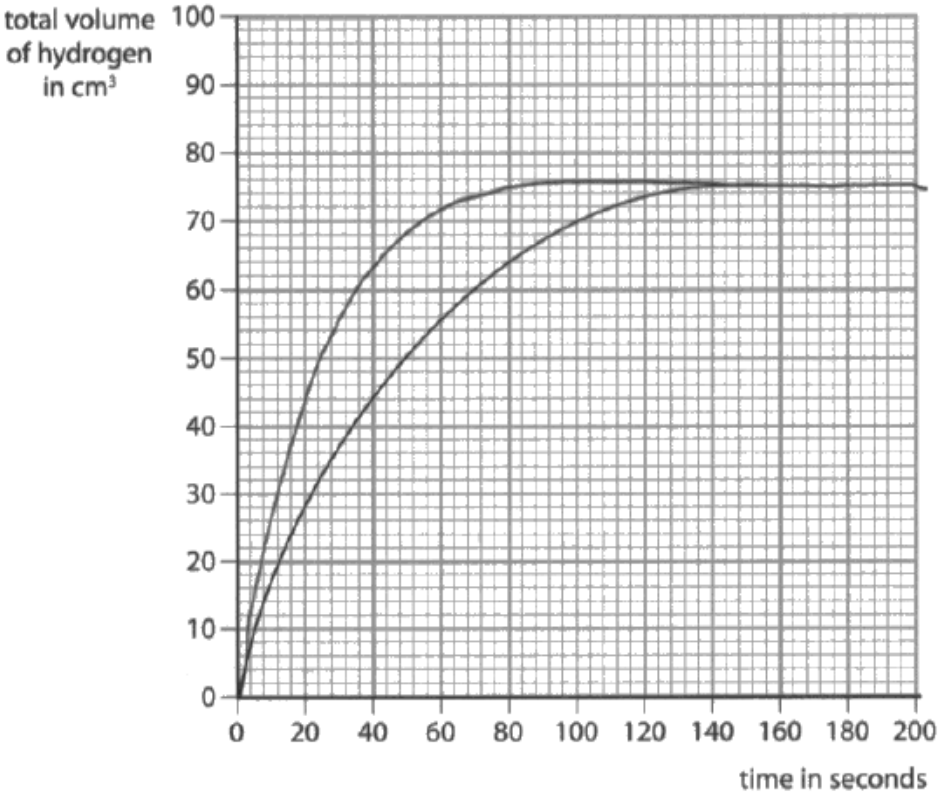
This was the most common correct answer.

(c) (ii)-(iii)

(ii) The majority of candidates did not appreciate when the reaction ended and gave an incorrect answer of 180cm^3.

(iii) Many candidates scored 1 mark for drawing a line above the original, but many fewer realised the curve should end at the same volume as the original.

The results are shown on the graph.



(ii) After how many seconds had all the magnesium reacted?

(1)

140 seconds

(iii) The experiment is repeated using the same volume of a more concentrated hydrochloric acid solution.
All other conditions were kept the same.

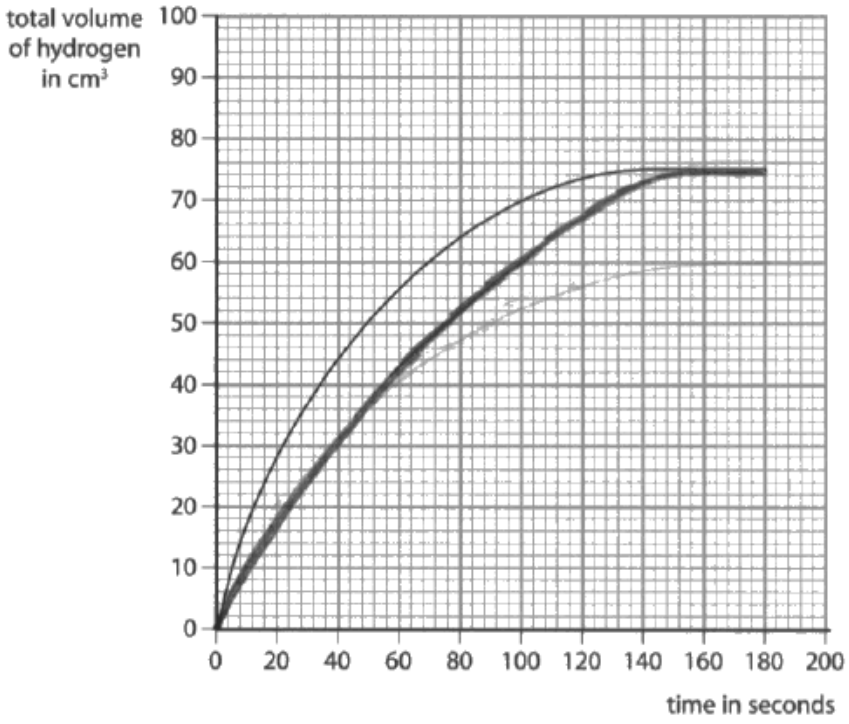
On the graph draw a curve to show how the volume of hydrogen changes with time during this experiment.

(2)

Results Plus: Examiner Comments

This is an example of a response worth all 3 marks.

The results are shown on the graph.



(ii) After how many seconds had all the magnesium reacted?

(1)

180 seconds

(iii) The experiment is repeated using the same volume of a more concentrated hydrochloric acid solution.
All other conditions were kept the same.

On the graph draw a curve to show how the volume of hydrogen changes with time during this experiment.

(2)

Results Plus: Examiner Comments

180 is incorrect and does not score a mark.

The curve is below the original one and so did not score the first mark but it finishes at the correct volume and so was awarded 1 mark.

(d)

The majority of candidates correctly stated that the rate of reaction increased or that the reaction was quicker, and many also gave a correct explanation. However it was common for candidates to mistakenly suggest that the reason for the increased rate was that the powder had a smaller surface area. A small but significant number gave an incorrect relationship stating that the reaction would be slower.

(d) A student repeated the original experiment using the same mass of magnesium as a powder instead of as ribbon.
All other conditions were the same as in the first experiment.

Explain the effect on the rate of reaction of using magnesium powder instead of magnesium ribbon.

(2)

It will React Quicker because there IS more Surface Area

Results Plus: Examiner Comments

A response worth two marks.

(d) A student repeated the original experiment using the same mass of magnesium as a powder instead of as ribbon.
All other conditions were the same as in the first experiment.

Explain the effect on the rate of reaction of using magnesium powder instead of magnesium ribbon.

(2)

The surface area has change so the rate of reaction will increase.

Results Plus: Examiner Comments

This scored a mark for stating the rate of reaction will increase but has stated the surface area changes not *increases* so was not worth the second mark.

(e)

Most candidates indicated the increase in temperature. However it then proved more difficult to gain the second mark with many suggesting the reaction was endothermic or contradicting themselves by saying it was an exothermic reaction as heat was taken in. Some candidates thought the temperature had risen due to various external factors and then explained the effect of raising the temperature on the rate of reaction.

(e) When magnesium reacts with dilute hydrochloric acid there is a change in temperature.

In an experiment the results were
temperature at start = 21 °C
temperature at end = 62 °C

Explain what conclusion can be made about the type of reaction, from these results.

(2)

There was an endothermic reaction as the temperature had increased from the beginning to the end. There was more temperature recorded at the end than there was at the beginning

(Total for Question 4 = 11 marks)



Results Plus: Examiner Comments

This was a common occurrence as the candidate scores a mark for stating the temperature had increased but then incorrectly states this meant it was an endothermic reaction.

Q50.

(b)

The majority of candidates gained a mark for stating that at a higher temperature the particles will have more energy or alternatively move faster. However, only about a third then gained a second mark by mentioning more *frequent* collisions or *more* successful collisions. Usually they did not gain the second mark because they simply mentioned more collisions without the key reference to a time factor. Another acceptable idea was a correct reference to activation energy

but these types of answers were not often seen.

(b) Explain why increasing the temperature of a reaction increases the rate of the reaction.

(2)

This gives the particles more energy. As a result they move faster and collide more frequently, with higher energy collisions. The more collisions between particles, the higher the rate of reaction.

Results Plus: Examiner Comments

A good response which refers to both the idea of the particles having more energy and colliding more frequently, and so was awarded two marks.

(b) Explain why increasing the temperature of a reaction increases the rate of the reaction.

(2)

Increasing the temperature of a reaction increases the rate of the reaction because it makes the particles in the reaction move faster.

Results Plus: Examiner Comments

The candidate was awarded one mark for stating that the particles would move faster but there is no reference to more frequent or more successful collisions.

(b) Explain why increasing the temperature of a reaction increases the rate of the reaction.

(2)

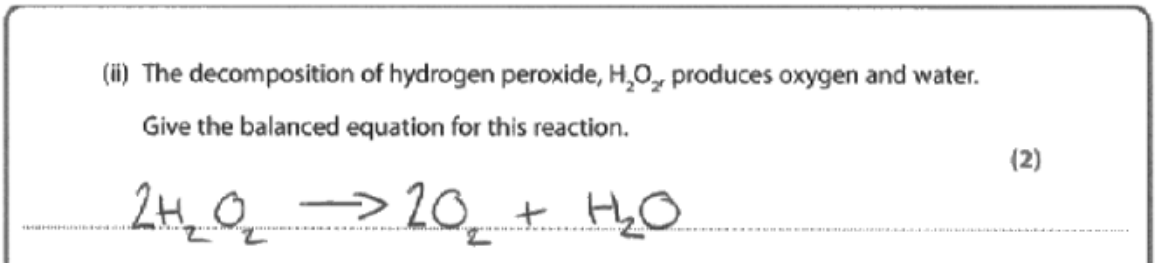
Increasing the temperature of a reaction increases the rate of reaction because it makes the particles move ~~quicker~~ faster, causing more collisions, speeding up the rate of reaction.

Results Plus: Examiner Comments

One mark was awarded for the particles moving faster but "more collisions" was not sufficient for a second mark which required a reference to "more frequent" or "more successful" collisions.

(c)(ii)

Almost half the candidates gave a fully correct answer and others gained a mark for giving three correct formulae. However it was disappointing to see oxygen gas often being shown as O, rather than O_2. Even more disappointingly, the formula for water was sometimes incorrect as was the formula of hydrogen peroxide despite it being given in the question.


(ii) The decomposition of hydrogen peroxide, H_2O_2, produces oxygen and water.

Give the balanced equation for this reaction.

