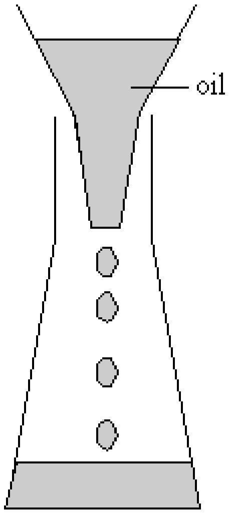
Q1.

A teacher carried out an experiment to study car engine oil. The experiment was carried out in a fume cupboard and the teacher wore plastic gloves. The oil was poured through a funnel. The time taken for all the oil to go through the funnel was measured. The experiment was repeated with the oil at different temperatures.



(a) What **two** safety precautions were taken in the experiment?

1. ____

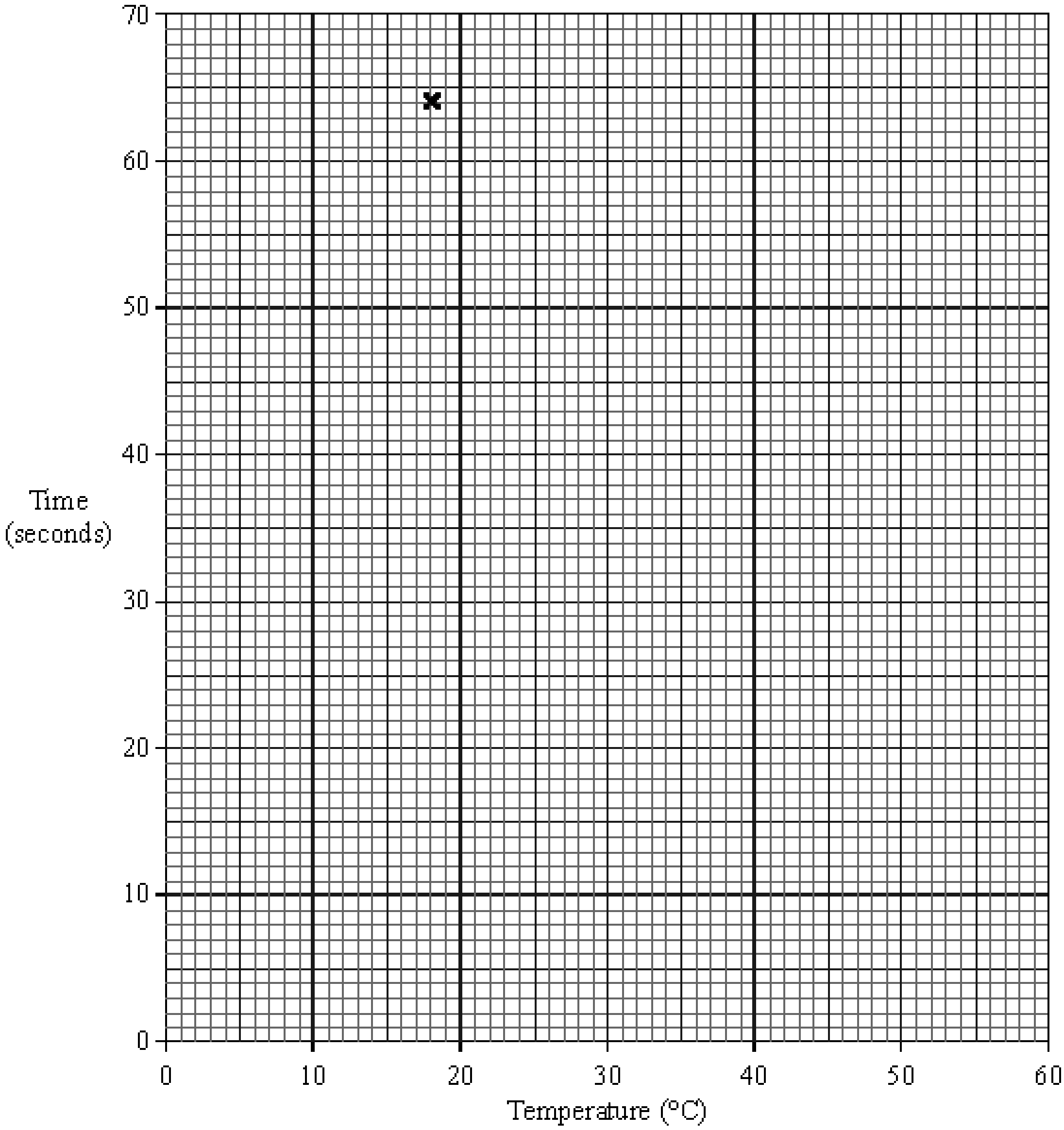
2. ____

(1)

(b) The results of the experiment are shown in the table below.

TEMPERATURE (°C)	TIME (seconds)
18	64
25	43
32	28
42	19
52	15

(i) Plot the results on the graph paper. One of the results has been plotted for you. Join the points in a smooth curve.



(3)

(ii) Use your graph to find the time it would take the oil to travel through the funnel at 37 °C.

Time = ____________________ seconds

(1)

(iii) How does the time taken for the oil to go through the funnel change when the temperature is increased?

____

____

(1)

(c) An engine oil must be viscous enough to stop the metal parts of the engine from rubbing against each other. It must not be too viscous or the parts cannot move freely.

(i) Complete the sentences below.

The more viscous a liquid is, the less easily it ______________________ .

As the liquid gets hotter it gets ____________________________ viscous.

(2)

(ii) Why should the oil in a car engine **not** be allowed to get too hot?

____

____

____

(1)

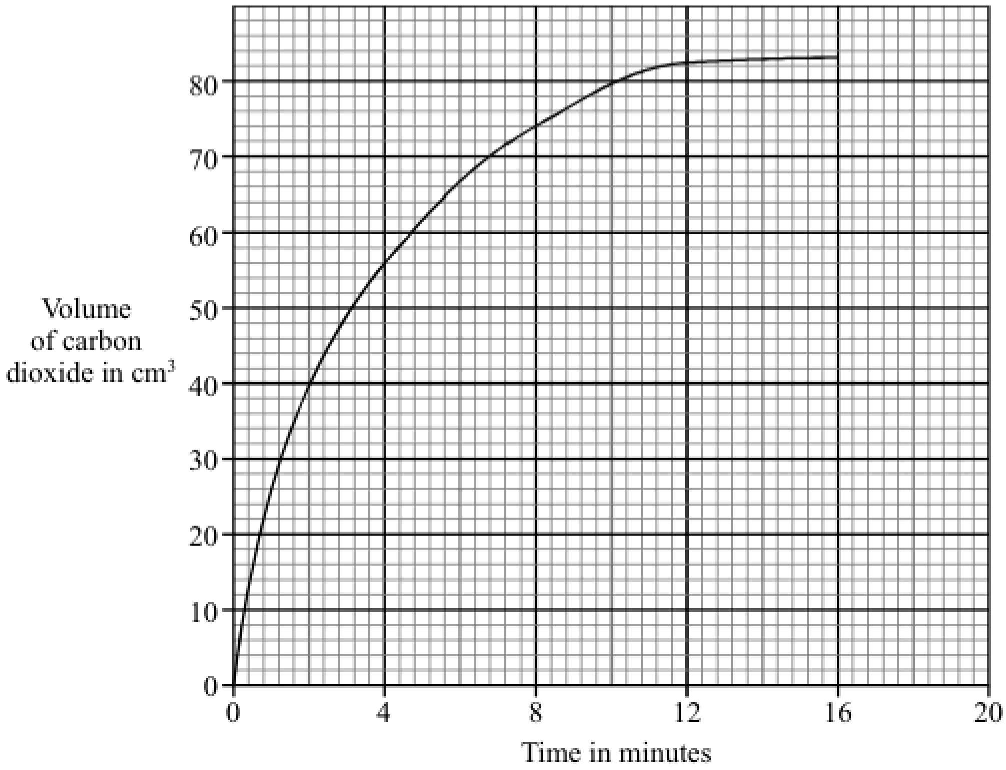
(Total 9 marks)

Q2.

