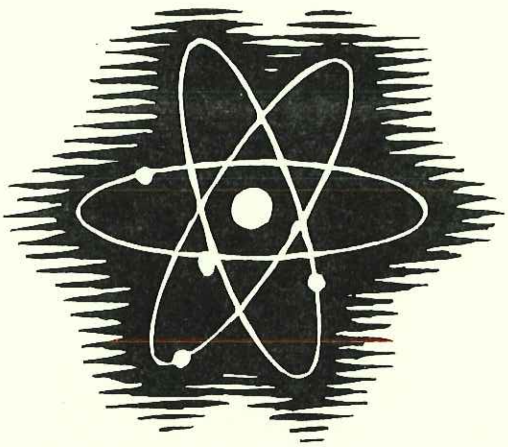
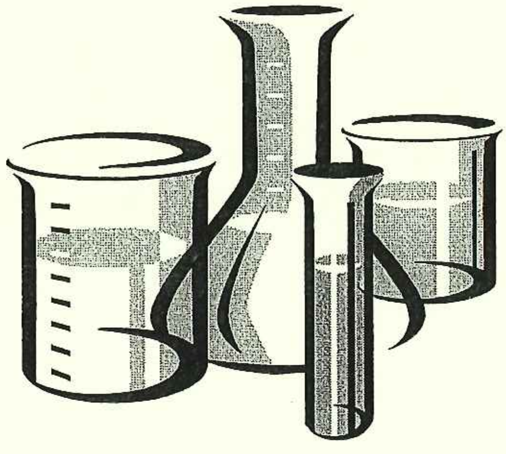
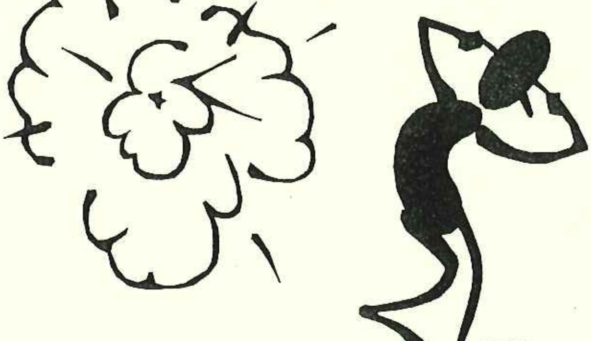


# Chemical Changes and Structure Rates of Reaction National 4/5

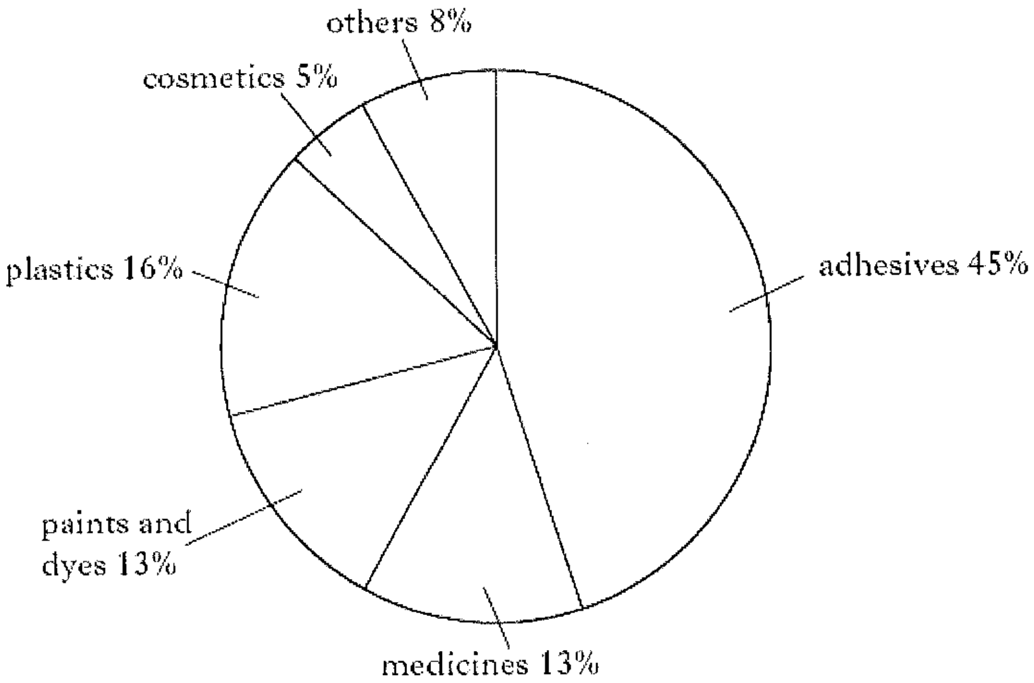




## Drawing Graphs

1.