(2)

$2H_2O_2 \rightarrow 2O_2 + H_2O$

Results Plus: Examiner Comments

This response gained one mark for all the correct formulae, but not the second mark, as it was not correctly balanced.

(d)

This question proved very challenging with only just over a third of candidates gaining any credit for their answers. Most either simply did not appreciate that bond breaking requires energy and bond formation releases energy or, as was often the case, they made contradictory statements such as "the energy needed to break the bonds is less than the energy needed to make the bonds".

Some students failed to make the link between bond making and bond breaking in their answers, and just gave simple statements such as "in exothermic reactions heat is given out".

(d) Explain, in terms of the energy involved in the breaking of bonds and in the making of bonds, why some reactions are exothermic.

(2)

When bonds are being made in a reaction and heat is given off then this is an exothermic reaction.

(Total for Question 2 = 8 marks)

Results Plus: Examiner Comments

This response gained one mark for a correct reference to bond making involving heat being given off.

(d) Explain, in terms of the energy involved in the breaking of bonds and in the making of bonds, why some reactions are exothermic.

(2)

Some reactions are exothermic (they give off heat). As there is more energy released when new bonds are formed than the energy taken in to break the old bond so more energy is given out overall making it exothermic.

(Total for Question 2 = 8 marks)

Results Plus: Examiner Comments

This answer was worth both marks.

(d) Explain, in terms of the energy involved in the breaking of bonds and in the making of bonds, why some reactions are exothermic.

(2)

Making bonds are endothermic
This is because alot of heat energy is released in making bonds where as breaking bond is exothermic and requires less energy and energy is released when breaking bonds

(Total for Question 2 = 8 marks)

Results Plus: Examiner Comments

Unfortunately incorrect responses similar to this, in which the ideas were completely mixed up, were quite common.

Q51.

(a) (i)

This question was generally answered well and scoring the mark. Unfortunately, several candidates were giving two or sometimes three HAZCHEM descriptors or contradictions that meant the mark could not be awarded. More worrying were answers of the type 'Sodium hydroxide is an acid....'.

Reactions

6 (a) A technician made some dilute sodium hydroxide solution by carefully adding some solid sodium hydroxide to pure water.

This is the hazard symbol on a bottle of solid sodium hydroxide.



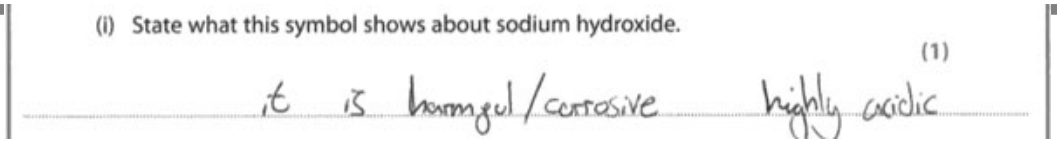
(i) State what this symbol shows about sodium hydroxide.

(1)

toxic - it can burn through anything (~~errove~~ arroding)

Results Plus: Examiner Comments

Many candidates were mixing the descriptions for the hazard symbols. 0 mark was given for the answer 'toxic'.


(i) State what this symbol shows about sodium hydroxide.

(1)

it is harmful/corrosive highly acidic

Results Plus: Examiner Comments

Several candidates were hedging their bets by giving alternative answers. Candidates should be deterred from this as an incorrect alternative will negate the mark as in this case. 0 mark given.

Results Plus: Examiner Tip

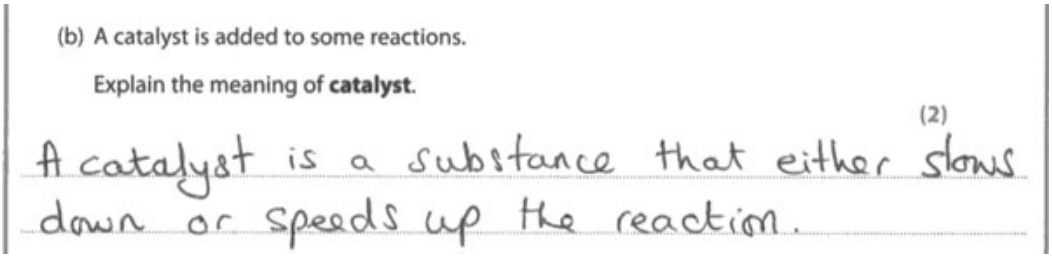
Know the meanings of the hazard symbols.

Avoid giving alternative answers as in this example as an incorrect answer will negate the mark.

(b)

Of the candidates who scored a mark on this question, the overwhelming majority was for stating that a catalyst speeds up a reaction. However the second point about it not being used up or changed during the reaction was only scored by a minority of the candidates. Many candidates made at an attempt at the second point but stated something similar to 'not involved/does not take part' in the reaction, despite saying it speeded up the reaction. A few of the most able on this paper did write about lowering activation energy, which gained credit, but is not a requirement of this specification.

The weaker candidates where they did attempt this question were making reference to catalytic convertors on vehicles.


(b) A catalyst is added to some reactions.

Explain the meaning of **catalyst**.

(2)

A catalyst is a substance that either slows down or speeds up the reaction.

Results Plus: Examiner Comments

At this level we consider catalysts as increasing the speed of a reaction. This answer contradicts

itself, perhaps by the candidate not being completely sure, so does not score the mark.

(b) A catalyst is added to some reactions.

Explain the meaning of **catalyst**.

(2)

This speeds up a chemical reaction, so if you react two chemicals and the reaction is slow you add a ~~catalyst~~ catayst to speed it up.

Results Plus: Examiner Comments

The same point is being made twice here, so only 1 mark was awarded.

(b) A catalyst is added to some reactions.

Explain the meaning of **catalyst**.

(2)

A catalyst is something thats added to a chemical reaction to speed it up. But it doesn't take place in the reaction.

Results Plus: Examiner Comments

This was given 1 mark for the first sentence in the answer; however, the second sentence was frequently seen and gained no credit.

Results Plus: Examiner Tip

Know the factors that can increase the rate of a chemical reaction and be able to explain how changing that factor causes the increase in the reaction rate.

(c)

There was much confusion over size of calcium carbonate pieces and its surface area; many stated that large had a large surface area, small pieces a small surface area. The majority of the candidates repeated the data in the question and consequently narrowed down their possible score to one by stating that 'the smaller the pieces the faster the reaction'. There were some really elegant one sentence responses scoring both marks, but they were sadly, few and far between.

Describe what this shows about the effect of the surface area of calcium carbonate on the rate of this reaction.

(2)

The smaller the size of calcium carbonate pieces used, the bigger the volume of carbon dioxide released in five minutes.

Results Plus: Examiner Comments

This answer merely summarised the table of information in the question and scored 0 marks.

Describe what this shows about the effect of the surface area of calcium carbonate on the rate of this reaction.

(2)

the longer the surfuace are the less carbon dioxide released the smaller the surface of calcium carbonate use the the higher the volume of carbon dioxide released.

Results Plus: Examiner Comments

This is where a candidate has confused particle size with its surface area. In addition, the second half of this answer is the reverse argument of the first half. Many candidates fell into this situation of incorrectly linking large particle size with large surface as well as repeated their answer with the reverse argument as demonstrated here.

Results Plus: Examiner Tip

If you take a large lump of solid and start to break it up into smaller pieces, the total surface of the smaller pieces is greater than that of the large lump. This means there is more surface over which reactions can occur and so the reaction is faster.

Remember: the smaller the pieces - the larger the surface area - the faster the reaction.

(d)

As with the other 6-mark question, the response to this was equally disappointing. The weakest candidates largely left this unanswered. About a quarter of the candidates achieved a level 1 answer by a very simple description of adding pieces of magnesium to different concentrations of hydrochloric acid in a suitable container. Some candidates developed this idea to describe how to make or record observations or what conclusions could be drawn. However, few candidates secured level 3, due to the absence of a solid description of a workable method.

Often where no marks were scored the response was couched in general terms and collision theory, not addressing the point of 'tell me how you would do it'. Many candidates wasted lots of lines by repeating the question. Where candidates were more successful, many different methods used to collect the hydrogen gas were seen – some mentioned filling inverted test tubes in water, others mentioned collecting it in a balloon.

*(d) Hydrochloric acid reacts with magnesium metal to produce hydrogen gas.

magnesium + hydrochloric acid → magnesium chloride + hydrogen

Describe how you could use magnesium ribbon and a solution of hydrochloric acid to show that decreasing the concentration of the hydrochloric acid changes the rate of this reaction.

(6)

The higher the concentration of acid, the quicker the rate of the reaction will be. If you have 5 test tubes all with a piece of magnesium ribbon in and put the same amount of hydrochloric acid in each test tube, however each test tube has a different amount of concentration. For example ~~0.1m~~ 0m, 0.25m, 0.5m, 0.75m and 1m then you could witness the speed in which it takes, using a stopwatch, for the reaction between hydrochloric acid and magnesium metal to produce hydrogen gas. Also connecting the ~~gas~~ test tubes using a delivery tube to the gas cyclinder measuring how much hydrogen gas is produced in a set amount of time.

Results Plus: Examiner Comments

This was judged to be a level 3 answer. This answer could be read and understood as to how to go about finding out how decreasing the concentration of hydrochloric acid changes the rate of reaction. However, there were several spelling and grammar errors which meant that this answer scored 5 marks.

- As you change the concentration of acid the rate of reaction will change due to the collision theory.
- The higher the concentration the quicker the reaction as there will be more collisions meaning the magnesium and hydrochloric acid will react together quicker.
- The magnesium ribbon could be used as a way of identifying the rate this reaction has taken place.