Calcium carbonate reacts with nitric acid to produce carbon dioxide.

$$CaCO_3 + 2HNO_3 \rightarrow Ca(NO_3)_2 + H_2O + CO_2$$

A 10 g lump of calcium carbonate was reacted with 20 cm^3 of dilute nitric acid. When the reaction was finished, some of the calcium carbonate was left unreacted. The graph shows the volume of carbon dioxide made in each minute for sixteen minutes.



(a) The volume of carbon dioxide made in each minute decreases until it remains steady at 83 cm^3.
Explain why.

____

____

____

____

(2)

(b) Draw a graph line, on the axes above, for an experiment where 20 cm^3 of the same dilute nitric acid was reacted with 10 g of **powdered** calcium carbonate.

(2)

(c) Give **one** way of changing the rate of this reaction (other than using powdered calcium carbonate).

____

____

(1)

(Total 5 marks)

Q3.

Greenhouse gases affect the temperature of the Earth.

(a) Which gas is a greenhouse gas?

Tick **one** box.

Argon ☐

Methane ☐

Nitrogen ☐

Oxygen ☐

(1)

(b) An increase in global temperature will cause climate change.

What is **one** possible effect of climate change?

Tick **one** box.

Deforestation ☐

Global dimming ☐

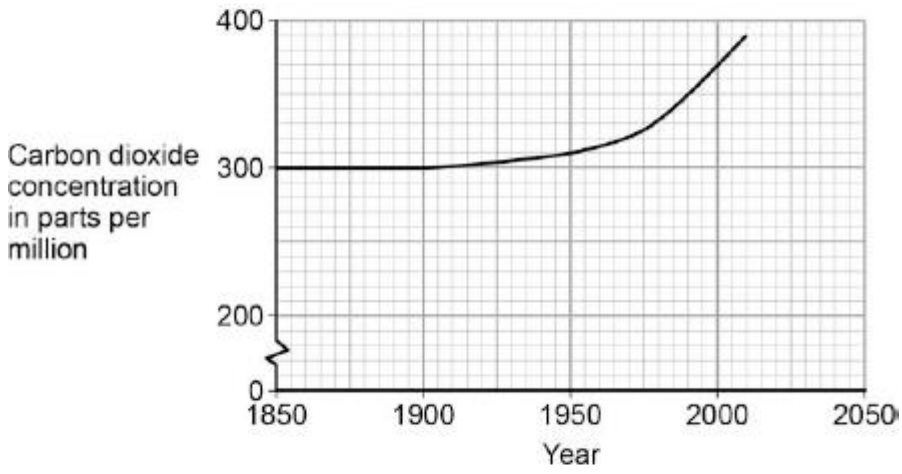
Sea levels rising ☐

Volcanic activity ☐

(1)

(c) Carbon dioxide is also a greenhouse gas.

The figure below shows how the concentration of carbon dioxide in the atmosphere has changed since 1850.



Which process is the reason for the change in carbon dioxide concentration shown on the figure above?

Tick **one** box.

Burning of fossil fuels ☐

Carbon capture ☐

Formation of sedimentary rocks ☐

Photosynthesis ☐

(1)

(d) Give **three** conclusions that can be made from the figure above.

1. ______________________________

____

2. ______________________________

____

3. ______________________________

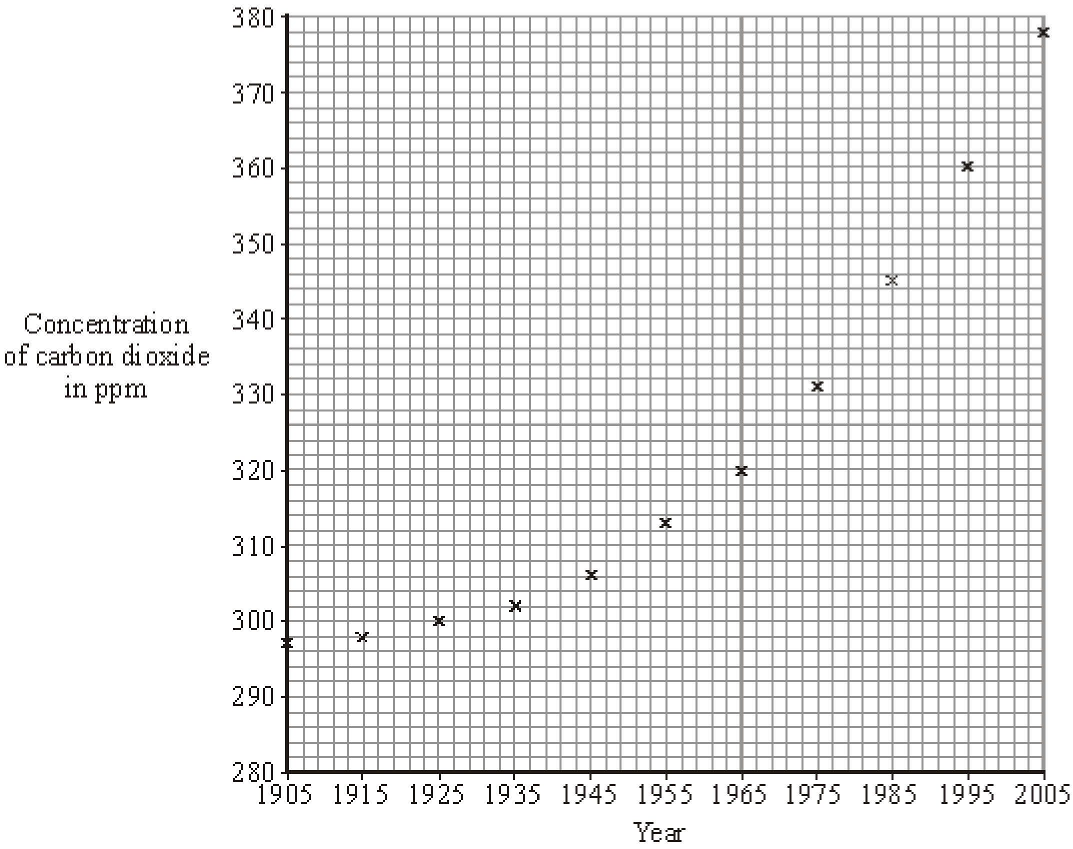
____

(3)

(Total 6 marks)

Q4.

Global warming is thought to be happening because of the increased burning of fossil fuels. The concentration of carbon dioxide in the air from 1905 to 2005 has been calculated.



(a) Draw a line of best fit for these points.

(1)

(b) (i) What was the concentration of carbon dioxide in 1955?

____ ppm

(1)

(ii) In what year did the concentration of carbon dioxide reach 350 ppm?

____

(1)

(c) Use the graph to describe, in as much detail as you can, what happened to the concentration of carbon dioxide from 1905 to 2005.

