RECOGNISING ACHIEVEMENT

TWENTY FIRST CENTURY
SCIENCE SUITE

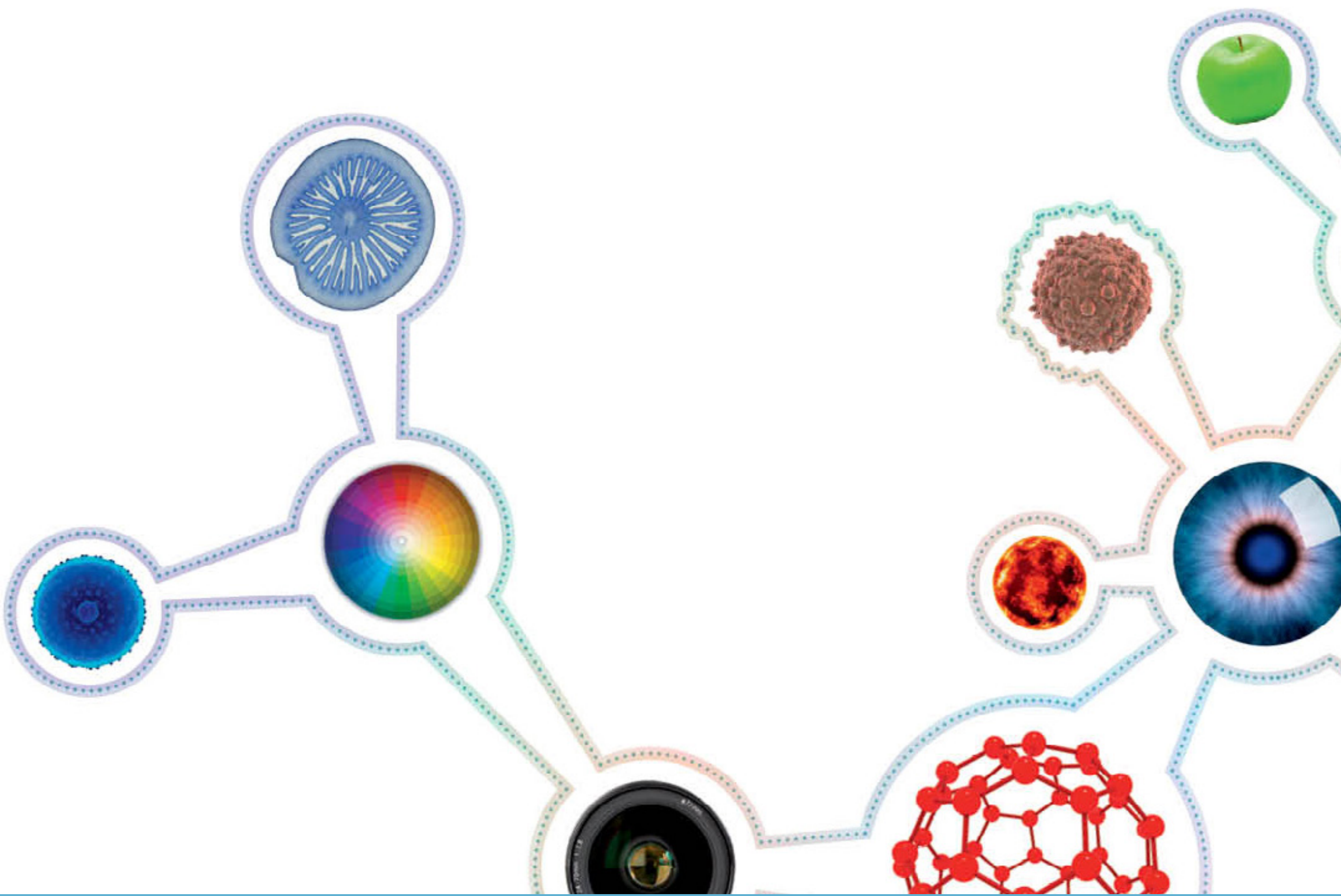
# UNIT A174 : SAMPLE CANDIDATE WORK AND MARKING COMMENTARIES

VERSION 1 MAY 2012

www.ocr.org.uk/science

# INDEX





# INTRODUCTION

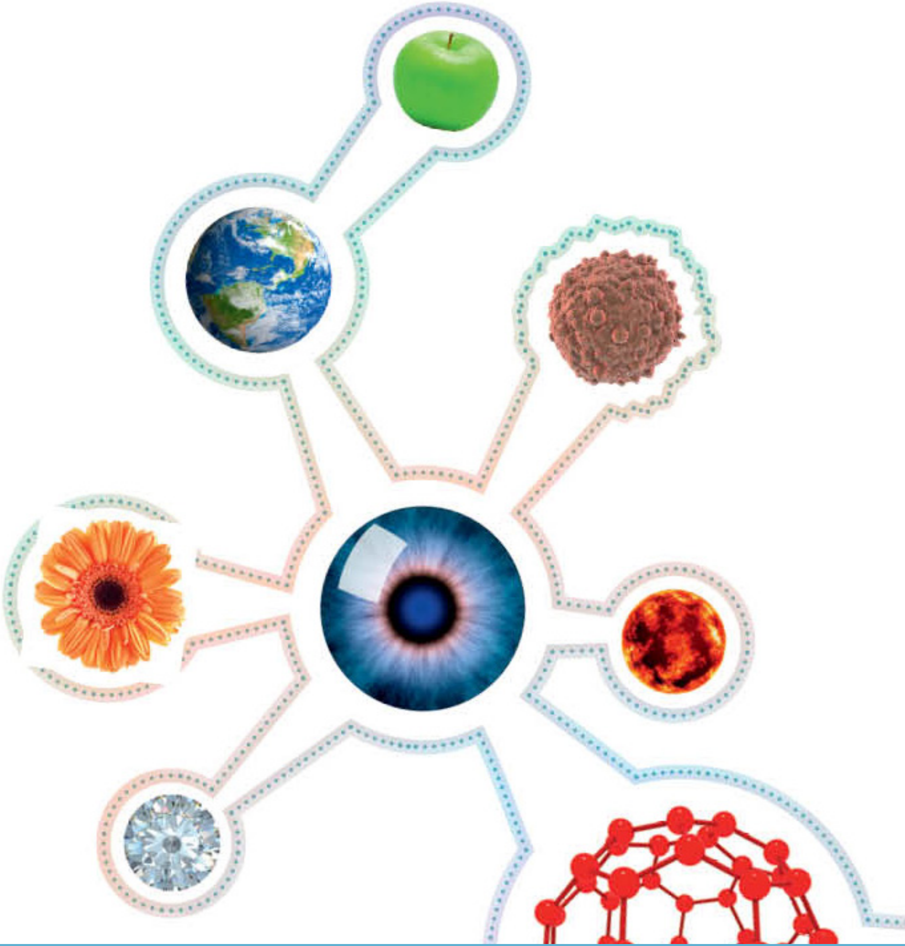
These support materials are intended to support teachers in their marking. There is a candidate style response with accompanying commentary. These exemplars are based on the published Specimen Assessment Materials (SAMs), which can be downloaded from the relevant OCR webpage for the specification.

The exemplars and commentaries should be read alongside the Specifications and the Guide to Controlled Assessment for GCSE Twenty First Century Science, all of which are available from the website.