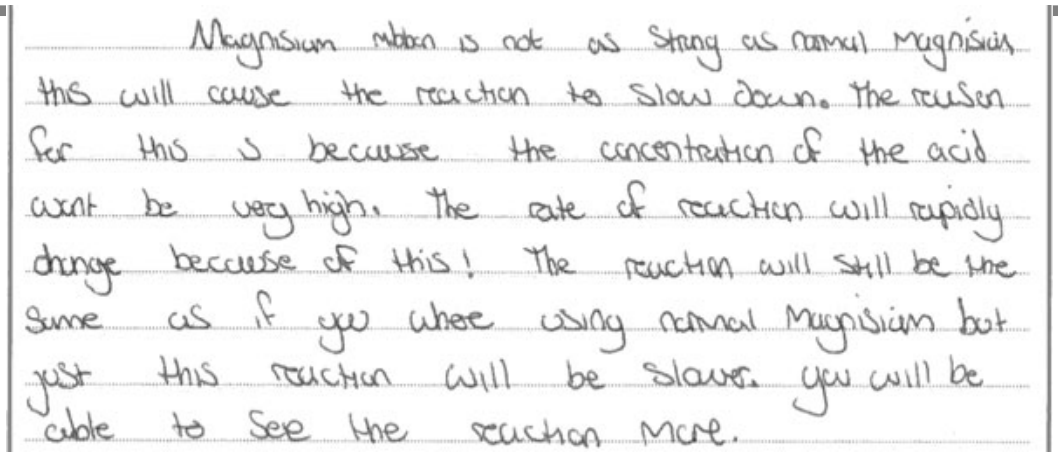
Results Plus: Examiner Comments

Many candidates did not answer the question of how this reaction could be carried out to show that decreasing the concentration changed the rate of reaction. This candidate did give a valid conclusion which was judged to be a level 1 answer with a mark of 1.

adding the magnesium ribbon into the solution of hydrochloric acid can show the reaction between the two by doing this repeatedly with different concentrations of hydrochloric acid will show the decomposing of the magnesium. Therefore showing the reaction between the two. Recording the time of reaction and stages of reaction will help determine whether different concentrations of hydrochloric acid changes the rate of reaction with the magnesium ribbon.

Results Plus: Examiner Comments

This answer was judged to be level 2. However it lacked the detail needed for level 3 and was awarded 4 marks.


Magnisium ribbon is not as strong as normal magnisium this will cause the reaction to slow down. The reason for this is because the concentration of the acid wont be very high. The rate of reaction will rapidly change because of this! The reaction will still be the same as if you where using normal Magnisium but just this reaction will be slower. you will be able to see the reaction more.

Results Plus: Examiner Comments

Several candidates were well off the mark when it came to answering this question. This was an example of where a candidate was probably unsure as to what magnesium ribbon was. Another candidate could only give the response 'I don't know what magnesium ribbon is so I can't answer the question.' This answer really did not answer the question at all and was given 0 marks.

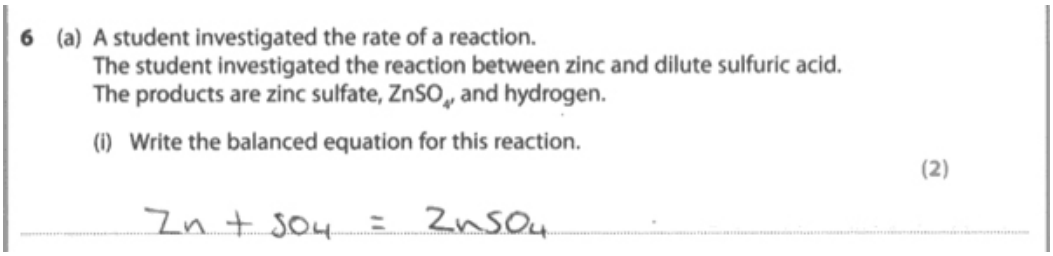
Results Plus: Examiner Tip

Practice answering the 6-mark questions. Read the question carefully and use the information to help you put together your ideas and then write out your answer.

Q52.

(a) (i)

Very few candidates could write a correct formula for sulphuric acid. SO4 was often seen even though hydrogen still appeared on the right-hand side of the equation. More candidates gained the mark for correct products as the formula for zinc sulphate was given but some even lost this mark as they wrote hydrogen as H.


6 (a) A student investigated the rate of a reaction.
The student investigated the reaction between zinc and dilute sulfuric acid.
The products are zinc sulfate, $ZnSO_4$, and hydrogen.

(i) Write the balanced equation for this reaction.

(2)

$Zn + SO_4 = ZnSO_4$

Results Plus: Examiner Comments

A common incorrect attempt for the formula of sulfuric acid.

(a) (ii)

This proved to be a very accessible and hence well answered question, with the large majority of candidates producing a level 2 or 3 answer. Most candidates demonstrated a good understanding of the collision theory. The effect of the changed conditions was often well described, with the best answers containing separate considerations of the effect of concentration and temperature. However many candidates did not distinguish between their explanations for temperature and concentration and gave a combined answer rather than explaining each factor in turn. As a result these candidates often referred to an increase in concentration making the particles move faster or having more energy. Sometimes candidates lost marks because they only referred to concentration effects or temperature effects, rather than both. Many candidates omitted the need for successful collisions, simply stating that collision frequency would be increased.

Evaluate these results, explaining the reasons why the rate of reaction in experiment 2 is faster than the rate of reaction in experiment 1.
In your answer you should refer to the frequency and energy of collisions between particles.

(6)

The rate of reaction is higer in experiment 2 because the temprature is higer. This is because higher temprature give the particles more energy, this means the particles will be moving at a greater speed. If they are moving at a greater speed it increases the chance of a sucsessful collision. If their are more sucsessful collishions happening at a faster rate this means the reaction will happen quicker.

Results Plus: Examiner Comments

This answer contains a good description of the effect of increasing temperature but does not mention concentration and so is unable to access level 3.

Evaluate these results, explaining the reasons why the rate of reaction in experiment 2 is faster than the rate of reaction in experiment 1.
In your answer you should refer to the frequency and energy of collisions between particles.

(6)

The rate of reaction was alot faster due to the difference between the tempurature that was use in experiment 1+2. In experiment 1 the temp was 20 and 2 the temp was 40. This praves that the higher the temp the quicker the reaction is. Also using different amounts of concemtrated Sulfuric acid helps to increase the rate of reaction. This is because the peiece of zinc would have more to react with making the reation stronger.

Results Plus: Examiner Comments

This answer just gives a limited description and so is a level 1 response.

Evaluate these results, explaining the reasons why the rate of reaction in experiment 2 is faster than the rate of reaction in experiment 1.
In your answer you should refer to the frequency and energy of collisions between particles.

(6)

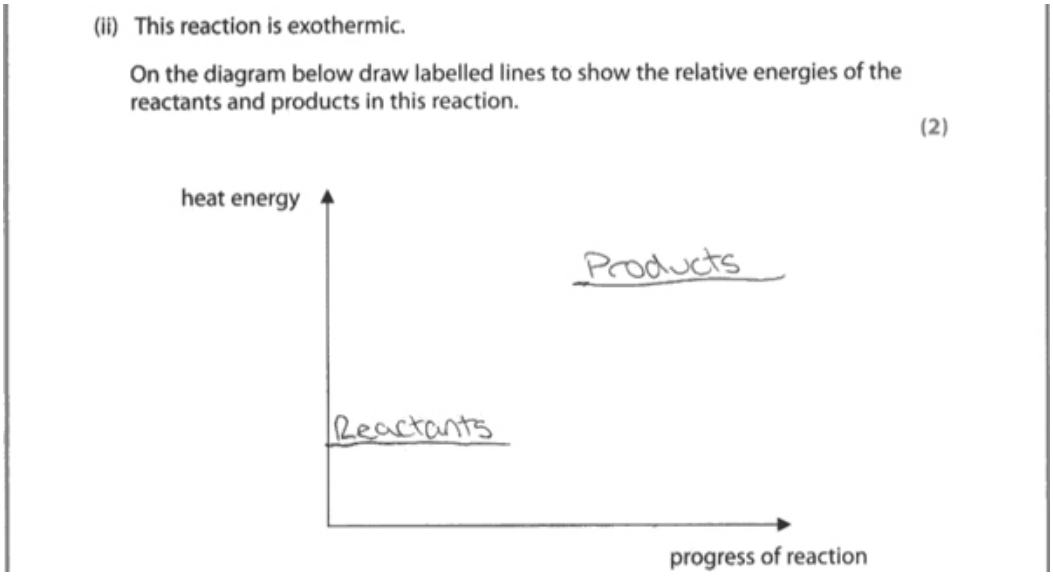
As the concentration of sulfuric acid and the temperature increases, the rate of the reaction also increases. When the concentration increases, there are more particles per cm^3 which means there are more frequent collisions between the particles. More frequent collisions means more successful collisions. When the temperature is increased, the particles move a lot faster. When the particles move faster, they move with a lot more energy which means there are more frequent collisions. The more frequent the collisions are, the more successful the collisions are and therefore the rate of the reaction increases.

Results Plus: Examiner Comments

A detailed description of the effect of increasing the concentration and temperature and worthy of six marks.

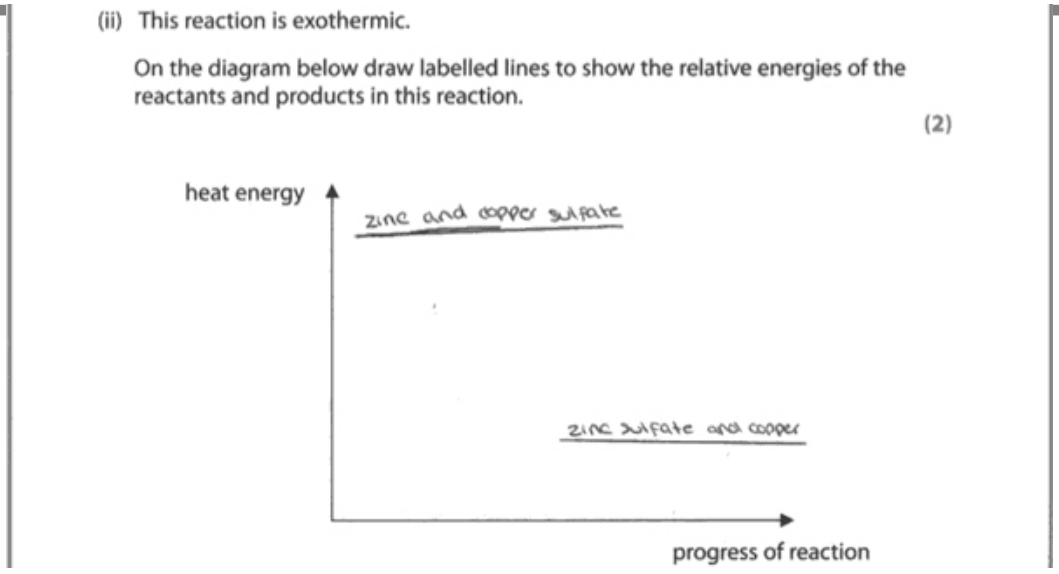
(b) (ii)

Many candidates scored both marks but some lost a mark by either labelling the lines incorrectly or not labelling them at all. Many candidates drew a reaction profile diagram and put in the activation energy "hump" which was obviously acceptable. Some thought the products would be at a higher level than the reactants but others did not draw any horizontal lines and seemingly tried to plot some sort of graph.