____

____

____

____

(2)

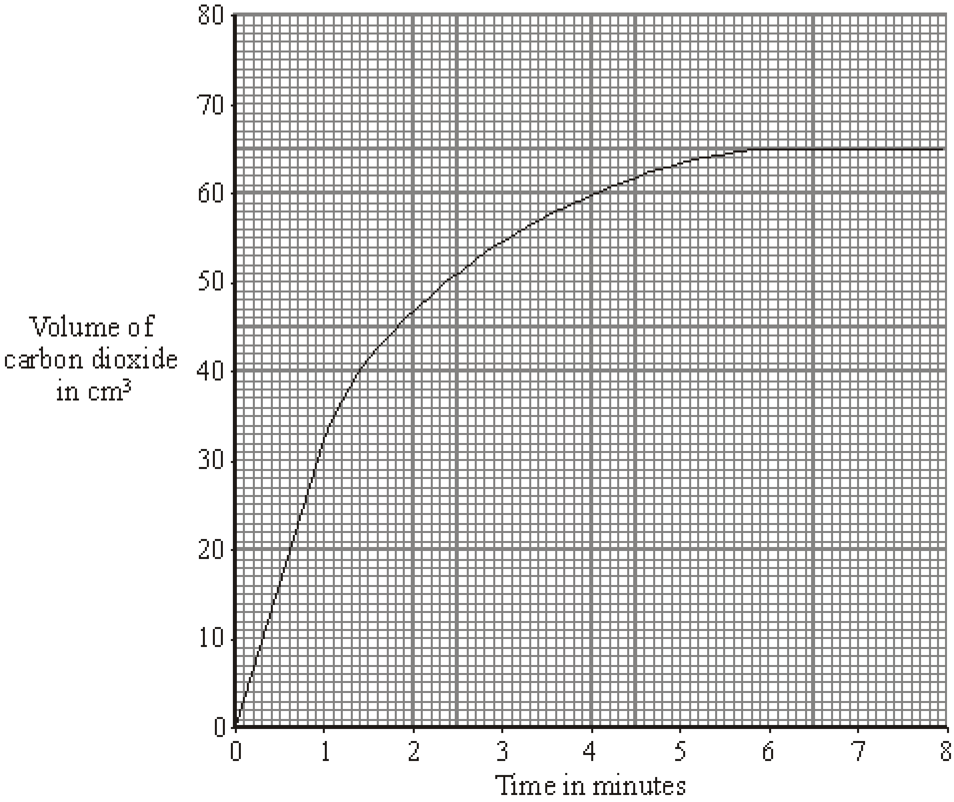
(Total 5 marks)

Q5.

A student studied the reaction between dilute hydrochloric acid and an **excess** of calcium carbonate.

calcium carbonate + hydrochloric acid → calcium chloride + water + carbon dioxide

The student measured the volume of carbon dioxide produced in the experiment. The results are shown on the graph.



(a) After how many minutes had all the acid been used up?

______________________ minutes

(1)

(b) The student wrote this conclusion for the experiment:

'The reaction gets slower and slower as the time increases.'

Explain why the reaction gets slower. Your answer should be in terms of particles.

____

____

____

____

(2)

(c) A second experiment was carried out at a higher temperature. All other factors were the same.

Draw a line on the graph above to show the results that you would expect.

(2)

(Total 5 marks)

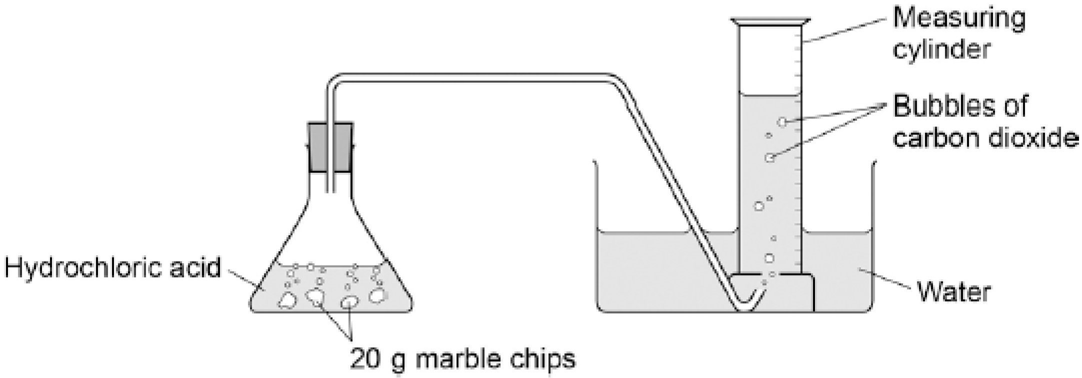
Q6.

Marble chips are mainly calcium carbonate ($CaCO_3$).

A student investigated the rate of reaction between marble chips and hydrochloric acid (HCl).

Figure 1 shows the apparatus the student used.

Figure 1



(a) Complete and balance the equation for the reaction between marble chips and hydrochloric acid.

_________ + _________ → $CaCl_2$ + _________ + _________

(2)

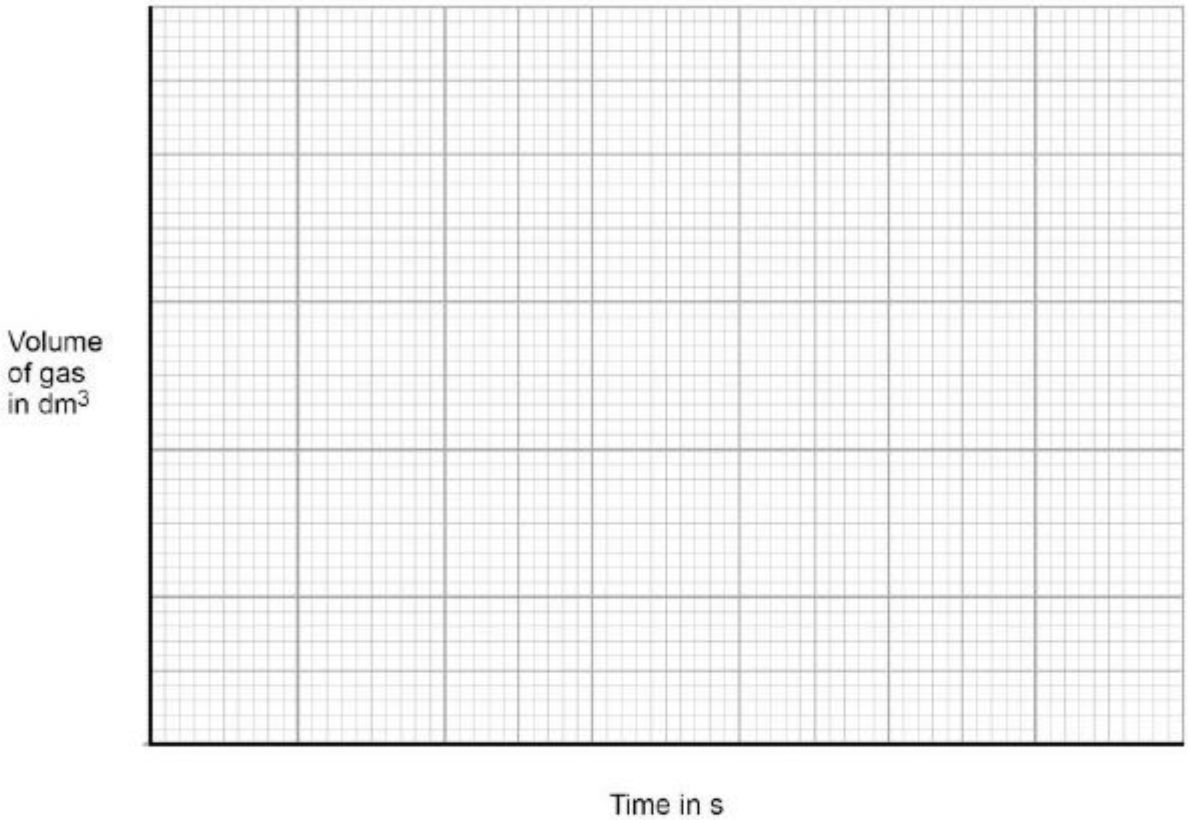
(b) The table below shows the student's results.