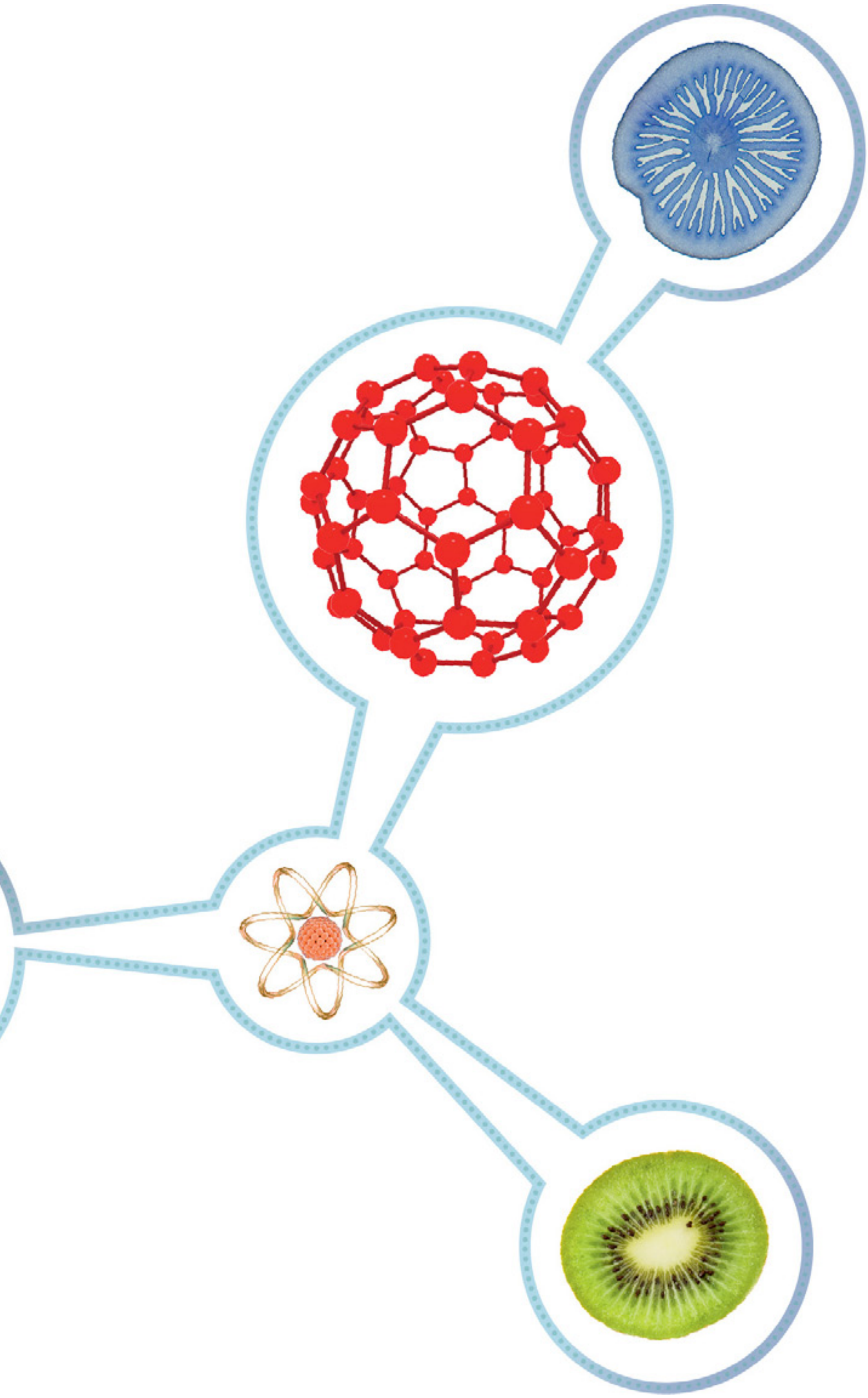
OCR will update these materials as appropriate.

Centres may wish to use these support materials in a number of ways:

- teacher training in interpretation of the marking criteria
- departmental standardisation meetings
- exemplars for candidates to review.



# INFORMATION FOR TEACHERS



OCR
RECOGNISING ACHIEVEMENT

SPECIMEN

# GCSE TWENTY FIRST CENTURY SCIENCE
# ADDITIONAL SCIENCE A A154
# CHEMISTRY A A174

**Practical Investigation**
Factors that affect the rate of reaction of calcium carbonate with acid

**CONTROLLED ASSESSMENT**
**INFORMATION FOR TEACHERS**

This assessment will be changed every year. Please check on OCR Interchange that you have the Controlled Assessment material valid for the appropriate assessment session.

- This document is confidential to teachers and must not be released to candidates.
- For details of the level of control required for this assessment refer to Section 5 of the specifications.
- There are two documents provided for candidates for this Controlled Assessment task:
  **Information for candidates (1)** defines the topic of the investigation and places it into a relevant context. This should be issued to candidates at the start of the task.
  **Information for candidates (2)** provides some secondary data to supplement that which candidates collect for themselves. It should be issued to candidates only on completion of the data collection part of their investigation.
- The total number of marks for this Controlled Assessment task is **64**.
- Internally assessed marks **must** be submitted by 15 May.
- This Controlled Assessment task is valid for submission in the June examination series only.
- This document consists of **4** pages. Any blank pages are indicated.

**Teachers are responsible for ensuring that assessment is carried out against the Controlled Assessment set for the relevant examination series (detailed above).**

**Assessment evidence produced that does not reflect the relevant examination series will not be accepted.**


Released: June 20##
DC (AC/SW) 49106/3


**Turn over**

## Introduction

This ‘Information for teachers’ is confidential and must not be released to candidates.

This document gives information about the Practical Investigation task for Additional Science A Unit A154 / Chemistry A Unit A174:

| |
|---|
| **Task title:** Factors that affect the rate of reaction of calcium carbonate with acid |

Each candidate for Controlled Assessment in the June examination series must present marks for one of the Practical Investigation tasks that is appropriate to the applicable specification. All internally assessed marks must be submitted by 15 May.

The marked work of all candidates must be retained by the centre. Some of the work will be required for moderation.

## General guidance for teachers

These notes provide background information for the preparation of candidates for these tasks and advice on the assessment of the Practical Investigation report.

Reference should also be made to Section 5 of the specification for Additional Science A or Chemistry A and to the *Guide for Controlled Assessment for GCSE Twenty First Century Science*.

Task setting is under high control. Tasks are therefore set by OCR. Where appropriate, tasks may be contextualised by individual centres to take account of local circumstances, including availability of resources and the needs of candidates. However, assessments must be based on the published marking criteria (within Section 5 of the specifications). If there is any doubt about whether a contextualised task still sufficiently matches the task and criteria, centres should seek confirmation from OCR that the task is still valid.

## Preparation of candidates

It is expected that before candidates attempt a Controlled Assessment task they will have received general preparation in their lessons. Learning activities to develop the relevant skills should have been provided and the broad requirements of the assessment made clear to candidates.

More specific details of practical techniques, the development of skills associated with these techniques, and possible methods and choice of equipment for the task should be covered when teaching the relevant part(s) of the specifications, and must be completed prior to setting the task.

From their work for Module C3: Chemicals in our Lives - Risks and Benefits and Module C6; Chemical Synthesis, candidates should be familiar with reactions of acids with carbonates, the properties of strong and weak acids and rates of reactions.

## Assessment of the quality of written communication (QWC)

The quality of written communication is assessed in Strands S and R of this Controlled Assessment task. Candidates should be advised that the quality of their written communication will be assessed. Further information about the assessment of QWC may be found in the specifications.

## Risk assessment

It is the centre's responsibility to ensure the safety of all candidates. Teachers are responsible for making their own risk assessment for the task prior to candidates attempting the practical work, and for ensuring that appropriate health and safety procedures are carried out. However, teachers must not provide candidates with a risk assessment since this is included in the marking criteria for Aspect S(b). If candidates require additional guidance on managing safety once the task has started then this will need to be reflected in the marks awarded.

## Guidance on assessment

All assessment of the Practical Investigation Controlled Assessment is based on the final report submitted by the candidates.

The marking procedure and marking criteria are described in detail within Section 5 of the specifications. Marking decisions should be recorded on the respective cover sheets (available to download from www.ocr.org.uk and included in the *Guide for Controlled Assessment for GCSE Twenty First Century Science*). Candidates' reports should be annotated to show how marks have been awarded in relation to the marking criteria.

