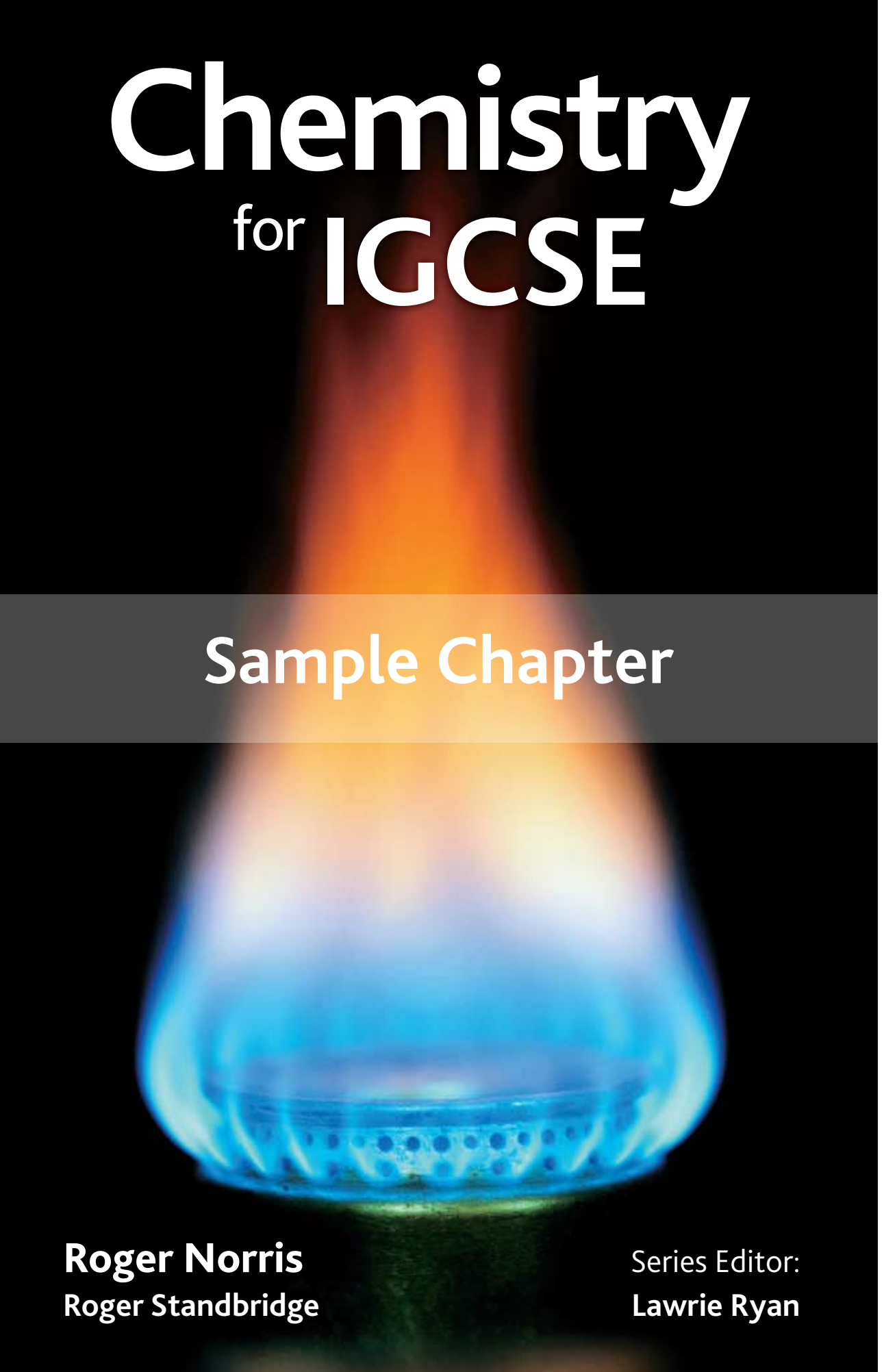
Chemistry for IGCSE



Sample Chapter

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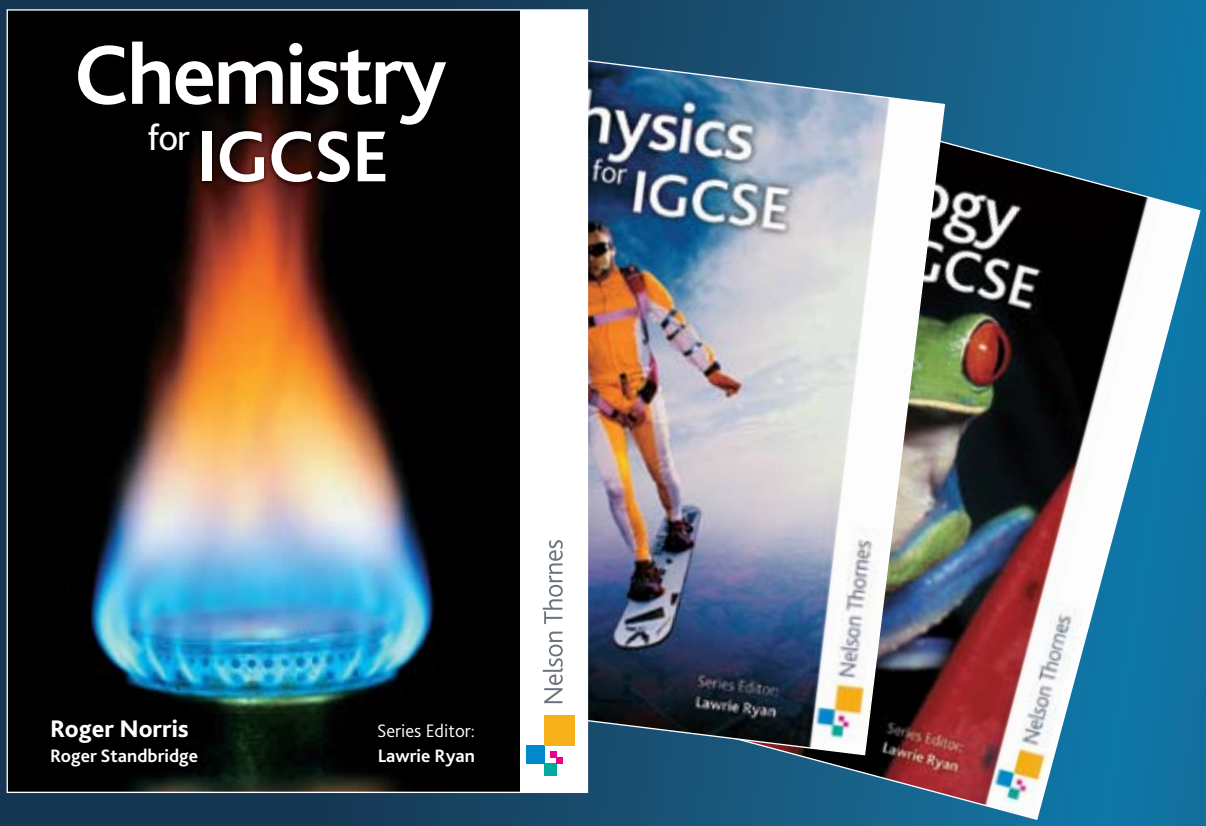

Author credentials

Author

Roger Norris is a science educator and examiner with 27 years' experience in a variety of educational establishments. For 15 years he has been involved with CIE and OCR as a Principal Examiner. As an author he has been involved with numerous OCR projects and regularly writes training material and conducts teacher training courses for teachers of the 0620 Chemistry syllabus.

Series Editor

Lawrie Ryan, is an experienced author and science educator. As a freelance writer, he has written numerous science courses and publications, mainly for Nelson Thornes, including the best-selling Chemistry for You. He is also a professional development trainer and editor.