Time in s	**Volume of gas in dm³**
0	0.000
30	0.030
60	0.046
90	0.052
120	0.065
150	0.070
180	0.076
210	0.079
240	0.080
270	0.080

On **Figure 2**:

- Plot these results on the grid.
- Draw a line of best fit.

Figure 2



(4)

(c) Sketch a line on the grid in **Figure 2** to show the results you would expect if the experiment was repeated using 20 g of smaller marble chips.

Label this line **A**.

(2)

(d) Explain, in terms of particles, how and why the rate of reaction changes during the reaction of calcium carbonate with hydrochloric acid.

____

____

____

____

____

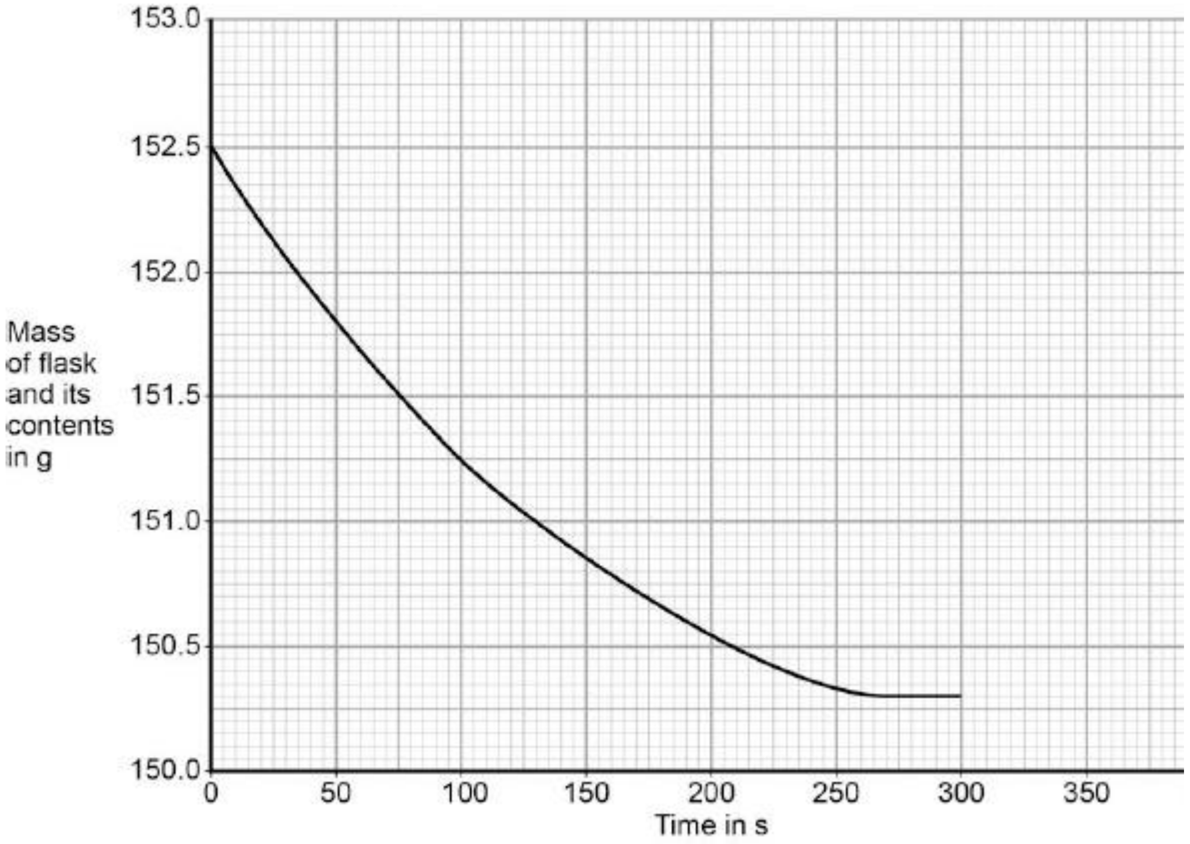
____

(4)

(e) Another student investigated the rate of reaction by measuring the change in mass.

Figure 3 shows the graph plotted from this student's results.

Figure 3



Use **Figure 3** to calculate the mean rate of the reaction up to the time the reaction is complete.

Give your answer to three significant figures.

____

____

____

____

____

____

____

____

Mean rate of reaction = ____________________ g / s

(4)

(f) Use **Figure 3** to determine the rate of reaction at 150 seconds.

Show your working on **Figure 3**.

Give your answer in standard form.

____

____

____

Rate of reaction at 150 s = ______________________ g / s

(4)

(Total 20 marks)

Q7.

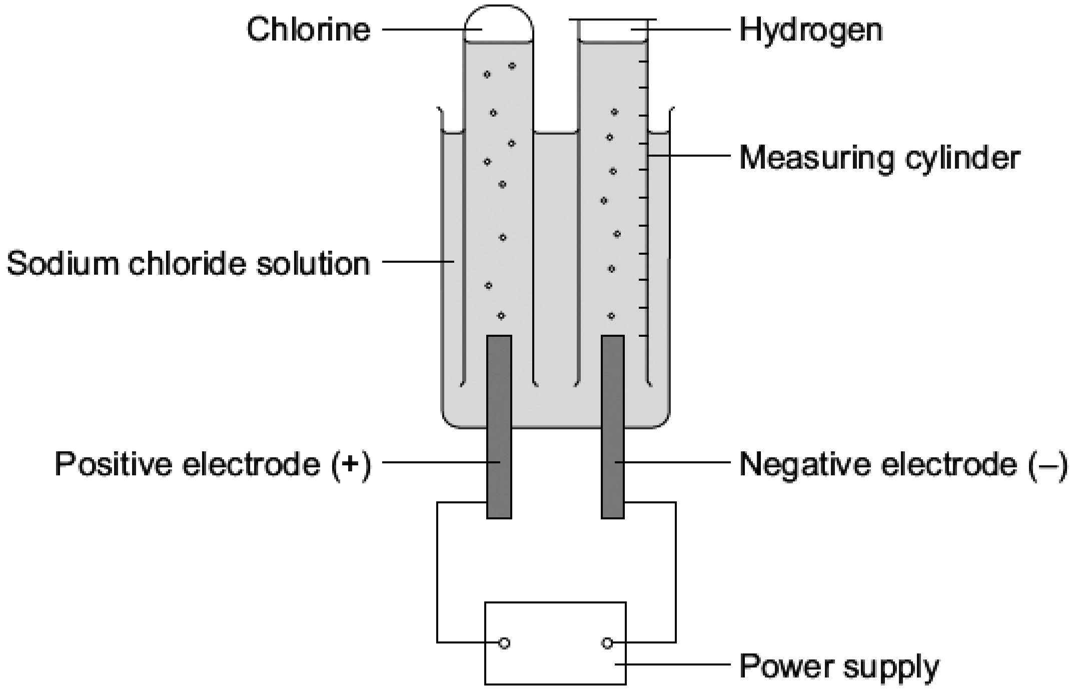
A student investigated the electrolysis of sodium chloride solution.