## Additional guidance on marking criteria

Detailed guidance on applying the marking criteria will be found in the *Guide for Controlled Assessment for GCSE Twenty First Century Science.*

The following additional brief notes provide some clarification of what may be expected from candidates in some strands. However, all marking decisions must be consistent with the marking criteria.

**Strand S**

Reference should be made to the appropriate science in Module C3: 'Chemicals in our Lives - Risks and Benefits' and Module C6: 'Chemical Synthesis'.

Quality of written communication is assessed in this strand.

**Strand R**

Reference should be made to the appropriate science in Module C3: 'Chemicals in our Lives - Risks and Benefits' and Module C6: 'Chemical Synthesis'.

Quality of written communication is assessed in this strand.

# Guidance for technicians and teachers

| **Task title** |
| --- |

Candidates plan their own investigations and may therefore require access to other apparatus at the discretion of the centre.

Teachers are advised to check that the range of apparatus provided will enable candidates to plan and carry out appropriate experiments to collect valid data.

The factors under investigation may include temperature, the concentration of acid, and/or the type of acid. Suitable acids include hydrochloric acid, citric acid and ethanoic acid

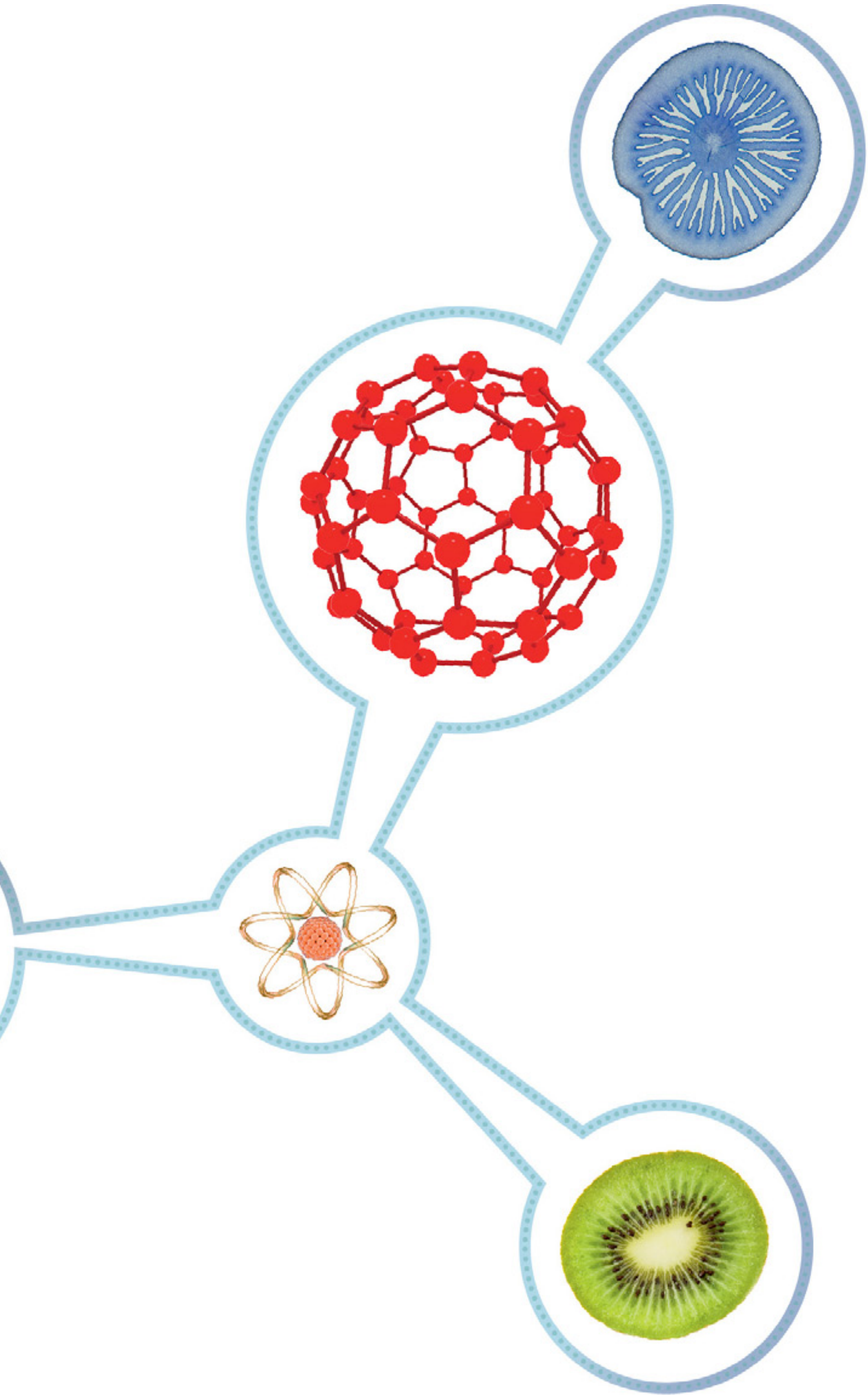
**Apparatus suggested**

- Acid(s)
- Marble chips (Note 2)
- top pan balances
- thermometers
- stop clocks or watches
- beakers or large test-tubes or conical flasks (various sizes), measuring cylinders (10 $cm^3$, 25 $cm^3$ and/or 50 $cm^3$)
- cotton wool (Note 3)
- filter papers (Note 3)

Notes

1. When providing acids, it may be advisable to make up at least the total volume required in one batch, so that the concentration will not vary from one lesson to the next.
2. A large stock of marble chippings will be required. These should be as nearly as possible all of the same size. It may be helpful to use a sieve when selecting from the main stock bottle, so that fine dust or small broken pieces are removed.
3. To put in neck of flasks to prevent loss of acid spray; to cover beakers to prevent loss of spray.

# INFORMATION FOR CANDIDATES



OCR RECOGNISING ACHIEVEMENT

SPECIMEN

**GCSE TWENTY FIRST CENTURY SCIENCE**
**ADDITIONAL SCIENCE A A154**
**CHEMISTRY A A174**

**Practical Investigation**
Factors that affect the rate of reaction of calcium carbonate with acid

**CONTROLLED ASSESSMENT**
**INFORMATION FOR CANDIDATES (1)**

This assessment will be changed every year. Please check on OCR Interchange that you have the Controlled Assessment material valid for the appropriate assessment session.

- To be issued to candidates at the start of the task.
- Your quality of written communication will be assessed.
- The total number of marks for this Controlled Assessment task is **64**.
- This Controlled Assessment task is valid for submission in the June examination series only.
- This document consists of **2** pages. Any blank pages are indicated.

**Teachers are responsible for ensuring that assessment is carried out against the Controlled Assessment set for the relevant examination series (detailed above).**

**Assessment evidence produced that does not reflect the relevant examination series will not be accepted.**



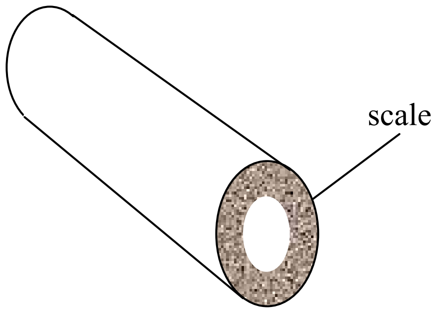
**Turn over**

## Information for candidates

**You are going to carry out an investigation into a factor that affects how calcium carbonate is dissolved by acid.**

## Background

In many parts of Britain, our water supply contains small amounts of calcium hydrogencarbonate dissolved in it. When water is heated, for example in kettles or boilers, the heat turns calcium hydrogencarbonate into calcium carbonate, which sticks to the insides of the kettle (or boiler) forming 'hard water scale' which blocks up the spout or water pipes.




Hot water pipes can become almost completely blocked by calcium carbonate.

The scale can be removed by using acid, which dissolves it.