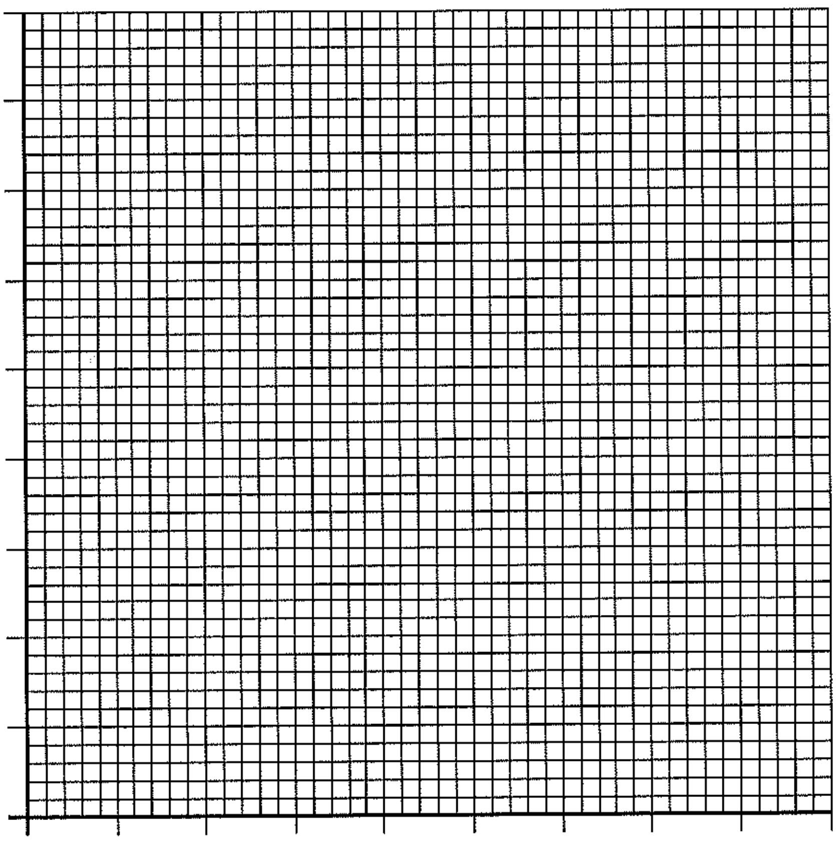
The pie chart shows the uses of ethanoic acid.




(*a*) Draw a bar graph to show the information in the pie chart.

*Use appropriate scales to fill most of the graph paper.*

(Additional graph paper, if required, can be found on page 23.)



2.

Ice cream is made from a mixture of milk, fat and sugar.
The table shows how the freezing point of 100 grams of ice cream changes when the mass of sugar changes.

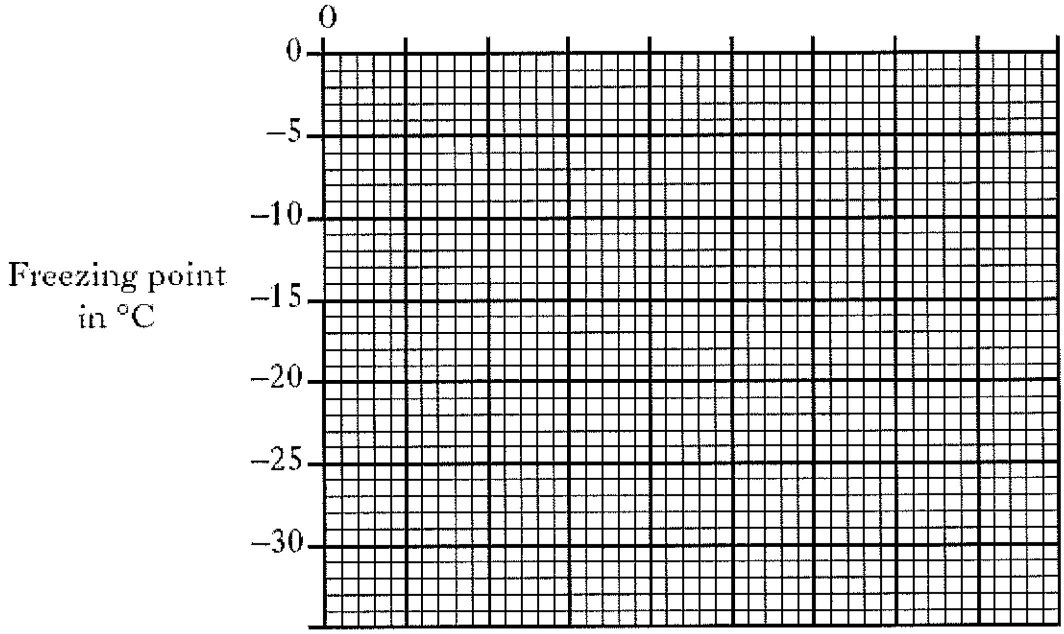
| | | | | |
|---|---|---|---|---|
| **Mass of sugar in grams** | 10 | 20 | 30 | 40 |
| **Freezing point in °C** | –1 | –4 | –11 | –23 |

(*a*) Use the above information to:

(i) label and complete the scale on the horizontal axis;

(ii) draw a line graph of the results.

(Additional graph paper, if required, will be found on page 22.)




(*b*) Using the graph, find the freezing point of ice cream when the mass of sugar used is 35 grams.