Five sodium chloride solutions were made. Each solution had a different concentration.

To make each solution the student:

- weighed the amount of sodium chloride needed
- dissolved it in water
- added more water until the total volume was one cubic decimetre (1 dm^3).

The solutions were placed one at a time in the apparatus shown below.



The student measured the volume of hydrogen gas produced in ten minutes.

The results are shown on the graph below.

(a) Sodium chloride does not conduct electricity when it is solid.

Explain, in terms of ions, why sodium chloride solution conducts electricity.

____

____

(1)

(b) Chlorine is produced at the positive electrode.

Why are chloride ions attracted to the positive electrode?

____

(1)

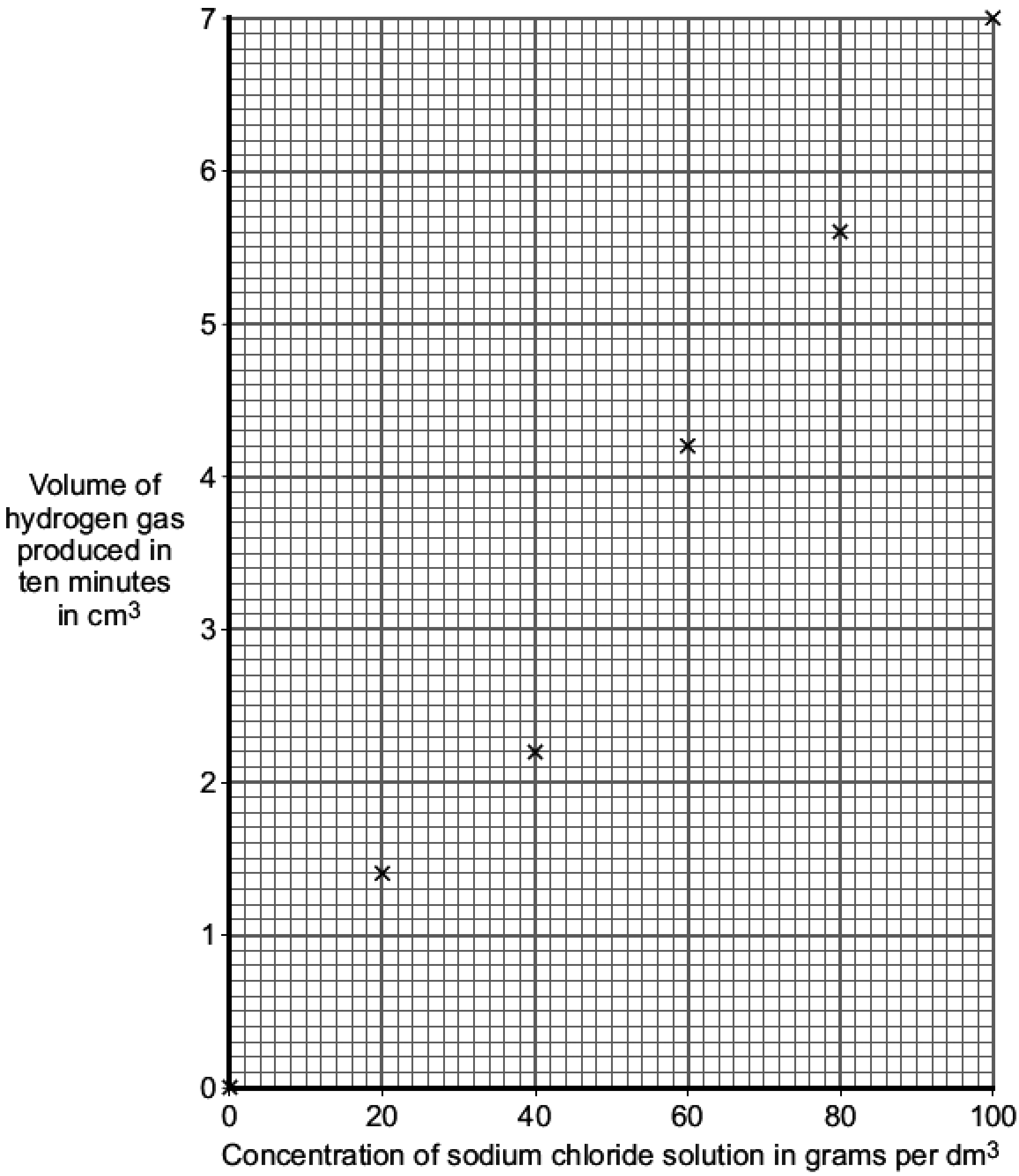
(c) The solution left at the end of each experiment contains sodium hydroxide.

Draw a ring around **one** number which could be the pH of this solution.

2 **5** **7** **13**

(1)

(d) The results for the experiment above are shown on the graph.



(i) Draw a line of best fit on the graph.

(1)

(ii) The result for one concentration is anomalous.
Which result is anomalous?

The result at concentration ____________ grams per dm^3

(1)

(iii) Suggest **two** possible causes of this anomalous result.

1. ____

____

2. ____

____

(2)

(iv) Suggest how the student could check the reliability of the results.

____

____

(1)

(iv) How did an increase in the concentration of the sodium chloride solution affect the volume of hydrogen gas produced in ten minutes?

____

____

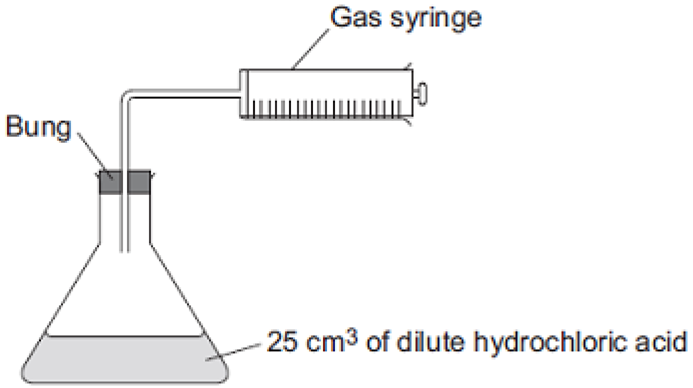
(1)

(Total 9 marks)

Q8.

A student investigated the reaction between magnesium metal and dilute hydrochloric acid.