Results Plus: Examiner Comments

This is worth one mark as the products line is to the right of the reactants but does not gain the second mark as it shows an endothermic reaction.



Results Plus: Examiner Comments

A good answer giving the names of the reactants and products (although just "reactants" and "products" was also acceptable) in their correct relative positions.

Q53.

It was pleasing to see that the majority of candidates were familiar with this experiment and therefore the apparatus that should be required. However, the skill of drawing apparatus was weak. For the first marking point, where candidates lost marks, it was often as they missed key pieces of apparatus for the apparatus to work such as the bung or drawing a bung that clearly left a big gap, meaning that the gas would not have been collected in the rest of the apparatus. Another common error was where candidates drew a delivery tube that extended down into the dilute hydrochloric acid. For the second mark, the majority keyed into the question and attempted to draw a gas syringe for accuracy rather than an inverted measuring cylinder over water, however both received credit for this part.

Calcium carbonate reacts with dilute hydrochloric acid to produce calcium chloride, water and carbon dioxide.

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$$

A student wanted to measure the amount of gas produced in two minutes.

The student suggested that this could be done by counting the number of bubbles formed.
However, the bubbles are produced too quickly to count them.

Figure 4 shows a conical flask in which the calcium carbonate and dilute hydrochloric acid are reacting.

Complete Figure 4 to show the apparatus that could be used to measure accurately the volume of gas given off in two minutes.

(2)

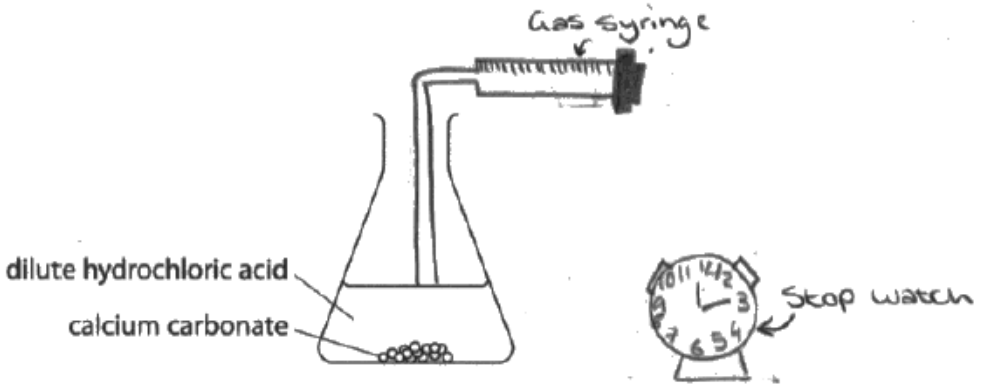


Figure 4

Results Plus: Examiner Comments

Where candidates lost marks, it was often as they missed key pieces of apparatus for the apparatus to work such as the bung, meaning that the gas would not have been collected in the

rest of the apparatus.

Results Plus: Examiner Tip

Marks were awarded for reasonably drawn apparatus, more time should be spent on drawing correct and scientifically accurate drawings of apparatus.

Q54.

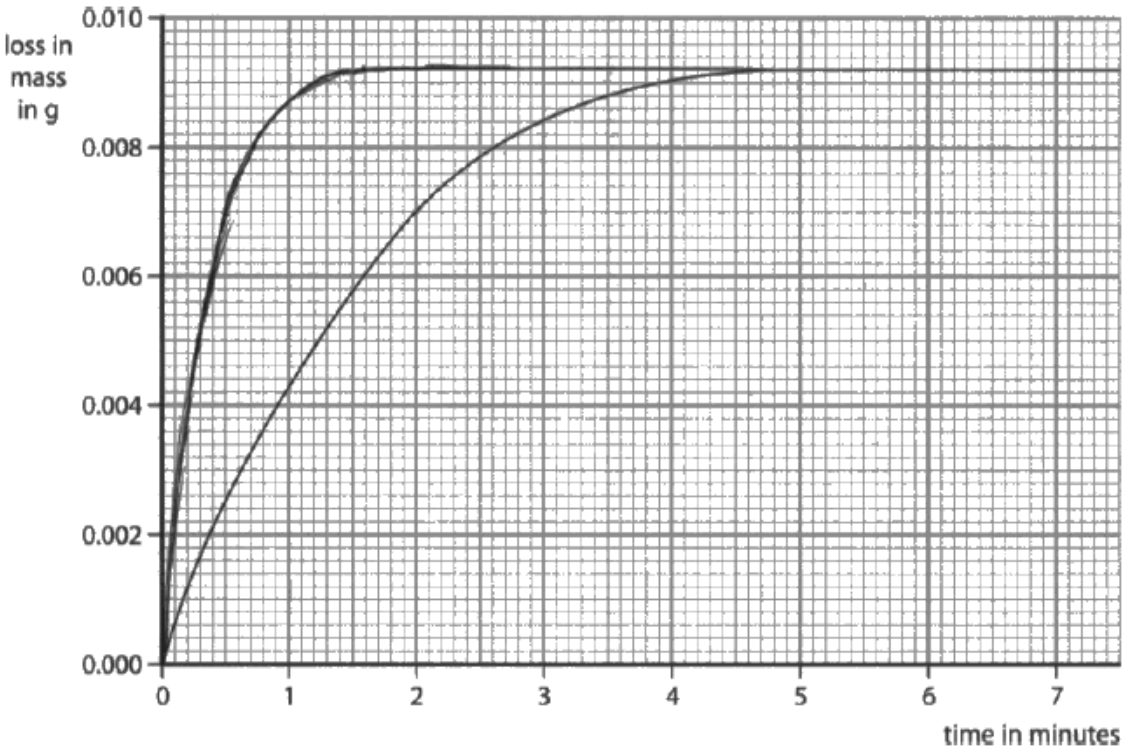
This question was not well answered, with approximately only half of the responses scoring a least 1 of the 2 marks available.

In those responses that scored 1 mark only, candidates correctly showed a steeper curve to the left of the existing curve on the graph, scoring on the first marking point. However, many of these graphs failed to score on the second marking point since either they did not level out at the same place or simply did not level out or levelled out at higher mass loss than original existing curve.

Examiners noted that there were many blank responses to this question and that often curves were very poorly drawn.

The original experiment was repeated using the same mass of magnesium powder instead of the magnesium ribbon.
All other conditions were kept the same.

Sketch, on the graph in Figure 12, the line you would expect for this experiment.



Results Plus: Examiner Comments

An example of a fully correct response, scoring both marks.

The curve has been drawn to the left and steeper than the original curve and also correctly levels off at the same height as the existing line.

Q55. No Examiner's Report available for this question

Q56.

(i)

This question was generally answered well and scoring the mark. Unfortunately, several candidates were giving two or sometimes three HAZCHEM descriptors or contradictions that meant the mark could not be awarded. More worrying were answers of the type 'Sodium hydroxide is an acid….'.

Reactions

6 (a) A technician made some dilute sodium hydroxide solution by carefully adding some solid sodium hydroxide to pure water.

This is the hazard symbol on a bottle of solid sodium hydroxide.



(i) State what this symbol shows about sodium hydroxide.

(1)

toxic - it can burn through anything (~~arrove~~ arroding)

Results Plus: Examiner Comments

Many candidates were mixing the descriptions for the hazard symbols. 0 mark was given for the answer 'toxic'.

(i) State what this symbol shows about sodium hydroxide.

(1)

it is harmful / corrosive highly acidic

Results Plus: Examiner Comments

Several candidates were hedging their bets by giving alternative answers. Candidates should be deterred from this as an incorrect alternative will negate the mark as in this case. 0 mark given.

Results Plus: Examiner Tip

Know the meanings of the hazard symbols.

Avoid giving alternative answers as in this example as an incorrect answer will negate the mark.

Q57.

(i)

Figure 2 shows a cold pack.

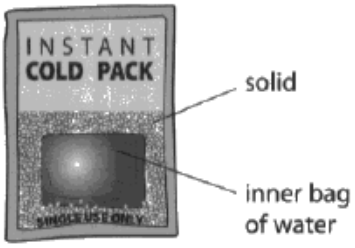


Figure 2

When the pack is squeezed hard the inner bag bursts.
Then the pack goes cold.

(i) Explain why the pack goes cold.

(2)

The water bag pops which produces a ~~reaction~~ endothermic reaction between the solid and water. The endothermic reaction means that it takes in heat energy rather than release it.

Results Plus: Examiner Comments

A well explained answer.

Figure 2 shows a cold pack.

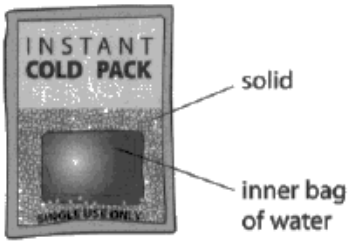


Figure 2

When the pack is squeezed hard the inner bag bursts.
Then the pack goes cold.

(i) Explain why the pack goes cold.

(2)

Because an endothermic reaction is taking place instead of giving heat, it takes it.

Results Plus: Examiner Comments

This answer states that there is an endothermic reaction, but does not relate this to the context

and talk about the water/solid.

(ii)

Most candidates made a good response to this part, although their language was sometimes unclear.The use of the key term 'irreversible' was not common but aided the examiner in easily awarding the mark. It was common to use an alternative and state that once the bag had been burst it could not be burst again.

Some simply restated that question, stating that the pack could only be used once.

Mark Scheme

Q1.

Question Number	Answer	Mark
	R P S Q T R P S as first 3 (1) Q T as last 2 (1)	**(2)** AO 3 2a AO 3 2b

Q2.

Question Number	Answer	Additional guidance	Mark
	2H_2O_2(aq) → 2H_2O(**l**) + O_2 (**g**) (2) OR **2**H_2O_2 (1) state symbols l, g (1)	 do not allow first marking point if equation unbalanced allow capital or small letters for state symbols do not allow words for state symbols	**(2)** AO 1 1 AO 2 1

Q3.