______________________________°C

3. Ammonia is made when nitrogen and hydrogen react together.

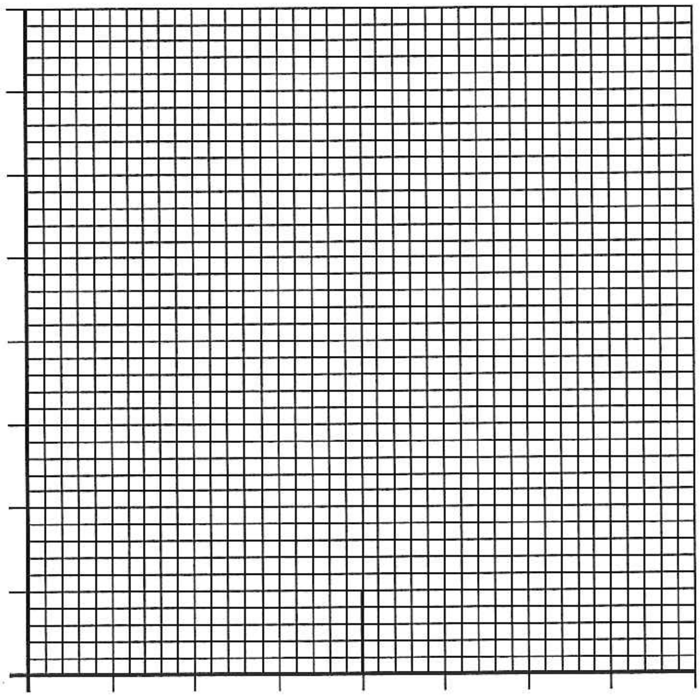
The table below shows the percentage yields obtained when nitrogen and hydrogen react at different pressures.

| *Pressure/atmospheres* | *Percentage yield of ammonia* |
| --- | --- |
| 25 | 28 |
| 50 | 40 |
| 100 | 53 |
| 200 | 67 |
| 400 | 80 |

(*a*) Draw a line graph of percentage yield against pressure.

*Use appropriate scales to fill most of the graph paper.*

(Additional graph paper, if required, will be found on page 27.)

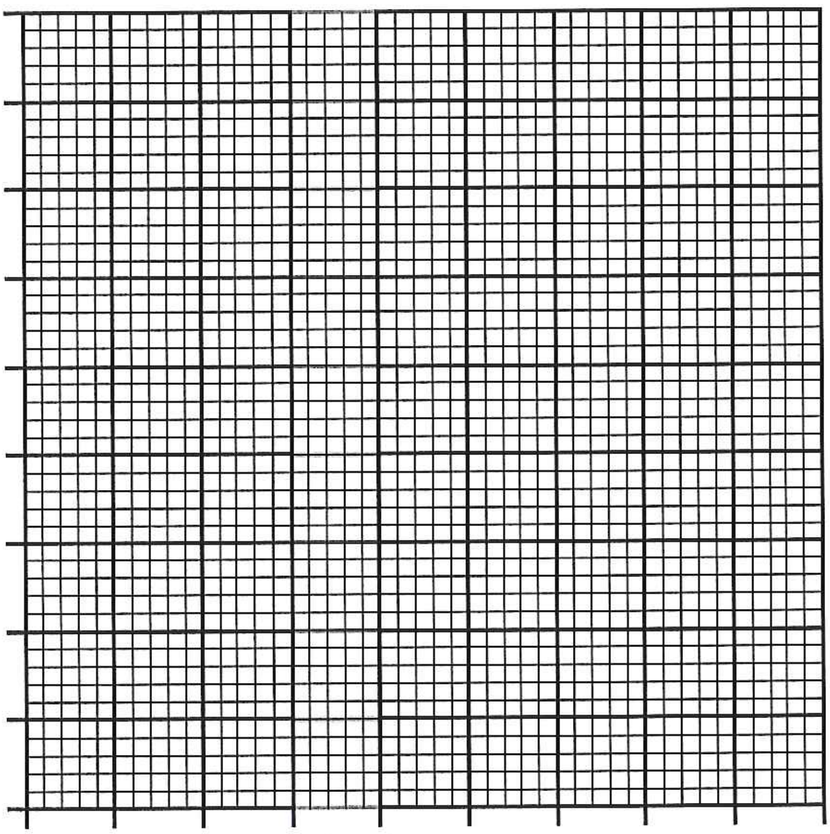


4. A series of fermentation experiments was carried out at different temperatures and the volume of carbon dioxide was measured.

| Experiment | Temperature (°C) | Volume of $CO_2$ ($cm^3$) |
|---|---|---|
| 1 | 15 | 8 |
| 2 | 20 | 25 |
| 3 | 25 | 35 |
| 4 | 30 | 42 |
| 5 | 35 | 27 |
| 6 | 40 | 14 |

(i) Plot a line graph of these results, showing the temperature of the reaction against the volume of $CO_2$ collected.

(Additional graph paper, if required, will be found on page 28.)