For example:

calcium carbonate (insoluble) + hydrochloric acid → calcium chloride (soluble) + carbon dioxide + water

This reaction with acid has been used for many years to remove calcium carbonate deposits, both in the home and on an industrial level.

You will choose one factor and investigate this factor's effect on how calcium carbonate is dissolved by acid.

OCR
RECOGNISING ACHIEVEMENT

SPECIMEN

**GCSE TWENTY FIRST CENTURY SCIENCE**
**ADDITIONAL SCIENCE A A154**
**CHEMISTRY A A174**

**Practical Investigation**
Factors that affect the rate of reaction of calcium carbonate with acid

**CONTROLLED ASSESSMENT**
**INFORMATION FOR CANDIDATES (2)**

This assessment will be changed every year. Please check on OCR Interchange that you have the Controlled Assessment material valid for the appropriate assessment session.

- To be issued to candidates **only** on completion of the data collection part of their Practical Investigation.
- Your quality of written communication will be assessed.
- The total number of marks for this Controlled Assessment task is **64**.
- This Controlled Assessment task is valid for submission in the June examination series only.
- This document consists of **3** pages. Any blank pages are indicated.

**Teachers are responsible for ensuring that assessment is carried out against the Controlled Assessment set for the relevant examination series (detailed above).**

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Released: June 20##
DC (AC/SW) 49106/3


**Turn over**

**2**

These secondary data can be used as part of your Practical Investigation.

You can select the data that is useful for you.

Hydrochloric acid does remove 'fur' from kettles very quickly, but it also corrodes metals and can be hazardous to use.

Researchers tested the effectiveness of some organic acids in limescale removal. Organic acids are safer to handle, and considered more 'friendly' to the environment.

In one investigation, they immersed a block of marble in different concentrations of each acid for 15 minutes. The mass of the marble was measured and the percentage decrease in mass calculated.

Some of their results are shown below.

| % concentration of acid | % decrease in mass of marble after 15 minutes | | |
|---|---|---|---|
| | citric acid solution | glycolic acid solution | lactic acid solution |
| 1 | 0.21 | | |
| 2 | 0.30 | 0.43 | 0.29 |
| 3 | 0.41 | 0.40 | 0.48 |
| 4 | 0.48 | 0.35 | 0.80 |
| 5 | 0.55 | 0.30 | 0.89 |
| 6 | 0.60 | 0.30 | 1.05 |
| 7 | 0.64 | 0.30 | 1.17 |
| 8 | 0.69 | 0.30 | 1.28 |
| 9 | 0.75 | 0.29 | 1.45 |
| 10 | 0.82 | 0.29 | 1.58 |

Research was also carried out at different temperatures, using 10% solutions of each acid.

Some of the results are shown below.

| temperature in °C | % decrease in mass of marble after 15 minutes | | | |
|---|---|---|---|---|
| | citric acid solution | ethanoic acid solution | glycolic acid solution | lactic acid solution |
| 20 | 0.8 | 2.0 | 0.4 | 1.8 |
| 25 | 1.2 | 2.1 | 0.6 | 3.0 |
| 30 | 1.5 | 2.0 | 0.8 | 4.3 |
| 35 | 1.7 | 2.4 | 1.1 | 5.5 |
| 40 | 2.0 | 2.7 | 1.6 | 6.6 |
| 45 | 2.1 | 3.3 | 2.1 | 7.3 |
| 50 | 2.4 | 3.7 | 2.6 | 7.9 |

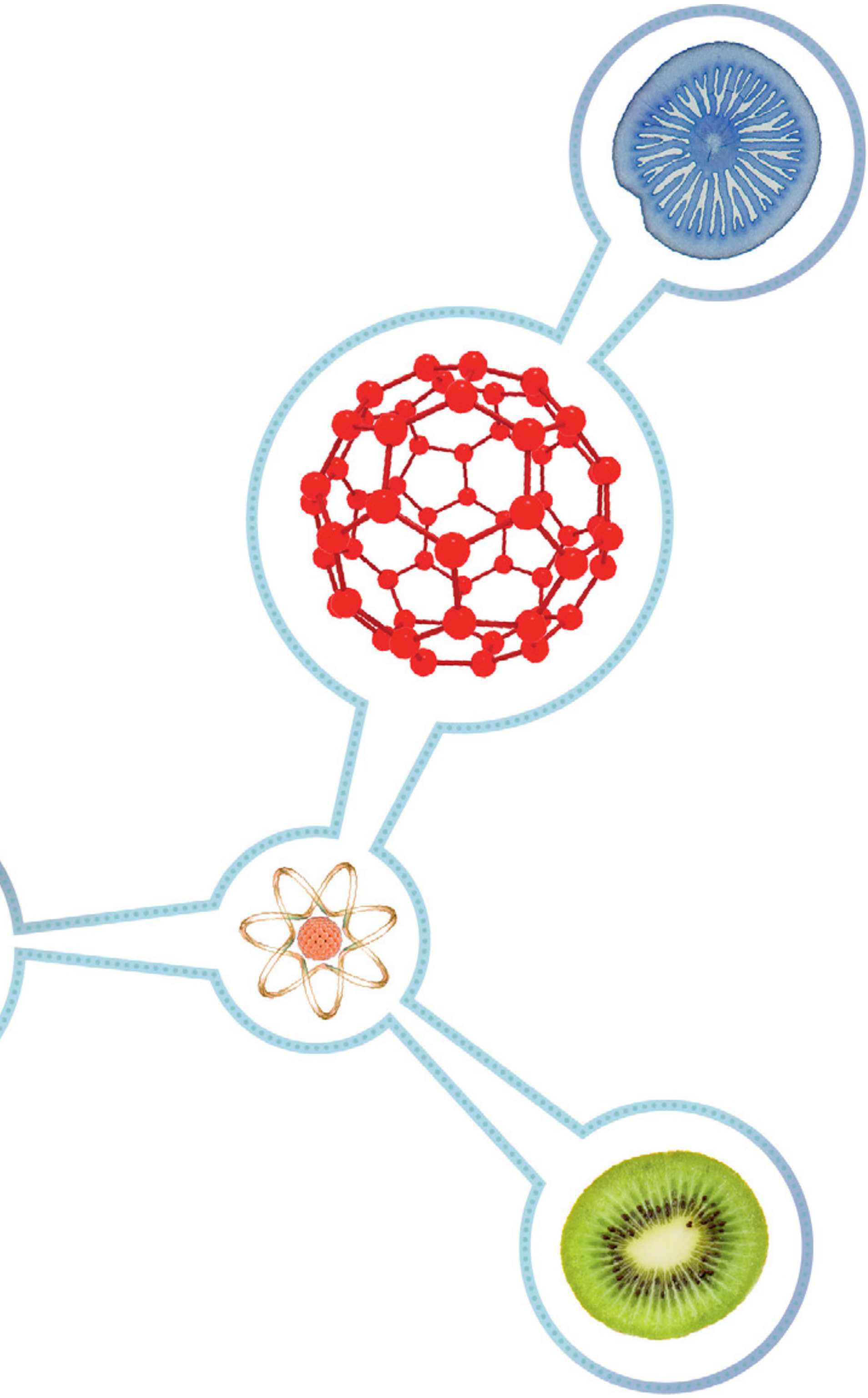
**3**

The research team also investigated the corrosive action of different acids. Pieces of brass were immersed for 72 hours in 10% solutions of each acid.