Question Number	Indicative content	Mark
*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlines in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. • reactions occur when particle collisions have sufficient energy (activation energy) • reaction rates are increased when the energy collisions is increased • and / or the frequency of collisions is increased • two factors in the reaction have been changed (temperature and concentration of one of the reactants) • experiment 2 was carried out at a higher temperature than experiment 1 • concentrations of reactant are the same in experiment 1 and 2 • particles have more (kinetic energy), so move faster • so there are more frequent collisions between particles in solution **A** solution and solution **B** • collisions will also occur with greater energy • so more collisions will have the minimum activation energy to react when they collide • so greater frequency of successful collisions (so decreased reaction time/increased rate in experiment 2 compared to experiment 1) • experiment 3 was carried out at a higher concentration than experiment 2/ a fourfold increase • temperatures of the reactants are the same in experiment 2 and 3 • there are more reacting particles in the same volume of reaction mixture • so there are more frequent collisions between particles in solution **A** and solution **B** • so greater frequency of successful collisions (so decreased reaction time/increased rate in experiment 3 compared to experiment 2) • reaction rate in experiment 3 is greatest due to combined effects of increased temperature and increased concentration	**(6)** AO 2 2 AO 3 2a

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1-2	• Interpretation and evaluation of the information attempted but will be limited with a focus on mainly just one variable. Demonstrates limited synthesis of understanding. (AO3) • The explanation attempts to link and apply knowledge and understanding of scientific ideas, flawed or simplistic connections made between elements in the context of the question. (AO2)
Level 2	3-4	• Interpretation and evaluation of the information on both variables, synthesising mostly relevant understanding. (AO3) • The explanation is mostly supported through linkage and application of knowledge and understanding of scientific ideas, some logical connections made between elements in the context of the question. (AO2)
Level 3	5-6	• Interpretation and evaluation of the information, demonstrating throughout the skills of synthesising relevant understanding. (AO3) • The explanation is supported throughout by linkage and application of knowledge and understanding of scientific ideas, logical connections made between elements in the context of the question. (AO2)

Q4.

Question number	Indicative content	Mark
*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlines in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **method** • measure volume of acid • measure mass of marble chips • mix • in a suitable container e.g. flask / boiling tube / test tube • collect the gas • in a {gas syringe/measuring cylinder over water/ burette over water / graduated tube over water} • measure volume of carbon dioxide • measure time • repeat experiment with different size marble chips • same mass of marble chips • same volume of acid • same concentration of acid • same temperature accept alternative method involving measurements of mass loss **results** • smaller chips (of marble) have a more vigorous reaction ORA • smaller chips take less time to {react/produce a certain volume of gas /have a certain mass loss} ORA • shorter time means faster reaction ORA	**(6)**

Level	Mark	Descriptor
	0	• No rewardable material.
Level 1	1-2	• Demonstrates elements of chemical understanding, some of which is inaccurate. Understanding of scientific, enquiry, techniques and procedures lacks detail. (AO1) • Presents a description which is not logically ordered and with significant gaps. (AO1)
Level 2	3-4	• Demonstrates chemical understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas, enquiry, techniques and procedures is not fully detailed and/or developed. (AO1) • Presents a description of the procedure that has a structure which is mostly clear, coherent and logical with minor steps missing. (AO1)
Level 3	5-6	• Demonstrates accurate and relevant chemical understanding throughout. Understanding of the scientific ideas, enquiry, techniques and procedures is detailed and fully developed. (AO1) • Presents a description that has a well-developed structure which is clear, coherent and logical. (AO1)

Q5.

	Answer	Acceptable answers	Mark
	A description to include • smaller pieces have larger surface area / ORA (1) • larger surface area, {higher / faster} rate (1) ORA	small**er** pieces give fast**er** rate (1) ORA allow 'bigger surface area produces more carbon dioxide' (or similarly phrased) for one mark	**(2)**

Q6.

Question number	Answer	Additional guidance	Mark
	$\frac{15.0}{60.0}$ (1) = 0.25 (1) ($cm^3\ s^{-1}$)	$\frac{60}{15}$ = 4 (1)	**(2)** **AO2**

Q7.

Question number	Answer	Additional guidance	Mark
	final answer of 0.3 with or without working scores 3 MP1 : conversion of time from minutes into seconds 5 x 60 = 300 (seconds) (1) MP2 : rate = volume / time rate = $\frac{90}{300}$ (1) MP3 : evaluation of the fraction = 0.3 ($cm^3\ s^{-1}$) (1)	 allow 90/5 (1) 90/5 = 18 (2) 300/90 = 3.33 (2) 5/90 = 0.0556 (1)	**(3)**

Q8.

Question number	Answer	Additional guidance	Mark
	heat energy change when bonds broken = 413 + 243 (1) heat energy change when bonds formed = 346 + 432 (1) overall heat energy change = (346 + 432) - (413 + 243) or vice versa (1) = 122 (or -122) (kJ mol^{-1}) more heat released than required therefore reaction exothermic (1) **OR** heat energy change when bonds broken = (4 x 413) + 243 (1) heat energy change when bonds formed = (3 x 413) + 346 + 432 (1) overall heat energy change = ((3 x 413) + 346 + 432) - ((4 x 413) + 243) (1) = 122 (or -122) (kJ mol^{-1}) more heat released than required therefore reaction exothermic (1)	allow full marks for correct numerical answer without working	**(4)**

Q9.

Question number	Answer	Additional guidance	Mark
	-730 as final answer with or without working scores 4 +730 as final answer with or without working scores 3 bonds broken = (4 x 435) + (2 x 496) = 2732 **(1)** bonds made = (2 x 805) + (4 x 463) = 3462 **(1)** energy change = broken – made **(1)** [2732 – 3462] = -730 (kJ mol^{-1}) **(1)**	allow ECF	**(4)**

Q10.

Question Number	Answer	Additional guidance	Mark
	• slower • slower • unchanged all 3 rows correct – 2 marks one or two rows correct – 1 mark	may indicate correct answer in any way e.g. by underlining do not credit a row if more than one answer is indicated in a row	**(2)** AO 1 1

Q11.

Question number	Answer	Mark
	B measuring cylinder **A, C** and **D** do not measure volumes	**(1)** **AO2**

Q12.

Question number	Answer	Mark
	diagram of • delivery tube with bung in flask connected to (1) • gas syringe / gas syringe labelled (1) or • delivery tube with bung in flask leading into water trough (below upturned measuring cylinder) (1) • upturned measuring cylinder containing water / measuring cylinder labelled (1) allow • connected delivery tube from flask to upturned test tube in water trough (1)	**(2)** **AO1**

Q13.

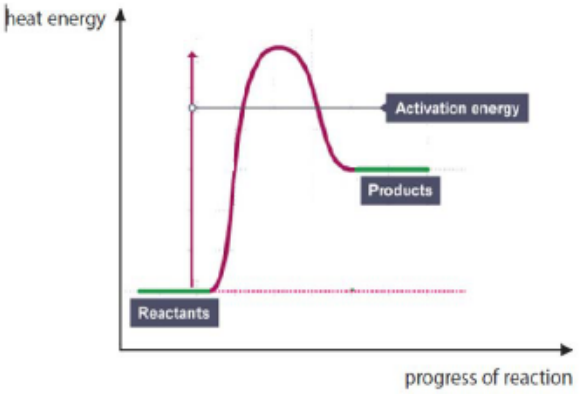
Question Number	Answer	Additional guidance	Mark
(i)	(gas) syringe / graduated tube / burette (instead of measuring cylinder)		**(1)** AO 3 3b

Question Number	Answer	Additional guidance	Mark
(ii)	final answer in range 0.44 – 0.52 inclusive with or without working (2) If answer not in range: $\frac{\text{difference in volume}}{\text{difference in time}} = \frac{(43 - 15)}{(60 - 0)}$ (1) $= 0.47 \;/\; 0.467$ (1)	allow ecf throughout where values are less than 1 (1 max) use of inverted gradient expression giving 2.27 – 1.92 scores 1 mark (evidence of working required)	**(2)** AO 2 1

Question Number	Answer	Additional guidance	Mark
(iii)	steeper **curve** to the left of printed curve and same final volume	line must not go above 40 cm^3 and curve back down	**(1)** AO 2 2

Q14.

Question Number	Answer	Mark
(i)	fuel oil	**(1)** AO 3 2a

Question Number	Answer	Additional guidance	Mark
(ii)	• reactant(s) and product(s) labelled in their correct positions (1)	example of diagram 	(3) AO 1 1
	• activation energy labelled (1)	ignore arrow heads	
	• energy of reactants lower than energy of products (1)	allow unlabelled diagram of an endothermic reaction showing the basic outline shape if exothermic reaction profile shown, allow (1) for reactants and products in correct position and (1) for correct labelling of activation energy	

Question Number	Answer	Additional guidance	Mark
(iii)	C_6H_{14}		(1) AO 2 1

Q15.

	Answer	Acceptable answers	Mark
	An explanation to include • (substance that) increases rate / speeds up reaction (1) • without being {used up / changed} itself (1)	ignore slows down a reaction lowers activation energy reject provides energy / heat (for 2nd mark)	(2)

Q16.

Question number	Indicative content	Mark
	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material that is indicated as relevant. Additional content included in the response must be scientific and relevant. A plan to include some of the following points • measure equal masses of zinc using balance • measure equal volumes of acid using measuring cylinder/pipette/suitable named piece of apparatus • pour acid in suitable container • record initial temperature • use of thermometer • add zinc to acid • place bung with delivery tube in container / reaction vessel immediately after the zinc is added • use of timer • start timer on addition of zinc • measure volume of gas evolved using a delivery tube and inverted measuring cylinder/burette over water OR delivery tube and (gas) syringe • record time to collect fixed volume of gas • record final/highest temperature • calculate the temperature increase • repeat for procedure • same initial temperature • same size pieces of zinc • same volume of acid credit use a suitable labelled diagram of apparatus for rate measurement/ temperature of acid	**(6)**

Level	Mark	Additional Guidance	General additional guidance – the decision within levels Eg - At each level, as well as content, the scientific coherency of what is stated backed up by planning detail will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	Additional guidance Identifies relevant practical operations such as • carries out basic reaction – add zinc to acid • measures at least one of mass, time, volume, temperature	Possible candidate responses • put zinc in test tube and add some acid • find the mass of zinc • measure volume of the acid • carries out basic reaction or measures at least one factor with details scores upper part of level
Level 2	3–4	Additional guidance Some correct sequencing of correct operations • carries out basic reaction with dilute acid and repeat with the more concentrated acid and • carries out reaction makes some relevant observation or obtains a result or • measures at least two of mass, time, volume, temperature	Possible candidate responses • put zinc in test tube, add acid and time the reaction • put zinc in test tube, add dilute acid, then repeat experiment and add more concentrated acid • measures mass of zinc and measures volume of acid before adding together • measures temperature of acid before adding to zinc and measures temperature at end of reaction • a similar description, but with detail of apparatus scores the upper part of the level
Level 3	5–6	Additional guidance Sequence of operations of an experiment to include two from • measures temperature and volume of acid, and mass of zinc • repeats expt but with more concentrated acid • measure temperature of reaction mixture at end and finds temperature rise	Possible candidate responses • record temperature of 25 cm^3 dilute acid, add to known mass of zinc, record temperature after reaction • using suitable apparatus measure volume of gas every minute • repeat experiment using same conditions but using the more concentrated acid • work out temperature rises for both reactions • descriptions with detail or workable method scores upper part of level

Q17.