## Rates of Reactions

Chemical reactions are happening all around us at different **speeds** or **rates**. The speed of a reaction is an indication of how fast it happens and this can be measured by finding out how much product is formed in a particular time.

The speed of any chemical reaction can be changed if we alter the conditions of the reaction.

## Experiment

When chalk (calcium carbonate) is added to acid, one of the products is carbon dioxide gas.

If **we collect and measure the volume of gas given off at different time intervals** then we can use this information to compare the reaction rates when one of the conditions is altered.

The results can be plotted on a graph to make the comparison easier.

### Rules for drawing graphs

1. Always choose a scale that means you use more than half of the graph paper.

2. Draw and **label the axes**, include **units** where appropriate.

3. The variable which you control should be plotted on the horizontal axis. The variable that you measure during the experiment is plotted on the vertical axis.

4. Plot the points and join them as a smooth curve or straight line.

## Concentration

**AIM** To find out if changing the concentration of the acid will affect the rate of the reaction between chalk and acid.

**METHOD**

**RESULTS**

**Concentrated Acid**

| Time | Vol of gas ($cm^3$) |
|---|---|
| | |

**Dilute Acid**

| Time | Vol of gas ($cm^3$) |
|---|---|
| | |

Draw a graph of your results

**CONCLUSION**

## Particle Size

**AIM** To find out if changing the particle size will affect the rate of the reaction between chalk and acid.

**METHOD**

**RESULTS**

**Chalk Lumps**

| Time | Vol of gas ($cm^3$) |
|---|---|
| | |

**Powdered Chalk**

| Time | Vol of gas ($cm^3$) |
|---|---|
| | |

Draw a graph of your results

**CONCLUSION**

## Temperature

**AIM** To find out if changing the temperature of the acid will affect the rate of the reaction between chalk and acid.

**METHOD**

**RESULTS**

**Hot Acid**

| Time | Vol of gas ($cm^3$) |
|---|---|
| | |

**Cold Acid**

| Time | Vol of gas ($cm^3$) |
|---|---|
| | |

Draw a graph of your results

**CONCLUSION**

## Catalysts and Enzymes

Hydrogen peroxide, formula $H_2O_2$, is not a very stable compound and easily breaks up to give **oxygen** and **water**. We can test for the presence of oxygen with a glowing splint. If oxygen is present then the splint will relight.

**A catalyst is a substance that speeds up a chemical reaction without being used up in the process.**

An ENZYME is a biological catalyst.

## Experiment

Aim to find out if we can speed up the decomposition of hydrogen peroxide.

Method

**Results**

**Conclusion**

## Changing the rate

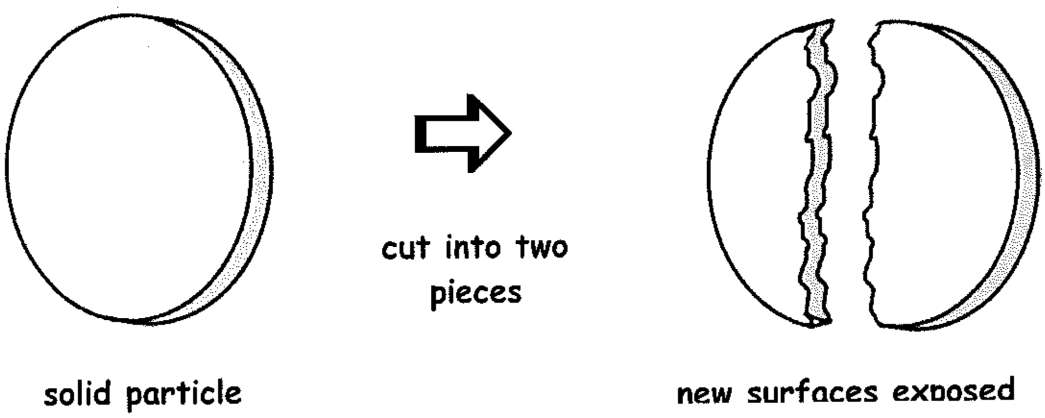
Chemists are not only interested in the rate of a chemical reaction. They also want to know how to make them go faster or even how to slow reactions down.

### (a) Surface area/particle size

***What happens to the rate of a chemical reaction as the particle size decreases (surface area increases)?***

Calcium carbonate powder reacts faster with dilute acid than calcium carbonate lumps.

As the particle size decreases, the surface area of reactant particles increases. The new surfaces give more opportunities for 'bumps' and so the reaction rate increases.

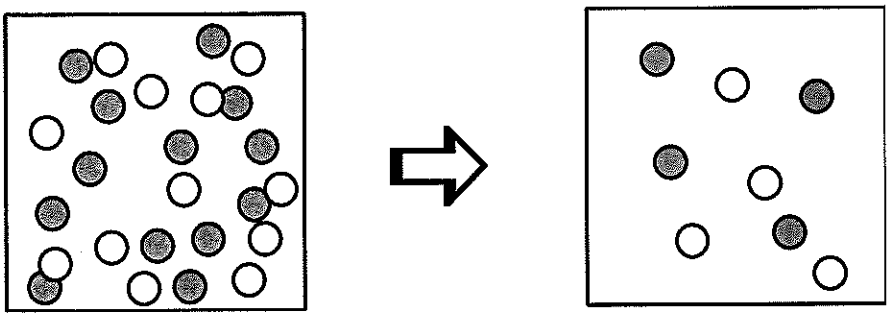


(b) Concentration

***What happens to the rate of a chemical reaction as the concentration decreases?***

When an acid is diluted, the rate of reaction between the acid and magnesium decreases.