Their results are shown below.

| acid | corrosive action in arbitrary units |
|---|---|
| citric acid | 1.2 |
| ethanoic acid | 4.3 |
| lactic acid | 1.0 |
| phosphoric acid | 2.8 |
| sulfamic acid | 2.9 |

# CANDIDATE SCRIPT AND COMMENTARY



# CA Investigation Exemplar 2 - Chemistry Carbonate - Script

## Rate of Reaction of Calcium Carbonate and Hydrochloric Acid

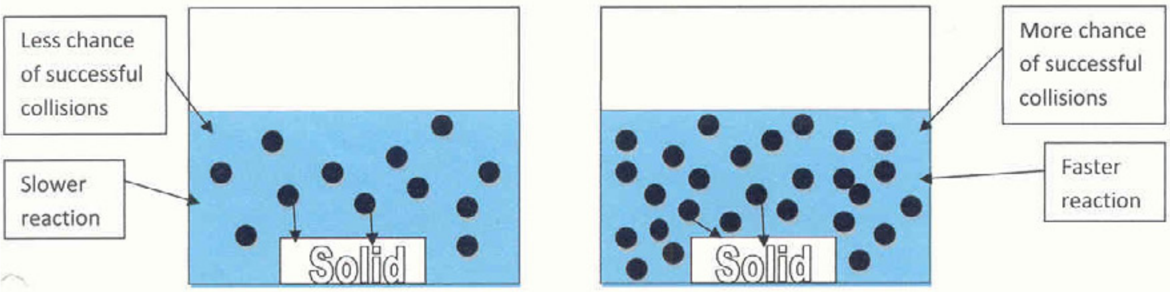
**Introduction**

I have several factors that can affect the rate of reaction Calcium carbonate with hydrochloric acid. They are concentration of acid, the temperature, having a catalyst present, the surface area of the solid calcium carbonate being used in the reaction and the stirring of the mixture. This can affect the experiment if I do not standardise the way in which I do it.

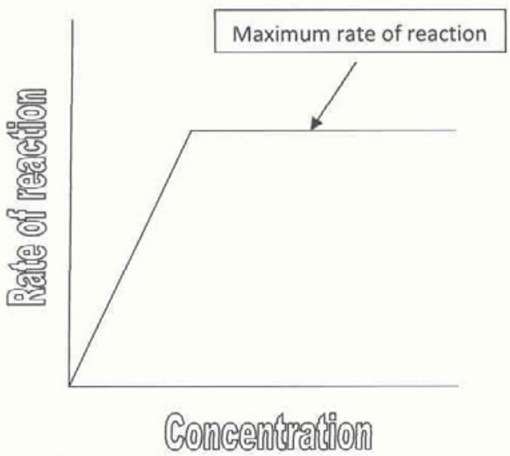
I have decided to investigate whether changing the concentration of acid affects the rate of reaction when the acid reacts with a solid, because I think I will be able to change this most easily. I will be taking all possible variables into account and I will try to make this experiment as reliable and accurate as I can possible make it. The experiments will be carried out in school and I shall be recording the results and concluding my experiment to find out if this hypothesis is correct.

**Prediction**

I predict that the higher the concentration of hydrochloric acid the greater the rate of reaction. I predict this because I know that when the concentration is higher there are more active particles. When a reaction takes place, these particles gain kinetic energy therefore if there are more particles there will be more successful collisions, this means the rate of reaction will be greater.




I also predict that there will be a point where the rate of reaction will reach its peak and will no longer increase, this is because at this stage of the reaction the whole surface area of the calcium carbonate will be covered by HCl molecules, therefore the rate of reaction would have reached its peak and since there will be no more surface area to cover the rate of reaction will no longer increase.




1

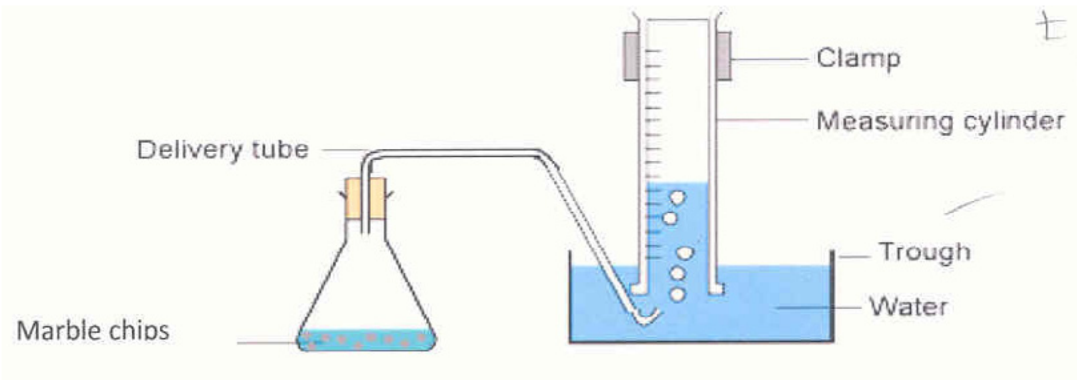
**Preliminary investigations**

**Rates of reaction – weighing how much gas is given off.**
We carried out a preliminary investigation. We were trying to find out how much gas ($CO_2$) was given off when we reacted some marble chips with hydrochloric acid. We carried out this reaction Hydrochloric acid + calcium carbonate = calcium chloride + water + $CO_2$

First we put 50ml of hydrochloric acid into a conical flask. We then put some marble chips into a beaker. Then we put some cotton wool in the end of the conical flask which had the acid in. After this we weighed both the flask and beaker on the balance. This weighed in at 126.489g. Then we took the cotton wool out and placed the marble chips into the conical flask, quickly replacing the cotton wool to minimise any liquid splashing out. The reaction began and we waited for it to finish reacting. Once it finished we read the reading. It now weighed 124.300g, this was a loss of 2.189g due to the $CO_2$ let off in the reaction. This was in one minute and to find out the gas given off in one second we divided 2.189 by 60. We got the answer of 0.0121 grams per second.

We then evaluated the experiment. We thought this was a bad experiment because the equipment we used was unreliable. The scales changed every time we took off the items and replaced them this is impossible to be accurate. Even though we achieved one thing, the removing of human error. We did this by using a machine. Even though we removed human error, the fact that we cannot trust the equipment is a big issue therefore we cannot possibly use this experiment for our final experiment.

**Rates of reaction – volume of gas given off.**
We carried out a preliminary experiment this was to test how the concentration of an acid affected the amount of $CO_2$ emitted when reacted with calcium carbonate. We used four different percentages of hydrochloric acid (HCl), some calcium carbonate, a conical flask, a bung and delivery tube, a bowl/tray, a measuring cylinder, a clamp stand and a stop watch. We predicted that the higher concentration of acid we used the more $CO_2$ emissions we would get. In order to make this a fair test we knew we had to standardise a few things. We knew we had to standardise the amount of marble chips used we also had to take into account the dip in the water when looking at it through the cylinder. We did this by looking at eye level.




First we poured 50ml of 100% concentration of HCl (1Mol) into a conical flask. We then filled the tray full of water. We then secured the cylinder with a clamp and stand. We took a measurement on the cylinder. After this we quickly dropped the marble chips into the HCl placing the bung on. As soon as we placed the bung in the tube we got someone to start the stop watch. The tube was placed under the cylinder and the gas was collected in the cylinder. As soon as the stop watch began timing we also started to shake the conical flask in a standardised fashion. This was timed for 1 minute. We repeated these steps with four different percentages of HCl.

2

| Concentration Of HCL (Mol) | Volume of $CO_2$ In 60 Seconds (ml) | Rate Of Reaction (ml/s) |
|---|---|---|
| 1 | 54 | 0.90 |
| 0.8 | 38 | 0.63 |
| 0.6 | 20 | 0.33 |
| 0.4 | 90 | 1.50 |

We then evaluated the experiment. We thought the concentrations used were ideal to use in our final experiment. The results I gathered showed that the higher the concentration, the greater the rate of reaction although something odd seemed to have happened with the 0.4 mol solution. For all the different concentrations I used the results we gathered were clear and the results were not too small that we couldn't measure them and there was a big enough gap between each one to get a good range. Because of this I chose to use those concentrations in my final experiment although not the 0.4 one.