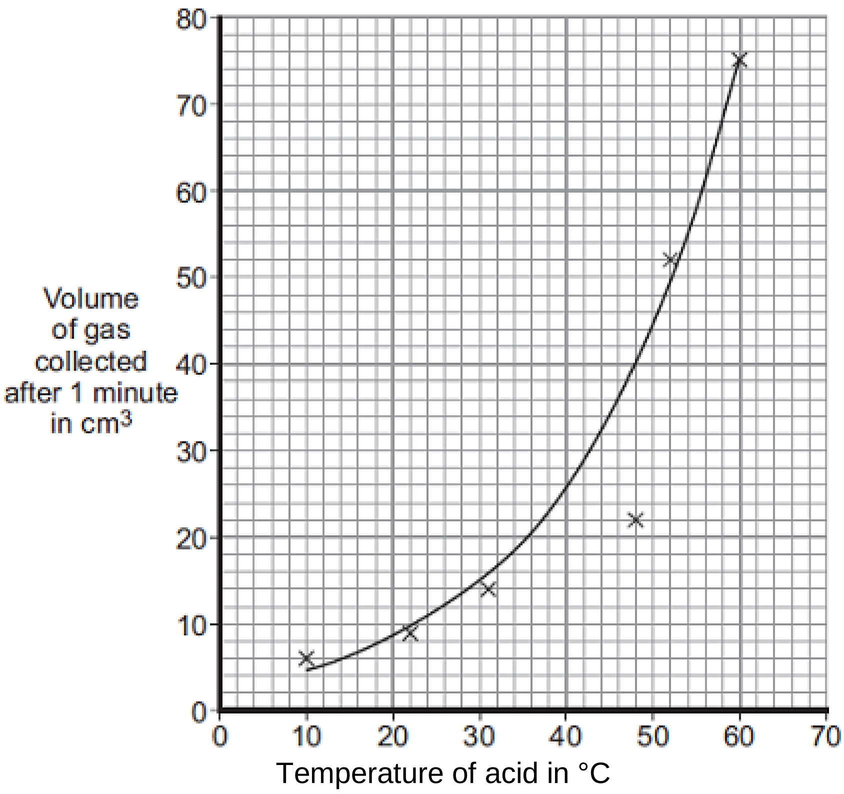
The student placed 25 cm^3 of dilute hydrochloric acid in a conical flask and set up the apparatus as shown in the diagram.



The student:

- took the bung out of the flask and added a single piece of magnesium ribbon 8 cm long
- put the bung back in the flask and started a stopwatch
- recorded the volume of gas collected after 1 minute
- repeated the experiment using different temperatures of acid.

The student plotted his results on a graph.



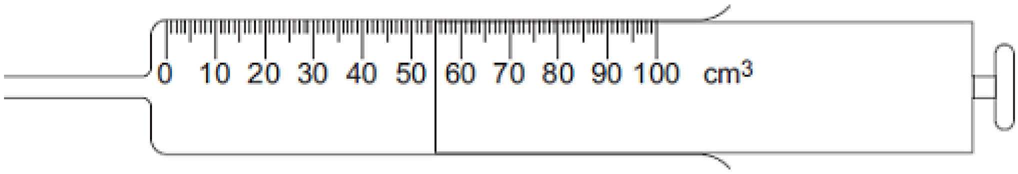
(a) Write the correct state symbols in the equation.

Choose from (s) for solid, (l) for liquid, (g) for gas and (aq) for aqueous.

Mg (….) + 2 HCl (….) ⟶ $MgCl_2$ (….) + H_2 (….)

(2)

(b) The diagram shows a gas syringe after 1 minute.



(i) What volume of gas has been collected in the gas syringe after 1 minute?

Volume = ____________ cm^3

(1)

(ii) Use the graph to determine the temperature of the acid used in this experiment.

Temperature = ____________ °C

(1)

(iii) Calculate the average rate of reaction, in cm^3 of hydrogen made per second (cm^3/s), for this experiment.

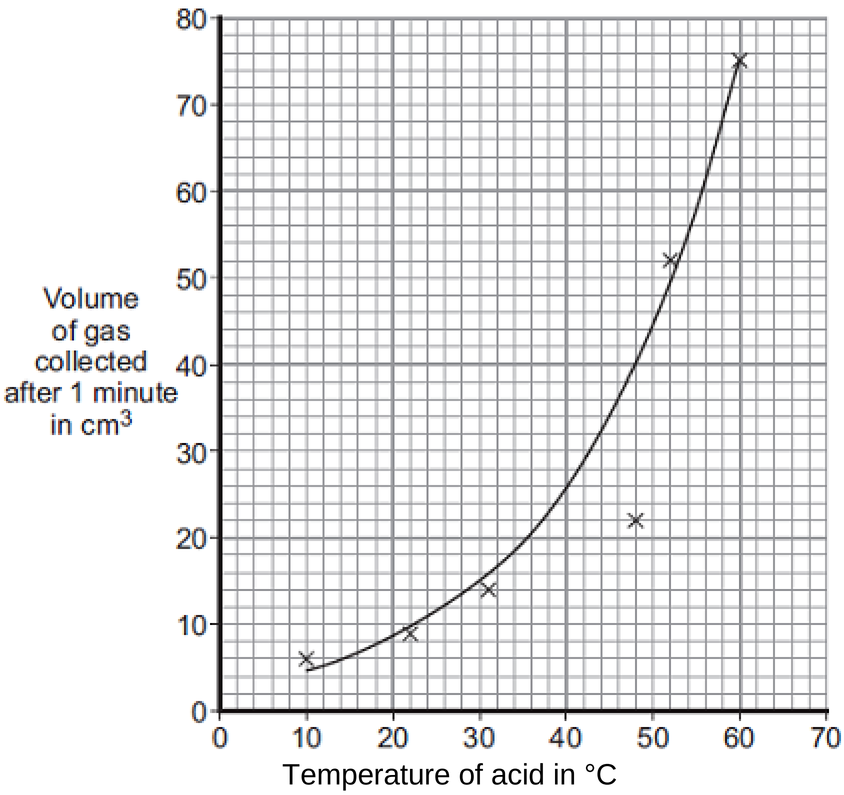
____

____

Rate of reaction = ____________ cm^3/s

(2)

(c) The student's graph has been reprinted to help you answer this question.



One of the results on the graph is anomalous.

(i) Draw a circle on the graph around the anomalous point.

(1)

(ii) Suggest what may have happened to cause this anomalous result.

Explain your answer.

____

____

____

____

____

____

(2)

(d) Explain how the student could improve the accuracy of the volume of gas recorded at each temperature.

____

____

____

____

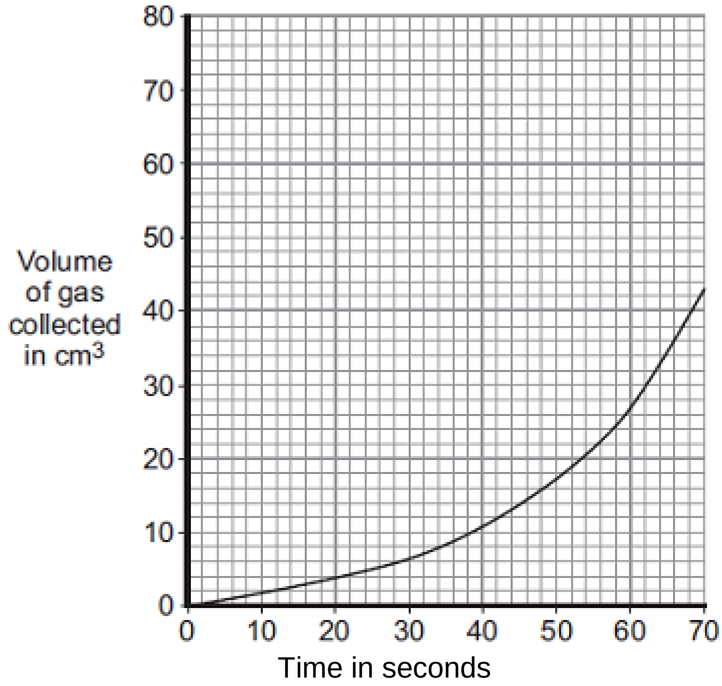
____

____

(3)

(e) The student then used the same apparatus to measure the volume of gas produced every 10 seconds at 40 °C.