Question Number	Answer	Additional guidance	Mark
	award full marks for correct numerical answer without working energy needed to break bonds = (2 x 435) + (1 x 500) = 1370 (kJ mol^{-1}) (1) energy released when bonds are formed = 4 × 460 = 1840 (1) energy change = 1370 – 1840 = (-) 470 (kJ mol^{-1}) (1) negative sign or 'energy released' (1)	 allow 1840 - 1370 = 470 (1) ignore sign allow exothermic (reaction) final answer 450 award 2 marks -450 award 2 marks final answer +450 award 3 marks	**(4)** AO 2 1

Q18.

Question Number	Answer	Acceptable answers	Mark
(a)(i)	An explanation linking {the temperature/it} {increased / went up (by 26°C)} (1) (so the reaction is) exothermic (1)	 it got hotter/it gets hot heat (energy){released /given out} ignore incorrect temperature rise do not allow just 'heat increases'	 **(2)**

Question Number	Answer	Acceptable answers	Mark
(a)(ii)	$ZnSO_4$ (1) Cu (1)	allow formulae in either order maximum if additional formulae are included maximum if balancing numbers added do not allow upper case N /superscript 4	 **(2)**

Question Number	Answer	Acceptable answers	Mark
(b)	An explanation linking **First mark – relating concentration to time** (as the concentration/amount of acid increases) the time (taken for the magnesium to react) decreases (1) Ignore any reference to negative correlation Ignore time gets faster/quicker **Second mark – effect on rate** (so){ the rate/it} increases/reaction becomes {faster/quicker} (1) Ignore any reference to positive correlation	Reverse arguments if candidate has related time and rate to decreasing concentration of acid {less/shorter} time	**(2)**

Question Number		Indicative Content	Mark
QWC	***(c)**	A description including some of the following points **Experiment 1** • measure volume of acid/stated volume • measure mass of marble chips/stated mass • add acid to marble or marble to acid in a suitable container eg flask, beaker, boiling tube, test tube • collect the gas in a {gas syringe/measuring cylinder over water/ tube over water}/bubble gas through limewater/bubble gas through water • measure {amount/volume} of carbon dioxide/count the bubbles/fixed volume of carbon dioxide • measure mass/mass loss (on a balance) • time/measure how long the reaction takes **Experiment 2** • do another experiment with different size marble chips • use the same mass of marble chips • use the same {volume/concentration/mass} of acid/same acid • crush the marble/use powdered marble **Results** • smaller chips (of marble) have a more vigorous reaction/produce more {fizzing/bubbles} ORA • smaller chips take less time to {react/produce a certain volume of gas /have a certain mass loss} ORA • smaller chips have a larger surface area ORA • smaller chips react faster ORA • larger surface gives a faster reaction	**(6)**

Level	0	No rewardable content
1	1 - 2	• a limited description e.g. crush the marble chips/smaller marble chips give more fizzing • the answer communicates ideas using simple language and uses limited scientific terminology • spelling, punctuation and grammar are used with limited accuracy
2	3 - 4	• a simple description e.g. put marble chips and acid in a flask and repeat with the same mass of small marble chips / collect the gas in a syringe, smaller pieces of marble react faster • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately • spelling, punctuation and grammar are used with some accuracy
3	5 - 6	• a detailed description e.g. put marble chips and acid in a flask, repeat the experiment with the same mass of crushed marble, crushed marble takes less time to react • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors

(Total for Question = 12 marks)

Q19.

Question Number	Answer	Mark
	A always higher **The only correct answer is A** ***B** is not correct because temperature rise* ***C** is not correct because temperature always rises* ***D** is not correct because temperature rises*	**(1)** AO 2 2

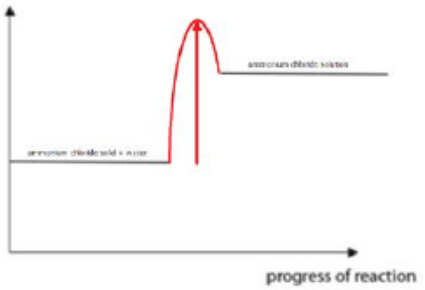
Q20.

	Answer	Acceptable answers	Mark
(i)	B displacement		**(1)**
(ii)	Shown on diagram • horizontal reactant line above product line (1) • horizontal product line to right of reactant line (1)	lines must be correctly labelled eg reactants/Zn + $CuSO_4$ and products/ $CuSO_4$ and Cu ignore any extra lines/curves/labels if not drawn lines but just labels in correct relative positions max 1 If two lines drawn in correct positions	**(2)**

		but no labels max 1	

Q21.

Question number	Answer	Additional guidance	Mark
(i)	an explanation linking two of: • {ammonium chloride solution/product} has more energy than {ammonium chloride solid and water/reactant} / ORA (1) • heat (energy) has increased / energy change is positive (1) • (therefore) heat energy has been {absorbed/taken in} (1)	ignore arguments about bond making / bond breaking	**(2)** **AO3**

Question number	Answer	Additional guidance	Mark
(ii)	heat energy  (2)	curve from reactants to products with peak higher than product energy (1) arrow labelled activation energy on correct curve (1)	**(2)** **AO2**

Q22.

Question number	Answer	Additional guidance	Mark
(i)	an explanation linking two of: • {ammonium chloride solution/product} has more energy than {ammonium chloride solid and water/reactant} / ora (1) • heat (energy) has increased / energy change is positive (1) • (therefore) heat energy has been {absorbed/taken in} (1)	ignore arguments about bond making / bond breaking	(2) AO3

Question number	Answer	Additional guidance	Mark
(ii)	 (2)	curve from reactants to products with peak higher than product energy (1) arrow labelled activation energy on correct curve (1)	(2) AO2

Q23.

Question number	Answer		Mark
	An explanation linking two from • catalyst particles have much larger surface area (when made from nanoparticles) (1) • leads to increased reaction rate (1)		(2) AO1

Q24.

Question number	Indicative content	Mark
*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material that is indicated as relevant. Additional content included in the response must be scientific and relevant. **AO1 (3 marks) AO3 (3 marks)** • less gas produced with large lumps in same amount of time • therefore, reaction slower ORA • larger lumps have smaller surface area ORA • fewer particles available for reaction • fewer collisions in given time • more gas produced at higher concentration in all experiments • higher concentration there are more particles in same volume • more particles available to react • more frequent collisions • most gas produced in same time with small lumps and highest concentration ORA • therefore, fastest reaction is with small lumps and highest concentration ORA	**(6)**

Level	Mark	Additional Guidance	General additional guidance – the decision within levels Eg - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	Additional guidance One statement (1) Two unlinked statements (2) One simple explanation (2)	Possible candidate responses less gas produced with large lumps (1) more gas produced with higher concentration of acid (1) smaller lumps have larger surface area (1) large lumps produced less gas and higher concentration produced more gas (2) the rate of reaction is higher with smaller lumps because they have a larger surface area (2) more gas at a higher concentration because there are more acid particles (2)
Level 2	3–4	Additional guidance Two simple explanations (4) One full explanation including reference to particles and frequency of collisions for either surface area OR concentration (4)	Possible candidate responses less gas with large lumps, reaction is slower due to smaller surface area. more gas at higher concentrations due to more particles (4) more gas at higher concentrations due to more particles having more frequent collisions (4) more gas at higher concentrations due to more particles having more collisions (3) Less gas with large lumps, reaction is slower due to smaller surface area as fewer particles fewer collisions in given time (4) with large lumps, reaction is slower as lower surface area fewer collisions in a given time (4)
Level 3	5–6	Additional guidance One full explanation including reference to particles frequency of collisions AND one simple explanation. The volume of gas must be referred to in at least one part of the answer. (6)	Possible candidate responses Less gas with large lumps, the reaction is slower due to smaller surface area. Fewer particles are available for reaction and fewer collisions in a given time. Whereas more gas is produced with a higher concentration as there are more particles (6) There is more gas produced at higher concentration because at a higher concentration there are more particles, this means that more particles available to react so there are more frequent collisions. Whereas less gas is produced with large lumps because they have a smaller surface area. (6) with large lumps the reaction is slower so less gas is produced because they have a smaller surface area so there are fewer particles available for reaction and fewer collisions. Whereas there is higher rate with a higher concentration as there are more particles in the same volume of solution (5)

Q25.

Question number	Answer	Additional guidance	Mark
	An explanation linking • temperature rises / increases (by 11 °C) (1) • exothermic process (1)	 allow gets hotter / water heats up {temperature / it} goes up Ignore heat increasing for MP1 allow heat / energy {given out / released to surroundings} reject endothermic for MP2	**(2)**

Q26.

Question number	Answer	Additional guidance	Mark
	an explanation linking breaking bonds {needs energy/ endothermic} (1) making bonds {releases energy/ exothermic} (1) more energy is **given out** than is **taken in** (1)	allow heat for energy Ignore refs to energy level diagrams ignore refs to number of bonds made/broken	**(3)**

Q27.

Question number	Answer	Additional Guidance	Mark
(i)	An explanation to include • a solid/ precipitate **(1)** • of sulfur **(1)**		**(2)**

Question number	Answer	Additional Guidance	Mark
(ii)	A description to include • flask placed {over/in front of} cross **(1)** • measure time **(1)** • when cross is obscured **(1)**	MP2 dependent on MP1 allow measure how long reaction takes for MP2	**(3)**

Question number	Answer	Mark
(iii)	**B** 150 cm^3 is the only correct answer. **A** is incorrect because this makes 16.7 g dm^{-3} HCl **C** is incorrect because this makes 25.0 g dm^{-3} HCl **D** is incorrect because this makes 33.3 g dm^{-3} HCl	**(1)**

Q28.

Question number	Answer	Additional guidance	Mark
	An explanation linking • MP1 : fewer reacting particles left / some particles reacted (1) • MP2: fewer collisions (1) • MP3: (fewer) frequent (collisions) (1)	for full marks, reference needs to be made to **particles** in answer allow more particles at the start (than at the end) allow less magnesium / less reactants (1) allow 'less' ignore particle speed allow (fewer collisions) per {second / unit time} (less/fewer) frequent collisions scores MP2 and MP3	**(3)**

Q29.