We thought this was a very good experiment. We standardised the stirring by counting a rhythm in our heads and we also measured the volume of acid very accurately we measured by the dip in the water. The only one thing that was bad was that of judging the amount of marble chips used. We counted out 10 each time but these may of been different sizes. Even though this is a problem it is near enough impossible to measure its surface area and the difference in surface area did not make any difference to our results. We also knew we had to take percentage error into consideration. Overall we thought the advantages in this experiment outweighed the disadvantages therefore we shall be using this method in our final experiment but we may tweak a few factors to make it that extra bit more reliable.

**Identifying My Variables:**
My **Input Variable** was the concentration of the Hydrochloric acid, this is to see if the change in concentration affects the rate of reaction.
My **Output Variable** is the rate of reaction. This is what I am going to try and find. I am going to do this by measuring the amount of $CO_2$ given off and dividing that figure by the amount of time taken. This gives me the rate of reaction in ml/s.
I have several **Control Variables**: these are factors I am going to control. I am going to control the temperature by performing all my experiments under room temperature (around 21°C). I also am going to control there being a catalyst present, by making sure I clean my equipment before I use it, this makes sure there is nothing present on my equipment that is going to either slow down or speed up the reaction in my experiment. A main variable I am going to control is the surface area of the calcium carbonate being used in the reaction. I am not going to measure the surface area as this is near to impossible. But I am going to use the same number of Calcium carbonate (marble) chips each time as close to the same size as possible. The last variable I am going to face is the way in which I am going to stir the mixture. This can affect the experiment if I do not standardise the way in which I do it. To overcome this variable and remove human error I have chosen to not stir my mixture, this way it will keep the experiment fair and more reliable.

**Final method:**
Equipment list: ~

- 5 different concentrations of hydrochloric acid (HCl) (1Mol, 0.9 Mol, 0.8 Mol, 0.7 Mol, 0.6 Mol)
- Calcium carbonate (marble chips)
- Conical flask
- Bung + delivery tube
- Bowl/trough cylinder
- Measuring cylinder
- Clamp stand
- Stop watch

3

- Drinking straw

**Safety**

The risks are acid burns and cuts from broken glass. We must be careful in using the acid and wear goggles. We must also be careful not to drop any glass and keep things in the middle of the bench.

**Making the concentrations:**
In the experiment I will need to use 5 different concentrations of HCl, I am going to make this myself and I will need to be accurate. To make the concentrations I will use 100% hydrochloric acid and dilute it using water, I will be repeating my experiment up to 7 times including the chance of having outlier results. Each time I repeat at the experiment I will be using 50ml of solution, therefore I am going to need 350ml of each concentration, I can produce a table to show how to do this.

| Concentration of HCL (Mol) | Water (ml) | 100% hydrochloric acid (ml) |
|---|---|---|
| 1 | 0 | 350 |
| 0.9 | 35 | 315 |
| 0.8 | 70 | 280 |
| 0.7 | 105 | 245 |
| 0.6 | 140 | 210 |

To do this I simply poured out the specified amount of HCl into a conical flask. I then added the appropriate amount of water into a separate conical flask. Next I poured some solution into the water and then poured the water into the solution. I repeated the process. After doing this a few times all of the solution was in one conical flask and the HCl was diluted and mixed appropriately.

**Method of experiment:**
1. Fill the bowl/trough with water.
2. Fill the measuring cylinder with water, turn upside down keeping the water in.
3. Place in the trough of water and secure in place with a clamp stand.
4. Make sure the cylinder in about 1 inch off the bottom of the trough.
5. Use a drinking straw and place it in the small gap between the cylinder and bottom of the trough. Blow some air until u get a clear reading on the cylinder. (e.g. a multiple of 10)
6. Remember you're measuring the bottom of the dip in the water not the top, this is to make your experiment more accurate.
7. Also check that the cylinder is straight and not crooked so the reading is clear
8. Next get your bung which is connected to a delivery tube ready by placing the end of the tube under the gap between the cylinder and the bottom of the trough.
9. Next pour out 50ml of HCl solution (the concentration you wish to use first) into a conical flask.
10. Pick up 10 average sized calcium carbonate (marble) chips and hold them in your hand
11. Get your friend to hold the stopwatch ready.
12. Quickly place all 10 calcium carbonate chips into the solution of HCl and place the bung on the conical flask.
13. As soon as you have placed the bung on the conical flask, yell to your friend to start timing.
14. Hold the delivery tube under the gap between the cylinder and the trough to make sure it doesn't fallout. This is not necessary if the tube stays in the gap and the bubbles are being collected in the cylinder.
15. Time this for 80 seconds.
16. After the 80 seconds is up, quickly remove the tube from underneath the cylinder
17. Count how much $CO_2$ has been given off into the cylinder. You can do this by reading it off the side of the cylinder. For example if the cylinder started on 30ml and it is now l00ml,

70ml of $CO_2$ has been given off.
18. Divide the amount of $CO_2$ given off by the amount of seconds it took. For example is 70ml of $CO_2$ was given off in 80 seconds. It would be 70 divided by 80. This will give you the rate of reaction in (ml/s)
19. Repeat the whole process 7 times for each concentration.
20. After you have repeated the process 7 times. Use a different concentration of HCl and complete steps 1-19
21. Do this for all 5 of your concentrations.

**Choosing the right equipment:**
I had to make many decisions which could affect the reliability of my experiment. A main decision I had to make was about which equipment I should use.
Measuring the amount of gas coming off was a big decision of mine. I chose the measuring cylinder because the measurements on it were very close with each dash being 2 ml., a burette however would have been most accurate. It all comes down to percentage error. Judging the accuracy of a piece of equipment is important. On the measuring cylinder I could have measured in-between 2 dashes. With each dash representing 2ml could of been bang in the middle meaning I could measure 1ml up or 1ml down. This means if I was measuring 100ml of liquid I could have been out by 2ml. 2ml out of 100 is 2%, this would be my percentage error. In the burette however the percentage error was much smaller. I still went ahead and used the measuring cylinder because we were measuring results up to 80ml. 2% of 80ml is 1.6ml. I made a decision that to be up to 1.6ml out was not bad and this equipment was accurate enough. The reason I did not use the burette is because we would have wasted more time filling it up and preparing it. It was also more complicated to use. Therefore we went with the most simple and quickest option.

**How And Why I Controlled My Control Variables.**
A variable I could have controlled to increase the accuracy of my experiment is the surface area of the calcium carbonate. This was impossible to measure. Therefore we could have weighed the calcium carbonate and used the same weight each time. But we didn't, we didn't weigh them because we knew weighing them wouldn't totally make sure the surface area was the same. Because we could not be 100% accurate and we could have risked being less accurate, we decided not to weigh the chips and just use a set number of them as close to the same size as I could.

Another variable that could affect the experiment is the temperature. We simply completed all our experiments under room temperature therefore the temperature remained the same during the whole of the investigation.

A variable I had to control was the idea of a catalyst being present. This is something that can speed up or slow down a reaction. To counteract this I made sure my apparatus was cleaned each time I repeated an experiment and obviously before I started the experiment. This ensured no catalyst was present and therefore my results were more reliable knowing nothing was present to speed up or slow down the reaction.