The student's results are shown on the graph.



The rate at which the gas was produced got faster over the first 60 seconds.

The student's teacher gave two possible explanations of why the reaction got faster.

Explanation 1
There was a layer of magnesium oxide on the surface of the magnesium.
The layer of magnesium oxide prevented the magnesium reacting with the acid.
As the magnesium oxide reacted slowly with the acid, the magnesium was exposed to the acid and hydrogen gas was produced.

Explanation 2
The reaction is exothermic, and so the temperature of the acid increased during the reaction.

(i) Describe further experimental work the student could do to see if **Explanation 1** is correct.

____

____

____

____

____

(2)

(ii) Describe further experimental work the student could do to see if **Explanation 2** is correct.

____

____

(2)

(Total 16 marks)

Mark schemes

Q1.

(a) fume cupboard
plastic gloves (only one tick)

for 1 mark

1

(b) (i) plotting points (allow ± 0.5 units either vertically or horizontally)
(all correct = 2) (3 correct =1)
curve (not joined with straight lines. Must be very close to all points. One line only) (1 mark)

gains 3 marks

3

(ii) as read from graph (±0.5 units) –
points must be joined

for 1 mark

1

(iii) decreases, gets less, quicker

for 1 mark

1

(c) (i) flows, moves, passes through (not rubbing/moving of engine parts)

for 1 mark

less etc

for 1 mark

2

(ii) parts rub against each other
increases wear of engine parts
damages the oil
engine seizes
overheating of engine
(not burns or blows up)
(not just 'damage')

any 1 for 1 mark

1

[9]

Q2.

(a) the concentration of the (nitric) acid is decreasing

accept the number of acid particles is decreasing ***or*** *there are fewer collisions*

1

(the volume of carbon dioxide remains at 83 cm^3)
when the concentration of the (nitric) acid is zero

accept no acid remains ***or*** *all the acid is used up* ***or*** *no acid particles*

1

(b) line starts at origin is steeper **and** remains to the left of the original line

1

graph line levels off at 83 cm^3 **and** before 12 minutes

tolerance ± square

1

(c) change the temperature

accept increase ***or*** *decrease the temperature*
accept change (increase ***or*** *decrease) the concentration (of the nitric acid)*
ignore amounts of reactants ***or*** *changes in pressure* ***or*** *stirring* ***or*** *use of catalyst*

1

[5]

Q3.

(a) Methane

1

(b) Sea levels rising

1

(c) Burning of fossil fuels

1

(d) carbon dioxide concentration stayed constant from 1850 to 1900

1

carbon dioxide concentration slowly increased from 1900

1

carbon dioxide concentration increased more rapidly from 1965

allow values from 1965 − 1975

1

[6]

Q4.

(a) curve of best fit drawn through

or close to all of the points

1

(b) (i) 313

1

(ii) 1989 +/– 1

1

(c) concentration / amount of carbon dioxide has <u>increased</u>

1

recently the rate of increase is <u>increasing</u>

1

[5]

Q5.

(a) 6

accept 5.8 – 6

1

(b) hydrochloric acid used up / reacted / combined / **or** fewer particles (of hydrochloric acid) **or** fewer hydrogen ions owtte

accept reactants used up
accept less calcium carbonate ***or*** *smaller surface area of calcium carbonate*
accept lower concentration / less crowded
do ***not*** *accept atoms / molecules*
ignore references to energy
do ***not*** *accept references to atoms or molecules*

1

fewer collisions owtte

independent mark

1

(c) steeper curve initially

independent marks

1

levels out at same volume

- *must indicate levelling out*
- *if line goes higher than 66 do* ***not*** *award this mark*
- *diagonal line only = 0 marks*
- *if steeper initially and then crosses the line and finishes correctly, then loses one*

1

[5]

Q6.

(a) $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

2

allow ***1*** *mark for correct formulae*

(b) sensible scales, using at least half the grid for the points

1

all points correct

± ½ small square
allow ***1*** *mark if 8 or 9 of the points are correct*

2

best fit line

1

(c) steeper line to left of original

1

line finishes at same overall volume of gas collected

1

(d) acid particles used up

allow marble / reactant used up

1

so concentration decreases

allow surface area of marble decreases

1

so less frequent collisions / fewer collisions per second

*do **not** accept fewer collisions unqualified*

1

so rate decreases / reaction slows down

1

(e) mass lost of 2.2 (g)

1

time taken of
270 s

allow values in range 265 − 270

1

$\frac{2.2}{270} = 0.00814814$

allow ecf for values given for mass and time

1

0.00815 (g / s)

or

8.15×10^{-3}

*allow **1** mark for correct calculation of value to 3 sig figs*

*accept 0.00815 or 8.15×10^{-3} with no working shown for **4** marks*

1

(f) correct tangent

1

eg 0.35 / 50

1

0.007

allow values in range of 0.0065 − 0.0075

1

7×10^{-3}

1

*accept 7×10^{-3} with no working shown for **4** marks*

[20]

Q7.

(a) the ions can <u>move</u> / <u>travel</u> / <u>flow</u> /are <u>free</u>

accept particles / they for ions

allow delocalised ions

or

ignore delocalised / free electrons
ignore references to collisions
accept converse with reference to solid

the ions carry the charge / current
ignore ions carry electricity

1

(b) any **one** from:

- because they are negative / anion
  allow Cl^-
  ignore chlorine
- opposite charges / attract

1

(c) 13

1

(d) (i) reasonable attempt at straight line which misses the anomalous point
must touch all five crosses
*do **not** allow multiple lines*

1

(ii) 40
ignore 2.2

1

(iii) any **two** sensible errors from:
ignore systematic / human / apparatus / zero /experimental / random / measurement / reading errors unless qualified

- gas escapes
- weighing error
  allow NaCl not measured correctly
- error in measuring (volume / amount) of hydrogen
- error in measuring (volume / amount) of water
  *allow error in measuring volume / scale for **1** mark if neither hydrogen or water mentioned*
- incorrect concentration
  *allow NaCl not fully dissolved **or** spilled **or** impure*
- timing error
- change in voltage / current
  allow faulty power supply
- change in temperature
- recording / plotting error

2

(iv) any **one** from:

ignore 'do more tests'

- repeat the experiment
- results compared with results from /other students / other groups / other laboratories / internet / literature.
- results compared with another method

1

(v) increases owtte

allow directly proportional or positive correlation

allow rate / it is faster / quicker

1

[9]

Q8.