Question number	Answer	Additional guidance	Mark
	An explanation linking • {hydrogen / gas} formed / OWTTE (1) • escapes (from the flask) (1)	allow released (from the flask) ignore references to magnesium reacting	**(2)**

Q30.

Question number	Answer	Additional guidance	Mark
	An explanation linking three of the following • particles have more energy (1) • so (particles) move faster (1) • (so) there are more frequent collisions between particles (1) • higher proportion of collisions have at least the activation energy to react when particles collide (1)	 Allow more kinetic energy for MP1 and MP2 needs to be comparative allow greater chance of collision allow higher {proportion / chance} of collisions are successful / productive allow more particles have activation energy	**(3)**

Q31.

Question number	Answer	Additional guidance	Mark
	(particles) have more energy / (particles) collide more frequently / more successful collisions	allow particles move faster	**(1)** **AO1**

Q32.

Question number	Answer	Additional guidance	Mark
	(top pan) balance (1)	allow (weighing) scale(s)	**(1)**

Q33.

Question number	Answer	Additional guidance	Mark
	An answer that combines the following points of application of knowledge and understanding to provide a logical description: • use a thermometer (1) • to measure initial and final temperature (1)		(2)

Q34.

		Indicative Content	
QWC	*	A description / comparison/ explanation / etc including following points **method – what needs to be carried out** • dilute the acid • (to make) different concentrations / stated con values • add magnesium to acid • in suitable container • equal volumes of the acids • equal lengths of magnesium **observations – to make** • observe/ count bubbles • highest concentration magnesium reacts, lowe concentration magnesium does not react • observe/ time magnesium disappearing • use of timer • measure volume gas produced • measure decrease in mass **conclusion – evidence gathered or seen** • formed bubbles faster • magnesium disappears faster • gas produced faster • mass lost faster	
Level	**0**	No rewardable content	
1	**1 - 2**	• a limited description e.g. add magnesium to acid and time the reaction • the answer communicates ideas using simple language and uses limited scientific terminology • spelling, punctuation and grammar are used with limited accuracy	
2	**3 - 4**	• a simple description e.g. dilute the acid, add magnesium to both acid solutions and more concentrated one bubbles faster or magnesium	

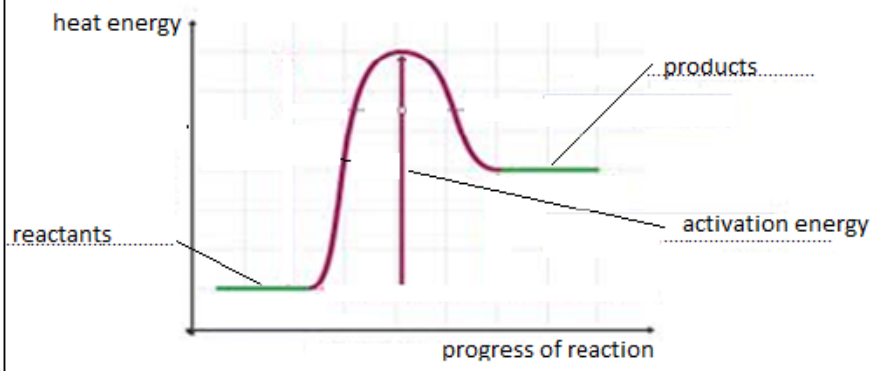
		reacts quicker • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately • spelling, punctuation and grammar are used with some accuracy	
3	**5 - 6**	• a detailed description e.g. add magnesium to different concentrations of acids in beakers: lower concentration longer time therefore slower reaction • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors	

Q35.

Question number	Answer	Additional guidance	Mark
(i)	measuring cylinder / (volumetric) pipette / burette	ignore dropping pipette / beaker	**(1)**

Question number	Answer	Additional Guidance	Mark
(ii)	measure the initial temperature (of the water)	allow subtract initial temperature from final temperature OR vice versa allow temperature before mixing	**(1)**

Question number	Answer	Additional Guidance	Mark
(iii)	insulator / reduces heat transfer / poor conductor of heat	ignore references to heat loss	**(1)**

Question number	Answer	Mark
(iv)	• any one label correct (1) • all three labels correct (1)  	(2)

Q36.

Question number	Answer	Mark
	B endothermic	(1)

Q37.

Question number	Answer	Mark
(i)	**C**  is the only correct answer **A** is the hazard symbol for corrosive substances **B** is the hazard symbol for substances that are harmful to the environment **D** is the hazard symbol for flammable substances	(1)

Question number	Answer	Additional guidance	Mark
(ii)	wear {goggles / **safety** glasses} / wear gloves	allow eye protection ignore tie long hair back ignore safety clothing / ppe	(1)

Q38.

Question number	Answer	Mark
	B dissolving	**(1)**

Q39.

Question number	Answer	Additional guidance	Mark
	conical flask in water bath [could be shown on diagram]	Reject heat with a Bunsen burner warm water alone is not enough.	**(1)** **AO3**

Question number	Answer	Mark
(ii)	Using tangent drawn on graph eg vertical difference (100 – 52) (1) horizontal difference 180 (1) (= 0.267) ($cm^3 s^{-1}$) calculation will depend on final graph 2 marks for rate being within a range eg 0.250 – 0.290 1 mark for rate being in range 0.230 – 0.249 or 0.291 – 0.310	**(2)** **AO3**

Question number	Answer	Additional guidance	Mark
(iii)	particle size / concentration of acid / volume of acid / mass of calcium carbonate	allow marble chips for calcium carbonate allow amount of calcium carbonate ignore size of container	**(1)** **AO1**

Question number	Answer	Mark
(iv)	An explanation linking • fewer successful collisions (between acid and calcium carbonate particles) / fewer collisions with activation energy (1) and any two from • (because) decreasing temperature (of the acid) particles have lower energy (1) • (because) the particles move slower (1) • (so) rate of reaction decreases (1)	**(3)** **AO1**

Q40.

Question number	Answer	Mark
(i)	value in the range 64 - 66 (s)	(1)

Question number	Answer	Mark
(ii)	all magnesium is used up	(1)

Question number	Answer	Additional guidance	Mark
(iii)	volume of hydrogen = 48 (1) rate = $\frac{48}{20}$ (1) = 2.4 ($cm^3 s^{-1}$)	2.4 only (2) incorrect volume/20 1 mark only	(2)

Question number	Answer	Mark
(iv)	curved line to the left of curve (1) same final volume (which is the maximum volume) (1)	(2)

Question number	Answer	Mark
(v)	**C** no change, no change	(1)

Q41.

Question number	Answer	Mark
(i)	value in the range 60 - 64 (s)	(1)

Question number	Answer	Mark
(ii)	all magnesium is used up	(1)

Question number	Answer	Additional guidance	Mark
(iii)	volume of hydrogen = 48 (1) rate = $\frac{48}{20}$ (1) = or 2.4 ($cm^3 s^{-1}$)	2.4 only (2) incorrect volume/20 1 mark only	(2)

Question number	Answer	Mark
(iv)	curved line to the left of curve (1) same final volume (which is the maximum volume) (1)	(2)

Question number	Answer	Mark
(v)	C no change, no change	(1)

Q42.

Question number	Answer	Additional guidance	Mark
(i)	Time in {s/min}	allow seconds/ minutes	(1) AO3

Question number	Answer	Additional guidance	Mark
(ii)	A description to include reaction is faster with liver (1) more {gas/oxygen} produced with liver (1)	 allow ORA	(2) AO3

Question number	Answer	Mark
(iii)	A description to include bung and delivery tube (1) connected to {a gas syringe / upturned burette / upturned measuring cylinder} (1)	(2) AO3

Q43.

Question Number	Answer	Mark
	(gas) syringe	(1) AO 1 2

Q44.

Question number	Answer	Mark
	$Mg + 2HCl \rightarrow MgCl_2 + H_2$ LHS (1) RHS (1)	(2)

Q45.

Question Number	Answer	Additional guidance	Mark
	use a **measuring cylinder**	allow pipette/ burette ignore syringe , measuring jug/tube etc.	**(1)** AO 3 3a

Q46.

Question number	Answer	Additional guidance	Mark
	Any suitable container for measuring volume of 100 cm^3 eg measuring cylinder	allow burette / pipette ignore beaker, conical flask, measuring jug	**(1)**

Q47.

Question number	Answer	Additional guidance	Mark
	Any two suggestions from the following: • (same) volume of water (1) • (same) mass of solid (1) • (same rate of) stirring (1)		**(2)**

Q48.

	Answer	Acceptable answers	Mark
(i)	$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$ reactants (1) products (1)	Accept multiples If not correctly balanced max 1 Must be subscripts where relevant	**(2)**

			Indicative Content	
QWC		***(ii)**	A description including some of the following points **general points** • reactions occur when particles collide • more frequent collisions cause higher rate of r • mass and size of zinc pieces same so no effect reaction • because same surface area • two factors have been altered in the same exp • cannot be certain of effect of each **concentration** • experiment 2 higher/triple concentration of ac • so more particles (in same volume) • so more frequent collisions between particles • more successful collisions **temperature** • experiment 2 higher temperature • particles move faster • particles have more energy • so more frequent collisions between particles rate) • more successful collisions • so more energetic collisions between particles • more particles have enough energy to react (a energy) when they collide	
Level	**0**	No rewardable content		
1	**1 - 2**	• a limited description e.g. temperature is higher and concentration is higher so reaction is faster e.g. temperature is higher so particles move faster so reaction is faster • the answer communicates ideas using simple language and uses limited scientific terminology • spelling, punctuation and grammar are used with limited accuracy		
2	**3 - 4**	a simple description e.g. temperature is higher so particles move faster and concentration is higher so more particles so reaction is faster		

		eg when concentration is higher there will be more particles so more frequent collisions so faster reaction e.g. when temperature is higher particles move faster so more successful collisions so faster reaction • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately • spelling, punctuation and grammar are used with some accuracy	
3	**5 - 6**	• a detailed description e.g. higher concentration of acid so more particles so more frequent collisions so faster reaction and higher temperature so particles have more energy so more successful collisions so faster reaction • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors	

Q49.