Another control variable was the stirring of the solution whilst the reaction was taking place. This could be human error if I were to not knowingly stir differently each time I repeated the experiment. This could affect my results and make them less reliable. To make sure this did not happen, I did not stir the solution during the reaction. This removed human error and guaranteed the results I collected were both reliable and accurate and that I did not affect them in any way.

| **Concentration of HCl (%)** | **Volume of $CO_2$ (ml)** | **rate of reaction (ml/sec)** | **Mean rate of reaction (ml/sec)** | **Range** |
|---|---|---|---|---|
| 100 | 80 | 1.000 | | |
| 100 | 78 | 0.975 | 1.000 | 0.975-1.025 |
| 100 | 82 | 1.025 | | |
| 90 | 77 | 0.963 | | |
| 90 | 76 | 0.950 | 0.963 | 0.950-0.975 |
| 90 | 78 | 0.975 | | |
| 80 | 70 | 0.825 | | |
| 80 | 74 | 0.925 | 0.916 | 0.825-1.000 |
| 80 | 80 | 1.000 | | |
| 70 | 57 | 0.713 | | |
| 70 | ~~72~~ | | 0.700 | 0.688-0.713 |
| 70 | 55 | 0.688 | | |
| 60 | 40 | 0.500 | | |
| 60 | 44 | 0.550 | 0.550 | 0.500-0.600 |
| 60 | 48 | 0.600 | | |

In my results I had to be careful that I didn't include outlier results. These are results that are not right and something must have gone wrong for that result to happen. I came up with a rule to detect an outlier results. If a result I got was 15% over or below any of the other results (whilst using the same concentration), I would rule it out and call it an outlier result. Amongst my results I had one outlier result. Whilst doing the concentration of 70% (0.7 Mol) I came across an outlier result. Both my other two results were in the 50's (being 57 and 55) my other result I got was 72 this had to be an outlier result. Because it was an outlier result I placed a cross through it in my table and I did not include it when calculating the mean rate of reaction. I also did not include that result in my range.

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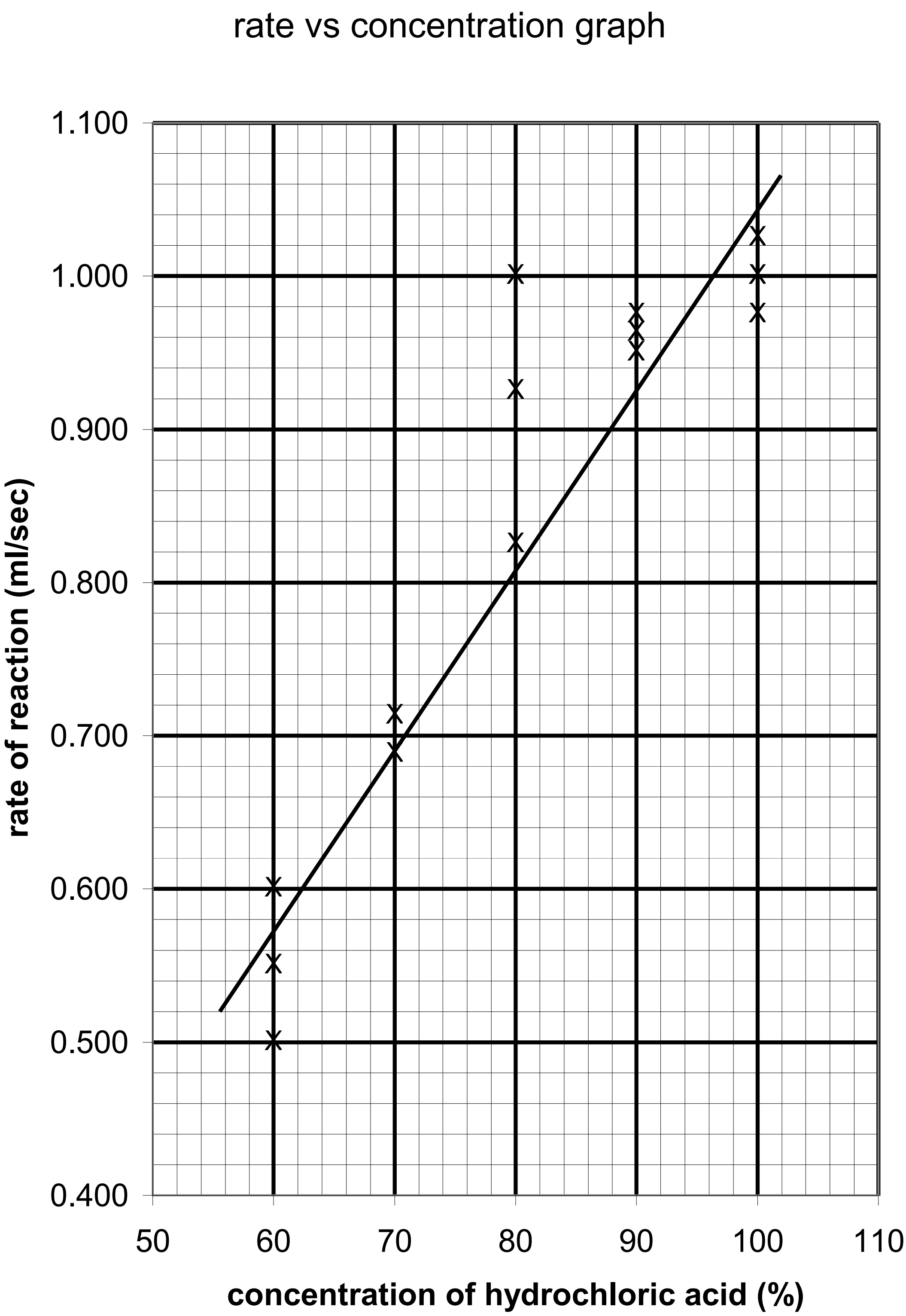


Gradient is y/x = 0.7/0.7 = 1.0
This shows that for each 0.1 mol the rate of reaction will increase by 0.1 ml/sec

**Analysis**
With the results I gathered from my experiment I used them to draw out a graph. On this graph I plotted the rate of reactions for each different concentration I used. Once I did this I drew a line of best fit. With the line of best fit I was able to work out a gradient for the line. I did this by using the equation, y/x I followed a point up from the Y and X axis and then

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worked out this simple equation. I ended up with, 0.7/0.7, this equalled 1. So I found out that for every 1Mol of hydrochloric acid the rate of reaction increased by 1 ml/sec.

With my graph I could then see if there was a trend. I found there was a positive linear correlation/relationship. This meant my results were gradually going up, based on this it showed that there was a correlation between the concentration of hydrochloric acid and the mean rate of reaction. This showed that the higher the concentration the greater the rate of reaction.

However even though there was a positive linear correlation doesn't necessarily mean my results were reliable. I have to take into account the real difference. This is the difference between a range of one concentration and the range of another. If the ranges of two different concentrations overlap there am no way I can be confident that there is a difference between the two concentrations.

On my graph there was a real difference between most of my concentrations apart from the 80% concentration one. Its range overlapped with another concentrations range. This made it difficult to accurately draw my line of best fit and this would affect the gradient that I calculated i.e. the ‘for each 0.1 mol the rate of reaction will increase by 0.1 ml/sec’. This overlapping could be caused by an outlier result but as I did not include those results into my graph this could not have been the case. The only thing that caused that concentration to appear without a real difference was a single result. If this result was lower there would have been a real difference between every concentration.

**Conclusion**

The science behind my results is simple. The results are due to the collision theory. Just as I said in my prediction this is that if the concentration of a liquid is higher, then there will be more atoms able to react. If there are more atoms available to react with the surface area of a solid then there will be more successful collisions. Meaning there will be a higher rate of reaction.

I am confident that my results are correct and that there is a real difference between different concentrations. I think this because in my results only one of the ranges overlaps with another. This may seem bad, but it was only due to one results being a bit too high. Therefore I am confident that my results show that there is an increase in the rate of reaction as the concentration of hydrochloric acid increases.

**Evaluation**

**Methods**

My preliminary investigations helped me decide on which concentrations to use. When carrying out my preliminary investigation I found out that the rate of reaction form 0.2 Mol was too small that we could not record the results this was true for the 0.4 Mol concentrations. Because of this I chose to uses the concentrations 0.6, 0.7, 0.8, 0.9 and 1Mol. This could have caused problems if I did not carry out my preliminary investigation as I would not have been able to record my data and therefore my whole investigation would have been a mess.

From my preliminary investigations I also found out which equipment and methods were best to use. I chose to use a measuring cylinder in my final experiment this was good because there was not much room for error. When measuring liquid in the cylinder I could of possibly been out by 1ml. Meaning I could been out by 1ml too high or 1ml too low, this meant the percentage error of the measuring cylinder was only 2%. This I thought was accurate enough for the experiment I was carrying out. I also made a rule to improve reliability, I said that whilst taking results for one concentration if a result was 15% higher or 15% lower than a result from the same concentration then I would count that result as an outlier meaning the result was an outlier result. I did not count these results in my table neither did I count these results in my graph or range.