Introduction

Nelson Thornes

Nelson Thornes are proud to present you with a sample chapter to our new title, Chemistry for IGCSE. Chemistry for IGCSE is the first in a unique series of titles from Nelson Thornes that matches CIE specifications and the needs of students and teachers studying CIE syllabuses. Written afresh and specifically for international schools, this series is the result of extensive market research among teachers in various parts of the world.

Key features include:

- Content is presented clearly and concisely to make it accessible for international school students with wide ranging backgrounds
- The examiners give tips and hints throughout that address common misconceptions and errors
- Each chapter has a section of exam-style questions, written by CIE IGCSE Principal Examiners, that closely match papers 1, 2 and 3
- Each title has a section dedicated to the Alternative to Practical paper prepared by the Principal Examiner for Paper 6
- All titles have a revision checklist that covers the whole CIE IGCSE Syllabus to make sure students know what they have covered

Topics are presented in an innovative 'lesson on a page' double page spread format, providing all pertinent material and emphasizing the key learning points.

Spread features:

- Learning outcomes – these are clearly stated at the start of each spread. Extension outcomes are also stated where applicable
- As well as being presented in a direct and accessible manner, content is supplemented by flow diagrams, tables and bulleted text
- Practical activities – these allow students to take an active approach to science
- Extension material – this is clearly distinguished where it occurs
- Examiner Says – notes written by CIE IGCSE Principal Examiners to help students overcome common errors and misconceptions
- Did you know – interesting information that uses contexts relevant to international school students
- Summary questions – test and consolidate students' learning
- Key points – at the end of the spread, these relate directly to the learning objectives and provide the key information that students need to learn

We hope you will be as pleased and excited by the results as we are, for further information please contact us using the details on the back of this booklet.

Yours faithfully,

Oliver Thornton
International Publishing Manager
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8 Speed of reaction

8.1 Rate of reaction

LEARNING OBJECTIVES

1 To describe a practical method for measuring speed of reaction where a gas is produced

2 To understand that speed of reaction involves quantity of material and time

Extension

3 To know how to investigate the effect of a given variable on the speed of a reaction

Some reactions, such as an old car rusting, are very slow. Other reactions are very fast. When you mix solutions of silver nitrate and potassium iodide, you get a yellow precipitate straight away.

The speed of a reaction – usually called **rate of reaction** – tells us how fast the products are formed from the reactants. Knowing how fast a reaction goes helps chemical companies make their products as quickly and as cheaply as possible.

Following the progress of a reaction

To find the rate of reaction we can either:

- measure how quickly the reactants are used up
- measure how quickly the products are formed.

Calculating rate of reaction depends on measuring something which changes with time, for example: volume of gas, mass of the reaction mixture or amount of light transmitted through a solution.

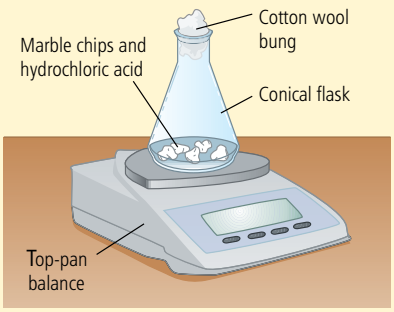
We run at different rates. The chemical reactions in our bodies supply our muscles with food at the rate needed.

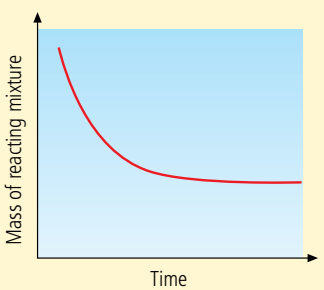
PRACTICAL

Following change in mass

You can use this method for reactions which give off a gas which is allowed to escape. As the reaction takes place the mass of the reaction mixture decreases. Record the mass at intervals of time. The loss of mass is equal to the mass of gas given off. When the total mass is plotted against time you get a graph like the one shown here.