As concentration decreases, there are fewer opportunities for 'bumps' and so the reaction rate decreases.



**high concentration of reactants**

**low concentration of reactants**

With gases, pressure is a measure of the concentration. The rate of reaction of gases in industry is increased by increasing the pressure of the reactants.

(c) Temperature

***What happens to the rate of a chemical reaction as the temperature increases?***

Coal burns (reacts with oxygen) in a hot fire but it doesn't react with oxygen to any extent at room temperature.

The increase in the rate of a chemical reaction with increasing temperature is not really due to 'more bumps' because reactants are moving faster at the higher temperature, e.g. nitrogen and oxygen of the air do not begin to react to form oxides of nitrogen even with a large increase in temperature.

The 'bumps' must have a critical level of energy before a reaction will take place.

As a rough guide, the rate of reaction doubles for every increase in temperature by 10 °C.

***Explain each of the following.***

Small sticks of wood burn faster than log

When bellows are used to blow air on to a fire, the fire burns brighter.

Food is preserved longer when stored in a fridge.

Plants grow faster in a green-house than in the open-air.

Large potatoes take longer to cook than small potatoes.

An oxy-acetylene flame is hot enough to cut through metal.
The flame obtained by burning acetylene in air is not.

The Haber Process for the industrial manufacture of ammonia ($NH_3$) is carried out at a temperature of about 250 °C and at high pressure.

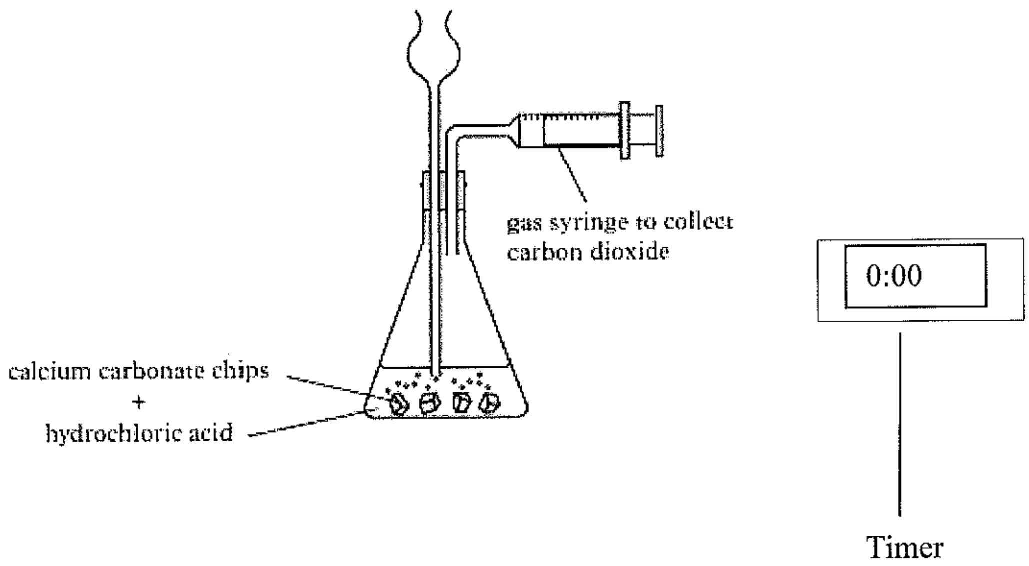
# Measuring rate of reactions

As a chemical reaction proceeds, reactants are being used up while products are being formed. The rate at which this happens can be followed by measuring the change in a 'property' of a substance involved in the reaction over a period of time, e.g. the reaction of calcium carbonate with dilute hydrochloric acid:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Calcium Carbonate | + | Hydrochloric Acid | $\longrightarrow$ | Calcium Chloride | + | Water | + | Carbon Dioxide |
| $CaCO_3$ (s) | + | HCl (aq) | $\longrightarrow$ | $CaCl_2$ (aq) | + | $H_2O$ (l) | + | $CO_2$ (g) |

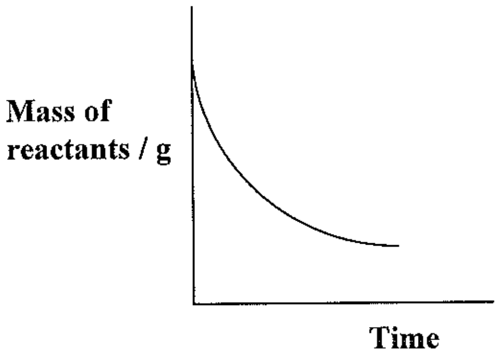
The change in mass (due to gaseous product being given off), volume of gas produced, concentration of acid or pH of acid can all be measured with time.