Question Number	Answer	Acceptable answers	Mark
(a)	An explanation linking (aq) (means) aqueous/dissolved in water (1) (l) (means) liquid (1)	 ignore diluted ignore can be dissolved in water/ magnesium chloride is soluble in water do not allow mixed with a solution/a liquid solution	**(2)**

Question Number	Answer	Acceptable answers	Mark
(b)	effervescence/bubbles/ fizzing OR magnesium/solid/it disappears OR temperature rise	ignore hydrogen/gas released/ formed /given off dissolves / gets smaller ignore reacts ignore heat given out but any incorrect observation scores 0	**(1)**

Question Number	Answer	Acceptable answers	Mark
(c)(i)	(gas) syringe	(upturned) burette/measuring cylinder/graduated flask (filled with water)	**(1)**

Question Number	Answer	Acceptable answers	Mark
(c)(ii) Clip (iii) + graph	140	range 136-144	**(1)**

Question Number	Answer	Acceptable answers	Mark
(c)(iii) Clip (ii) + graph	curve above original(1) levels at same volume (1)	curve must start at origin does not need to finish at same time as original curve no marks for over-writing original curve (after 10 cm^3 volume)	**(2)**

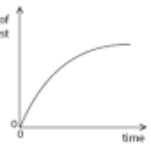
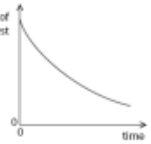
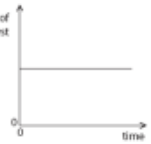
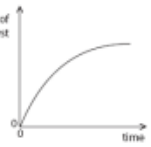
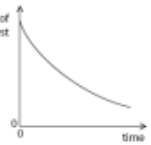
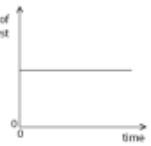
Question Number	Answer	Acceptable answers	Mark
(d)	Explanation linking (rate of reaction/it) increases (1) larger surface area (1)	 speed (of reaction) increases reaction/it is faster/quicker ignore takes less time more frequent collisions more collisions per second ignore just more collisions ignore greater chance of collisions	**(2)**

Question Number	Answer	Acceptable answers	Mark
(e)	An explanation linking: increase in temperature (1) (so) exothermic (reaction) (1)	 temperature went up (by 41ºC) it got hot(ter) ignore just 'heat increases' heat (energy) produced/released /given out/lost	**(2)**

Q50.

Question Number	Answer	Acceptable answers	Mark
(a)	A use hydrochloric acid which is more dilute		**(1)**

Question Number	Answer	Acceptable answers	Mark
(b)	An explanation linking two of M1 {particles/reactants/collisions} have more energy (1) M2 more frequent collisions (1) M3 more {productive/successful/effective} collisions (1)	 atoms/ions/molecules as alternatives to particles reject electrons particles move faster more collisions per unit time ignore collisions are more likely/greater chance/probability of collisions/faster collisions more particles have required activation energy	**(2)**

Question Number	Answer	Acceptable answers	Mark
(c)(i)	**C** ☐ A  ☐ B  ☐ C  ☐ D  ☐ A  ☐ B  ☐ C  ☐ D 		**(1)**

Question Number	Answer	Acceptable answers	Mark
(c)(ii)	$2H_2O_2 \rightarrow 2H_2O + O_2$ (2) all formulae correct (1) balancing correct formulae (1)	multiples or halves reject other reactants or products ignore heat on arrow or elsewhere ignore state symbols ignore use of lower case h, lower case o, or use of superscripts or large numbers inside the formulae	**(2)**

Question Number	Answer	Acceptable answers	Mark
(d)	An explanation linking M1 energy needed to break bonds / energy released when bonds formed (1) M2 more heat / energy is released than needed (1) M2 dependent on scoring M1	bond breaking is endothermic / bond making is exothermic if any contradictory statements made in M1, the mark cannot be awarded (and so M2 cannot be awarded either) ignore numbers of bonds eg more bonds formed than broken "more energy is released forming bonds than needed to break bonds" (2)	**(2)**

Q51.

	Answer	**Acceptable answers**	**Mark**
(a)(i)	corrosive	damages skin / clothes causes burns	**(1)**
(a)(ii)	C neutralisation		**(1)**
(b)	An explanation to include • (substance that) increases rate / speeds up reaction (1) • without being {used up / changed} itself (1)	ignore slows down a reaction lowers activation energy reject provides energy / heat (for 2nd mark)	**(2)**
(c)	A description to include • smaller pieces have larger surface area / ORA (1) • larger surface area, {higher / faster} rate (1) ORA	small**er** pieces give fast**er** rate (1) ORA allow 'bigger surface area produces more carbon dioxide' (or similarly phrased) for one	**(2)**

		mark	

		Indicative Content	
QWC	***(d)**	A description / comparison/ explanation / etc including following points **method – what needs to be carried out** • dilute the acid • (to make) different concentrations / stated con values • add magnesium to acid • in suitable container • equal volumes of the acids • equal lengths of magnesium **observations – to make** • observe/ count bubbles • highest concentration magnesium reacts, lowe concentration magnesium does not react • observe/ time magnesium disappearing • use of timer • measure volume gas produced • measure decrease in mass **conclusion – evidence gathered or seen** • formed bubbles faster • magnesium disappears faster • gas produced faster • mass lost faster	

Level	**0**	No rewardable content	
1	**1 - 2**	• a limited description e.g. add magnesium to acid and time the reaction • the answer communicates ideas using simple language and uses limited scientific terminology • spelling, punctuation and grammar are used with limited accuracy	
2	**3 - 4**	• a simple description e.g. dilute the acid, add magnesium to both acid solutions and more concentrated one bubbles faster or magnesium reacts quicker • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately • spelling, punctuation and grammar are used with some accuracy	
3	**5 - 6**	• a detailed description e.g. add magnesium to different concentrations of acids in beakers: lower concentration longer time therefore slower reaction • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors	

Q52.

	Answer	Acceptable answers	Mark
(a)(i)	$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$ reactants (1) products (1)	Accept multiples If not correctly balanced max 1 Must be subscripts where relevant	**(2)**

		Indicative Content
QWC	***(a)(ii)**	A description including some of the following points **general points** • reactions occur when particles collide • more frequent collisions cause higher rate of r • mass and size of zinc pieces same so no effect reaction • because same surface area • two factors have been altered in the same exp • cannot be certain of effect of each **concentration** • experiment 2 higher/triple concentration of ac • so more particles (in same volume) • so more frequent collisions between particles • more successful collisions **temperature** • experiment 2 higher temperature • particles move faster • particles have more energy • so more frequent collisions between particles rate) • more successful collisions • so more energetic collisions between particles • more particles have enough energy to react (a energy) when they collide
Level	**0**	No rewardable content
1	**1 - 2**	• a limited description e.g. temperature is higher and concentration is higher so reaction is faster e.g. temperature is higher so particles move faster so reaction is faster • the answer communicates ideas using simple language and uses limited scientific terminology • spelling, punctuation and grammar are used with limited accuracy
2	**3 - 4**	a simple description e.g. temperature is higher so particles move faster and concentration is higher so more particles so reaction is faster

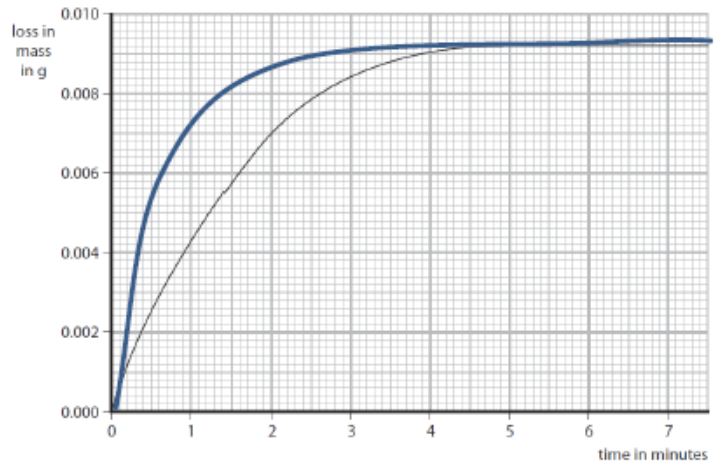
		eg when concentration is higher there will be more particles so more frequent collisions so faster reaction e.g. when temperature is higher particles move faster so more successful collisions so faster reaction • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately • spelling, punctuation and grammar are used with some accuracy	
3	**5 - 6**	• a detailed description e.g. higher concentration of acid so more particles so more frequent collisions so faster reaction and higher temperature so particles have more energy so more successful collisions so faster reaction • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors	

	Answer	**Acceptable answers**	**Mark**
(b)(i)	B displacement		**(1)**
(b)(ii)	Shown on diagram • horizontal reactant line above product line (1) • horizontal product line to right of reactant line (1)	lines must be correctly labelled eg reactants/Zn + $CuSO_4$ and products/ $CuSO_4$ and Cu ignore any extra lines/curves/labels if not drawn lines but just labels in correct relative positions max 1 If two lines drawn in correct positions but no labels max 1	**(2)**

Q53.

Question number	Answer	Additional guidance	Mark
	delivery tube, not in liquid, connected to flask sealed with a bung/cork (1) gas syringe / measuring cylinder or burette inverted over water (1)	do not allow a single line for a delivery tube allow sealed cross sections (e.g. delivery tube going through solid bung) labels and graduations not required mark independently	**(2)**

Q54.

Question number	Answer	Additional guidance	Mark
	 (2)	line drawn with steeper gradient to left of line (1) levelling off at the same height as the existing line (1)	**(2)**

Q55.

Question number	Answer	Mark
(i)	An explanation that combines identification via a judgment (1 mark) to reach a conclusion via justification/reasoning (1 mark): • temperature increases (1) • heat energy is released (1)	**(2)**

Question number	Answer	Mark
(ii)	Diagram showing • reactants line above products line (1) • products line drawn to right of reactants line (1)	(2)

Question number	Answer	Mark
(iii)	Any one from use a lid / polystyrene beaker / insulated container / insulation / draught shield	(1)

Question number	Answer	Mark
(iv)	C heat energy is required heat energy is released	(1)

Q56.

	Answer	Acceptable answers	Mark
(i)	corrosive	damages skin / clothes causes burns	(1)
(ii)	C neutralisation		(1)

Q57.

Question Number	Answer	Additional guidance	Mark
(i)	An explanation including • the solid {dissolves/ reacts with the water} (1) • {takes in /absorbs} heat / is endothermic (1)	Ignore just 'a (chemical) reaction occurs' etc allow energy for heat ignore reference to temperature change	(2) AO 2 1

Question Number	Answer	Additional guidance	Mark
(ii)	(reaction) irreversible	allow **reaction** can only occur once allow reactants are used up / reaction is complete /the reaction has happened allow bag can only burst once/ cannot get water back into bag	(1) AO 3 1a