Also to improve reliability I repeated my experiment 3 times for each concentration. This meant I could see the range and average mean rate of reactions. This gave me enough results to compare and see if there was a real difference between different concentrations. In my experiment there could have been errors that I did not control or fix. When measuring liquid in the measuring cylinder I could have made an error. I could have made a measurement error whilst looking at the meniscus at eye level. As I used a measuring cylinder my measurement error could have made my results more inaccurate this is because of the percentage error of that piece of equipment.

Surface area was another error I made whilst carrying out my practical work. The whole point of this experiment was to see if the concentration affected the rate of reaction this was due to the atoms of the concentration reacting with the surface area of the solid. As I did not control the surface area my results could be inaccurate. I did go to some lengths to control the surface area. As we cannot measure the surface area exactly I just counted 10 calcium carbonate (marble) chips each time of the same size as best I could. The chips could have been different sizes meaning there would have been a different surface area. This was hard to control but may have had an effect on my results

**Improvements**
To improve the reliability of my experiment I could have changed the way in which I dId some things. Instead of counting out 10 calcium carbonate (marble) chips, I could have weighed out the chips and then ground the chips into powder. If I did this the surface area would have been the same each time I repeated the experiment. However, the gas would come off very, very fast I think and this might cause other problems. Another factor I could have changed was the measurement device used. I used a measuring cylinder where as I could have used a more accurate device, the burette. The burette has a smaller gradient of measurements. Because of this, when I measured the liquid at eye level, looking at the meniscus. I could have been too high by 0.5ml or too low by 0.5ml. This meant the percentage error for the burette was 1% if I were measuring 100ml of liquid. The measuring cylinder could have been out by being 1ml too high or too low; this means the percentage error would have been 2% when measuring 100ml of liquid. Comparing the burette to the measuring cylinder, means my results could have been made more accurate by using the burette rather than the measuring cylinder. If I repeated this experiment again I would use a burette rather than a measuring cylinder to make my results more accurate, as there would be less percentage error.

**Data**
I think my results are very good. I only had one outlier result whilst carrying out all of my experiment. This meant all of my repeat results apart form one were very close to each other for that concentration and therefore I think they were reliable. They were also close to my final best fit line which meant they were accurate as well. On my graph only one concentrations range overlapped another concentrations. Even though this looks like my results are not confident. The overlapping of ranges was only caused by one result being too high. This result was not an outlier result but it may have been very close. To stop this I could have tweaked the rule to detect outlier results. Therefore because only one result caused the ranges to overlap I still feel confident in my results.

**Secondary data**
My research for secondary data found that the rate of a reaction should be directly proportional to the concentration of each of the reactants. ( http: //antoine.frostburg.edu/chem/senese/101 /kinetics/faq/concentration-and-reaction-rate.shtml. 2011).This fits with my data because my graph has a straight line with a gradient of 1.
I also looked at the data provided by OCR (OCR. Factors that affect the rate of reaction of calcium carbonate with acid. Information for candidates [2]. 2012). The results for changing concentration did not use hydrochloric acid as I did, they used three organic acids citric acid, glycolic acid solution and lactic acid. and they measured the change in mass instead of the gas given off as I measured. I don't think the difference in method is important because they probably had better apparatus than we did, which means their results would

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be accurate. The results for citric acid and lactic acid both agree with my results with the rate of reaction increasing with concentration. However the glycolic acid reaction appears to be slower when the concentration increases, I cannot explain this.

**Confidence in my Hypothesis**

In my experiment I did not totally control the surface area of the calcium carbonate. And I did not control the temperature. The temperature may have changed at times during the experiment to solve this I could have carried out my experiment in a water bath. Because I didn't these factors as well as other may have made my data inaccurate and unreliable.

Even though I could have made my experiment more reliable I still feel very confident that my results are correct and are reliable. I think this because there is a real difference between each concentration. And it is clear that the change in concentration affects the rate of reaction. My secondary data also supports my results (except for the glycolic acid solution. I can clearly see that the higher the concentration due to the collision theory means the rate of reaction will increase accordingly. So my hypothesis and prediction where correct.

If I did do this experiment again I would change the way in which I measured the surface area of the calcium carbonate, I would weigh and use a powder form of calcium carbonate. I would also try and control the temperature as this could have an effect on the results, I could do this by carrying out my experiment in a water bath where the temperature can be controlled. The last thing I would try to change would be the measuring divide I would use. I would use burette instead of a measuring cylinder as the percentage error would be reduced meaning my results would be 1% more accurate. This could make a big difference.

## Commentary - Investigation Title: Rate of Reaction of Calcium Carbonate with Acid

| Strand/Aspect | Mark | Comments |
|---|---|---|
| **S(a)** - formulate a hypothesis or prediction | 7 | Considers major factors and selects one, however with little detail for the selection. Presents a testable hypothesis (although not specifically called that) and a quantitative prediction. The report is comprehensive with generally effective use of scientific terms, spelling, punctuation and grammar. The criteria for 8 marks are not fully met. |
| **S(b)** - design of techniques and choice of equipment | 5 | Preliminary work was used to select the 'volume of gas' method rather than the 'mass loss' method and also to justify the selection of the measuring cylinder rather than the burette. The preliminary work provides a justification for the range used. However the assessment of risk is very limited. It correctly identifies some hazards and suggests some basic precautions. The criteria for 6 marks are not fully met. |
| **C** - range and quality of primary data | 7 | A suitable range of concentrations were used with appropriate repeat measurements taken of the volume of gas produced. However the outlier at 0.4 mol dm-3 was not investigated further. Preliminary work was used to inform and justify the concentration range selected, although the anomalous result at 0.4 mol dm-3 was not investigated further. From inspection, the data collected was generally of good quality. The criteria for 8 marks are not fully met. |
| **A** - revealing patterns in data | 8 | The scatter graph of rate vs concentration is suitably labelled and scaled; all raw data including repeats are plotted accurately and an appropriate (just) line of best fit drawn. All criteria for 8 marks are met. |
| **E(a)** - evaluation of apparatus and procedures | 8 | Limitations to the method are identified in terms of the difficulty in maintaining a constant surface area of marble chips and the use of a measuring cylinder. Possible temperature variations are also suggested as a possible problem. The use of a burette and grinding the marble into powder are suggested improvements. Further justification is provided by a consideration of the % errors involved in the two types of measuring device. |
| **E(b)** - evaluation of primary data | 7 | A simple rule is produced to identify potential outliers and one is specifically identified. However the presence of the outlier is not fully accounted for. Reliability and accuracy issues are also discussed with regard to repeat measurements and overlap and real differences are also mentioned. The difficulty of controlling the surface area of the marble chips is suggested as a possible reason for poor results. |
| **R(a)** - collection and use of secondary data | 5 | Two pieces of secondary data are used and referenced, although the internet reference is not complete but just an address. The differences and similarities are considered. Consideration is also given to whether the secondary data support the primary data. All the criteria for 4 marks are met and the criteria for 6 marks are partially met. |
| **R(b)** - reviewing confidence in the hypothesis | 7 | Some information about collection of extra data is given, but is limited to modifications of the experiment done. Some science is mentioned as supporting the hypothesis (more detail was given in the planning section of the report).The quality of the written communication is high, including the use of scientific terms, resulting in a comprehensive report which is generally logically sequenced. On balance the criteria for 6 marks are met, with some criteria met for 8 marks. |
| **Total:** | **54/64** | |

**GENERAL QUALIFICATIONS**
Telephone 01223 553998
Facsimile 01223 552627

science@ocr.org.uk
1 Hills Road, Cambridge CB1 2EU



**www.gcse-science.com**