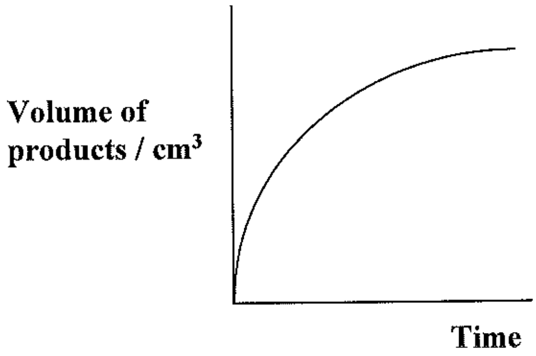
A more accurate experiment could look like this:



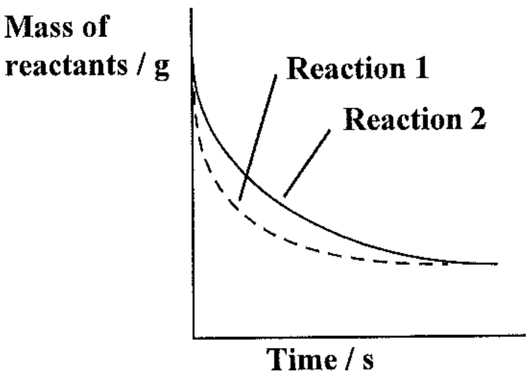

Special probes can be used to measure changes in concentration and also pH.

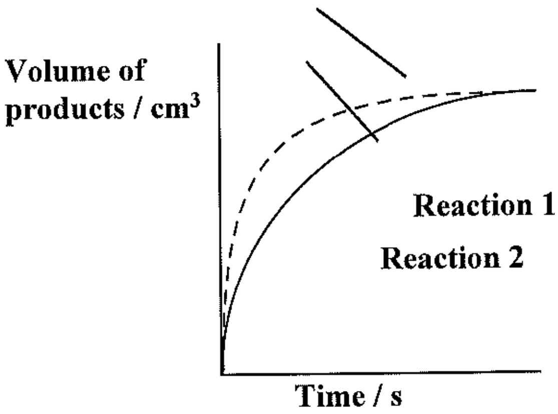
The reaction rate is most rapid at the start of the reaction and decreases as the reaction proceeds.




The steeper the slope, the faster the rate of reaction, e.g. in the following examples, **Reaction 1** is faster than **Reaction 2**.




The shorter the time for a particular change to take place, the faster the rate of reaction,
i.e. rate is inversely proportional to time:

$$\text{rate} = \frac{1}{t}$$

## Average rate of reaction

The **average rate of reaction** can be defined as the measured change divided by the time taken for this change, i.e.

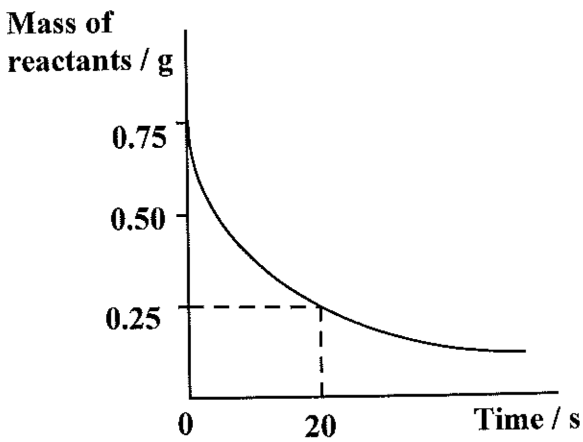
$$\text{Average rate of reaction} = \frac{\text{measured change}}{\text{time taken for the change change}}$$

The table shows units for average rate of reaction when the time is expressed in seconds.

| **Measured change** | **Unit** |
|---|---|
| Mass of reactants / g | $g\ s^{-1}$ (or g/s) |
| Volume of gas produced / $cm^3$ | $cm^3\ s^{-1}$ (or $cm^3$ /s) |
| Concentration / mol $l^{-1}$ (or mol/l) | mol $l^{-1}\ s^{-1}$ (or mol/l/s ) |

### Example 1

The average rate of reaction over the first 20s is:




$$\frac{\text{change in mass}}{\text{time}} = \frac{0.75 - 0.25}{20}$$

$$= \frac{0.5}{20}$$

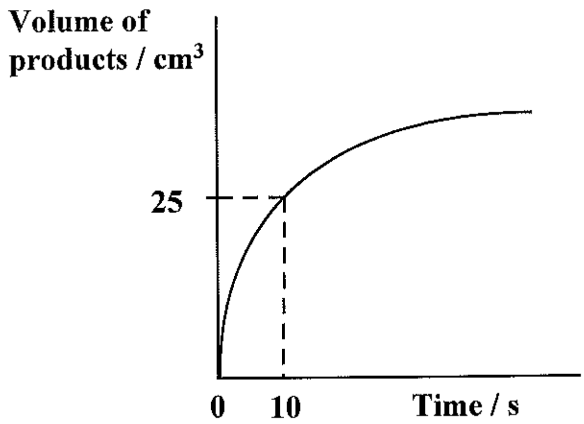
$$= \mathbf{0.025\ g\ s^{-1}}$$

**Example 2**

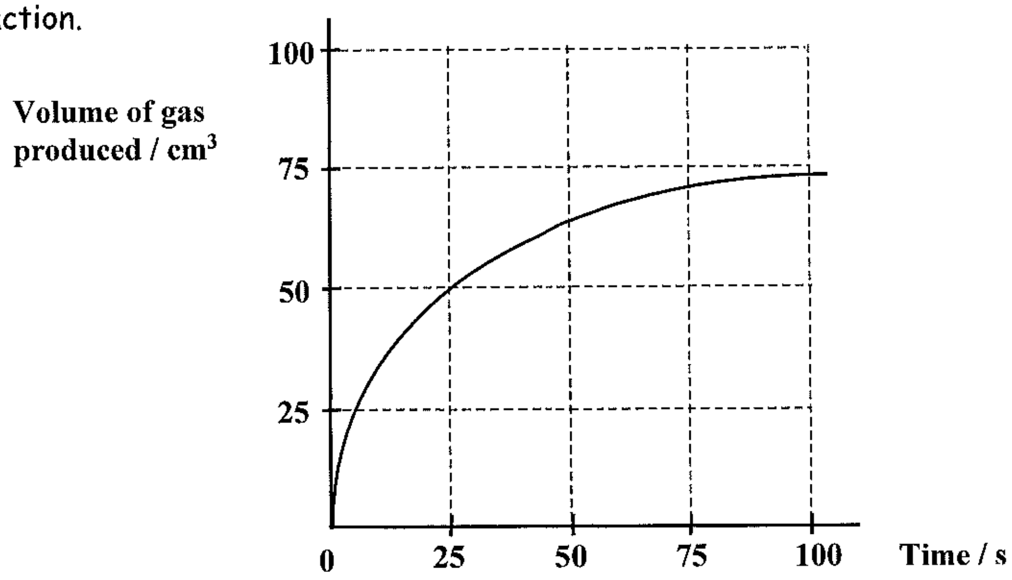
The average rate of reaction over the first 10s is

$$\frac{\text{change in volume}}{\text{time}} = \frac{25 - 0}{10}$$

$$= \mathbf{2.5\ cm^3\ s^{-1}}$$



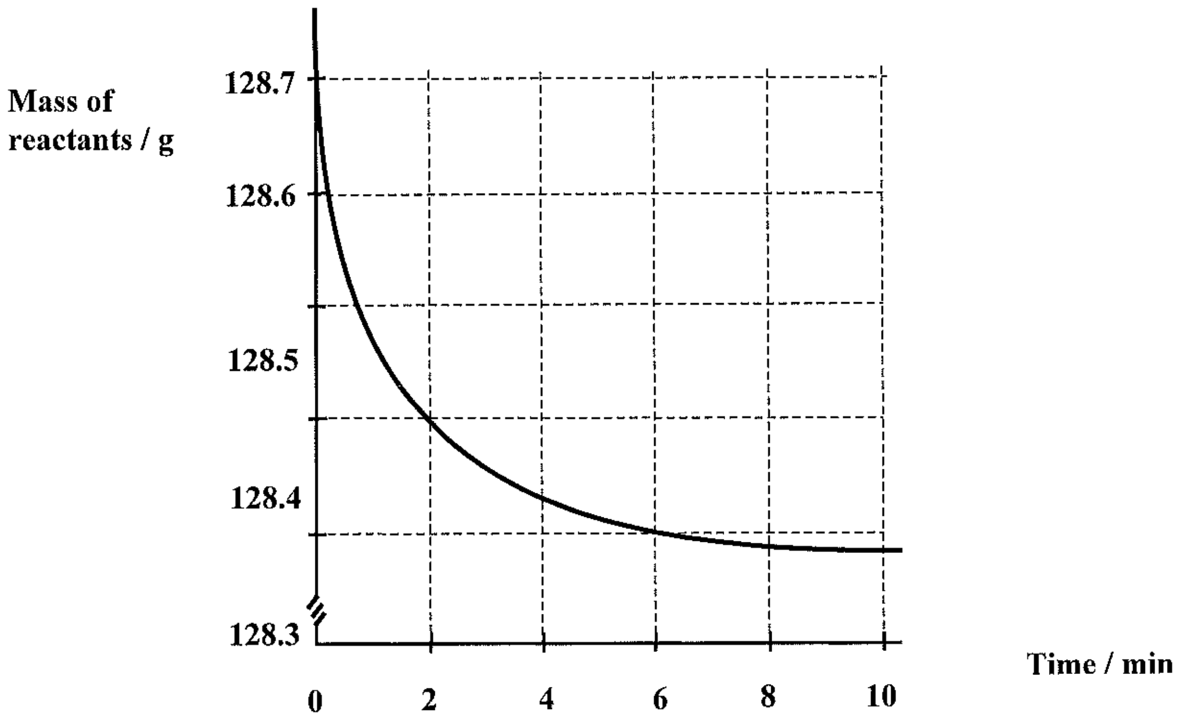
The graph shows how the volume of gas produced varies with time in a chemical reaction.