(a) (s) (aq) (aq) (g)

must be in this order

***2** marks if all four correct*

***1** mark if 2 or 3 correct*

2

(b) (i) 55

ignore units

1

(ii) 54

*allow ecf from **(b)(i)***

1

(iii) 0.92

*correct answer with or without working gains **2** marks*

*ecf from volume in **(b)(i)***

accept 2 d.p. up to calculator value

*if answer incorrect, allow rate = (b)(i) / 60 for **1** mark*

2

(c) (i) circle round point at (48,22)

1

(ii) problem (1) and explanation (1)

*explanation **must** give lower volume of gas or slower reaction*

ignore human error unless qualified

problem with bung

e.g. bung not placed in firmly / quickly enough

so gas lost

or

problem with reagent

e.g. acid was diluted **or** acid not replaced so reaction slower

or

problem with temperature

e.g. temperature was lower than recorded temperature

so reaction slower

or

problem with measurement

e.g. length of magnesium less than 8 cm **or** timed for less than a minute

so less gas produced

2

(d) repeat the experiment (several times)

1

because anomalous results could be excluded

1

and then the mean can be determined / calculated

*accept suggestion of alteration to method, which is explained as to why it would reduce the error, for **3** marks (e.g. place the magnesium in a container within the flask (1) so it can be tipped into the acid once the bung is in place (1). This will prevent anomalous results or gas loss (1))*

ignore idea of more accurate gas syringe
ignore shorter time intervals

1

(e) (i) use clean magnesium **or** use magnesium without oxide coating

1

compare results

1

(ii) **either**

measure the temperature of the acid before (adding magnesium)

1

and after adding magnesium

or

place the conical flask in a water bath (at 40 °C) (1)

compare results (1)

1

[16]

Examiner reports

Q1.

Part (a) was answered correctly by most candidates. A few candidates made up their own safety precautions. The points were often well plotted on the graph but some candidates failed to follow the instruction to draw a smooth curve and either drew no line at all or simply joined the points with a ruler. Although some very good graphs were seen a large number of candidates drew graphs in ink or with a very blunt pencil. Some made one attempt at the line and then made a second attempt without rubbing out the first so that two or more criss-crossed lines were shown. Part (ii) thus became impossible. Most candidates who drew a reasonable graph were able to answer part (ii). Most candidates gained the mark in part (iii). Some candidates took the word ‘how’ literally and tried to explain why the time decreased. The meaning of viscosity was not well known in part (c).

Q2.

Foundation and Higher Tiers

(a) Most candidates failed to use the information in the introduction to the question, which stated that some calcium carbonate remained unreacted. Consequently, the common answer that the reactants had been used up was unacceptable. Very few candidates realised that they had to explain both the reduction in rate up to 12 minutes and the end of the reaction at 12 minutes.

(b) Many candidates scored full marks on the graph but there were those who drew a curve to the right of the given curve, or whose curve started to the left of the given curve but failed to level off at 83 cm^3 before 12 minutes.

(c) Although several candidates correctly referred to changing temperature or the concentration of the nitric acid, most referred to changing the amount of reactants or the use of a catalyst.

Q4.

In part (a) to many candidates a line of best fit meant a straight line. To gain the mark candidates were expected to draw a curve which passed through or was close to all of the points.

In part (b) many candidates correctly read off the concentration of carbon dioxide. It was still possible to give the correct year in part (b)(ii), even if the curve had not been drawn correctly.

In part (c) the majority of candidates realised the carbon dioxide concentration was rising. A reasonable number of candidates also described the increasing rate of increase after about 1935 for the second mark.

Q5.

Part (a) was well answered by the vast majority of candidates.

A good number of the candidates were able to score one of the two marks in part (b), but very few gained both. In general the candidates realised that the concentration was decreasing but failed to link this to the collision theory. A number of candidates thought that the decreasing rate was caused by changes in energy or temperature.

Candidates often gained the first mark for part (c) by drawing the initial line more steeply, but failed to gain the second mark, which was for levelling out the curve at the same volume.

Q7.

(a) This part was answered incorrectly by the vast majority of candidates. Many discussed the conduction of the electricity by atoms or electrons without reference to ions. The idea of oppositely charged particles attracting was also common. Only a small number were able to identify the role of moving ions.

(b) Most answers either stated that chloride ions were negative or that opposite charges attract. Poor answers involved reference to negative electrodes and positive charge.

(c) This part was surprisingly poorly answered. The most popular responses were pH 5 and pH 7.

(d) (i) Many candidates correctly drew a straight line through 5 points missing out the anomalous point. Some lines only went through some of the points while others included the anomalous point and these lines were not given credit. Multiple lines and curves were also penalised. There was also evidence of lines drawn in ink or candidates with no eraser as a number of answers contained crossed out lines or annotations pointing to the “wrong” line. In some of these it was very difficult for examiners to distinguish which part of the line candidates intended to be their correct answer.

(ii) The anomalous result was often correctly identified though 2.2 was a common error and wild guesses were also evident.

(iii) This part discriminated very well between the candidates. Weaker answers were vague and candidates often wrote at length but without the required detail to gain credit. Common examples of vague answers were; ‘experiment was done wrong’, ‘there was a mistake or error’, ‘equipment was faulty’ and ‘incorrect measurement’.
There were frequent references to human, random and systematic errors, which received no credit unless they were further qualified with a specific idea e.g. error in weighing out sodium chloride or measuring the volume of the hydrogen.

(iv) This part was answered correctly by the vast majority of the candidates. The most common correct responses were those with the idea of repeating the experiment or comparing results with others. A few vague responses such as ‘do more tests’ or ‘average results’ received no credit.

(v) Most candidates realised that there would be an increase in the volume of hydrogen or that it would be produced faster. A minority of candidates confused time and rate and stated that it would take longer.

Q8.

(a) The use of (l) as the state symbol for an aqueous solution was common, and hence under half of the students scored both marks.

(b) (i) The vast majority of students read the gas syringe correctly.

(ii) Most students read the value from the graph correctly, but some got the scale wrong and so gave an incorrect value or read from the wrong axis (getting an answer of 58).

(iii) Many correct calculations of the rate of reaction were seen. However, errors where the rate was truncated (as opposed to rounded) were too common. Common errors included dividing the volume by the temperature (a look at the units of the rate given on the answer line should have shown students that it needed to be volume divided by time) and using a volume other than the volume recorded in (b)(i) – often 75 (the highest volume shown) or a mean of all six volumes.

(c) (i) Almost always correctly answered, the most common error being for a student not to attempt this part of the question. Students should read the entire paper; that way marks will not be lost by failing to see there is a question to answer.

(ii) The most common correct answer referred to gas being lost due to failing to put the bung back either quickly or firmly – many students were clearly familiar with conducting this type of experiment and the possible problems that occur. Simplistic answers such as 'measured the temperature wrongly' did not gain credit as this does not explain the direction of the error shown on the graph; explanations had to fit with the fact that the gas volume was too low for the temperature at which it was plotted. Some answers referred to a zero error with the syringe – either gas being left in the syringe from a previous experiment (this would have given too large a gas volume and so is wrong) or the syringe being set to show less than zero at the start (which is impossible).

(d) Some students were clearly well versed in repeating experiments, excluding anomalies and then taking the mean. However, many answers failed to exclude anomalies or confused accuracy with precision – with answers suggesting the use of a gas syringe or thermometer with smaller divisions.

(e) (i) While some completely correct answers were seen in which students removed the oxide coating in some way and then repeated the experiment and compared results, most students failed to score. Many students thought testing the gas produced for hydrogen or oxygen would work (presumably thinking magnesium oxide reacted with an acid to make oxygen while if there was no magnesium oxide it would make hydrogen) or even that they could test the magnesium ribbon for oxygen using a glowing splint. Some tested for the production of water, missing the fact that the acid used would already contain a large amount of water.

(ii) Most students correctly identified the need to see if the temperature of the acid increased. A number of students suggested that if the reaction was endothermic, then increasing the temperature would make it faster (or in some cases, slower) so they should repeat the experiment at a higher temperature and see if it was faster (or slower). There was also confusion with reversible reactions, with claims that the yield would increase if the temperature was raised.