***Calculate the average rate of reaction over each of the following periods.***

| *0 to 25 s* | *25 to 50 s* |
|---|---|
| | |

The graph shows how the mass of reactants changes with time in a chemical reaction.




***Calculate the average rate of reaction over each of the following periods:***

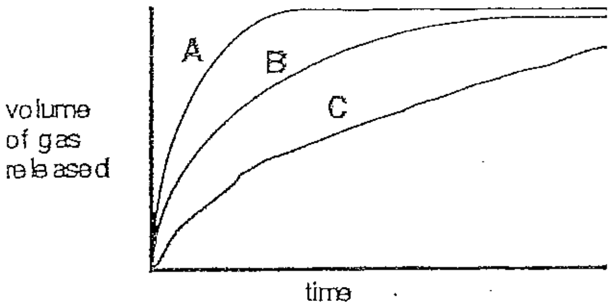
| 0 to 2 minutes | 2 to 4 minutes | 4 to 6 minutes |
| --- | --- | --- |
| | | |

SPEED OF REACTIONS | Exercise 2.1

Name: Class: Mark: /10 Teacher:

1. Look at the graph below showing the volume of gas released against time.

The graph shows 3 possible sets of results A, B and C.




State which of the lines A, B or C fits each of the following.

a) Acid reacting with lumps of chalk. ......
Acid reacting with finely powdered chalk. ......
Acid reacting with crushed lumps of chalk. ...... (1)

b) Zinc powder reacting with 25% acid. ......
Zinc powder reacting with 50% acid. ......
Zinc powder reacting with 100% acid. ...... (1)

c) Magnesium powder reacting with water at 20°C ......
Magnesium powder reacting with water at 80°C ......
Magnesium powder reacting with water at 45°C ...... (1)

2. When copper carbonate reacts with acid carbon dioxide gas is released.
Some results obtained when 1g of copper carbonate was added to acid are shown below.

| | | | | | |
|---|---|---|---|---|---|
| Concentration of acid / % | 100 | 80 | 60 | 40 | 20 |
| Time / seconds | 9 | | 48 | 70 | |

a) On the graph paper overleaf plot a graph of the results from the table. (3)

b) Use your graph to suggest values for the 80% acid and 20% acid

80% ...... 20% ...... (2)

c) How would you know when the reaction had stopped? ..............................

.............................................................................. (1)

d) From these results, explain what happens to the speed of the reaction as the acid becomes more dilute.

..............................................................................

.............................................................................. (1)

Total (10)

Name: Class: Mark: /10 Teacher:

3. Calcium reacts with water releasing hydrogen. A group of pupils measured the volume of hydrogen gas collected every half minute. They obtained these results at room temperature, 20°C.

| time / seconds | 0 | 30 | 60 | 90 | 120 | 150 | 180 | 210 |
|---|---|---|---|---|---|---|---|---|
| volume of hydrogen / $cm^3$ | 0 | 32 | 64 | - | 86 | 89 | 90 | 90 |

a) Draw a graph of these results. (3)

b) The group missed the reading at 90s. Suggest a likley value. __________ (1)

c) Explain why your answer in (b) is not found on a straight line between $64cm^3$ and $76cm^3$ of hydrogen. __________

__________ (2)

d) Predict the volume of hydrogen after 4 minutes. __________ (1)

e) Mary said that she could tell from the shape of the graph that the reaction had finished. Explain what she meant. __________

__________ (1)

f) Draw on your graph the results you would expect if the experiment was repeated (2)
i) at 40°C ii) using larger lumps of calcium.
Label your graph clearly.

Total (10)

## Candidate Guide

Your **plan** must include:

- an aim — which is a clear statement of what you are trying to do in this experiment
- the dependent and independent variables
- the relevant variable(s) to be kept constant
- what you will be measuring/observing
- a list of equipment/materials you will use
- a labelled diagram of the experimental arrangement, if appropriate
- a description of how you will carry out your experiment (including safety where appropriate)

**Checkpoint**: Ask your assessor to check your plan before you start the practical work.

- You should carry out your experiment safely and **record your observations/measurements** in an appropriate way.

**Checkpoint**: Ask your assessor to check your results.

- **Present** your findings/results in an appropriate way. You should:
  - record the information/data in a clear and systematic way, with well organised tables of raw data
  - process/analyse the results and present your findings in an appropriate format. This may be a table, line graph, chart, key, diagram, flow chart or summary. Graphs should be plotted on squared graph paper.
  - use appropriate SI units and standard abbreviations

- State your **conclusion(s)** — which should include reference to the aim and address the following questions:

  - are the results as you expected?
  - include reference to the aim

- **Evaluate** your experimental procedures. Your evaluation should include at least one of the following, with justification :
  - effectiveness of procedure
  - control of variables
  - limitations of equipment
  - possible sources of uncertainty
  - possible improvements