Modern balances can be attached to a data logger and computer so that loss in mass can be recorded continuously.





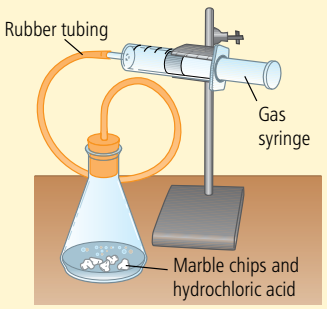
EXAMINER SAYS...

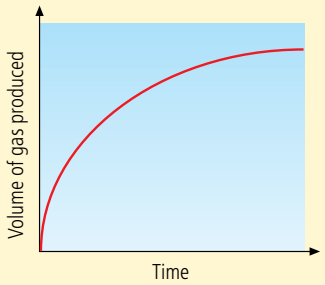
Remember that rate of reaction depends on two things: (1) the change in amount or concentration of reactant or product and (2) the time taken for this change.

PRACTICAL

Following change in the volume of gas given off

If a gas is given off in a reaction, you can collect it in a gas syringe. The volume of gas is recorded at intervals of time. You can draw a graph of volume of gas against time.





DID YOU KNOW?

Some reactions can be followed by recording tiny changes in the volume of a solution which takes during some chemical reactions.

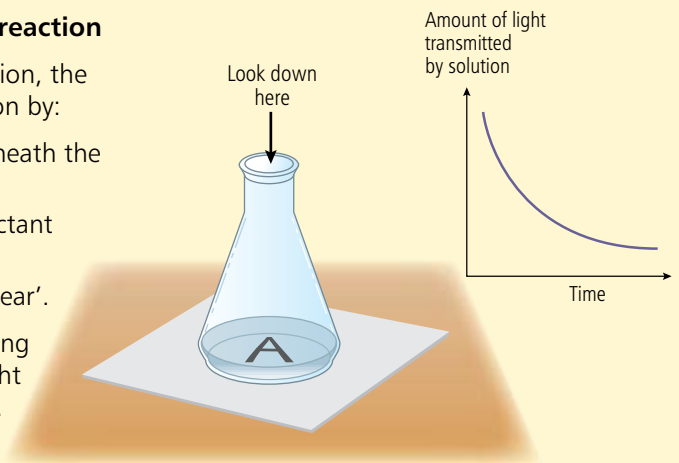
PRACTICAL

Following the progress of a precipitation reaction

If a precipitate is one of the products in a reaction, the solution goes cloudy. We can follow the reaction by:

- placing the paper with a letter A on it underneath the flask containing one of the reactants
- starting the reaction by adding the other reactant and starting the clock
- recording the time taken for the A to 'disappear'.

We can also measure the amount of light passing through the solution. We do this by using a light meter attached to a data logger and computer. This gives a graph as shown.



Extension

A variety of methods

There are many methods for measuring rate of reaction. You can use any property which changes during a reaction. You could use a pH meter or electrical conductivity meter if the hydrogen ions are used up in the reaction. You could also record changes in pressure for reactions involving only gases.

SUMMARY QUESTIONS

1 Sketch a graph to show how the volume of gas changes with time for the reaction

$$Mg + 2HCl \rightarrow MgCl_2 + H_2$$

2 Put the following in order of increasing speed of reaction

cement setting **firework exploding** **iron rusting**

KEY POINTS

1 We can follow the progress of a chemical reaction by measuring how fast the reactants are used up or how fast the products are formed.

2 We can use change in volume of gas, loss of mass of reactant or the time taken for a precipitate to make a mark 'disappear' to measure the rate of reaction

8.2 Interpreting data

LEARNING OBJECTIVES

1. To be able to interpret graphs of volume of gas produced against time
2. To be able to interpret graphs of mass of reactant changing with time

Extension

3. To be able to calculate speed of reaction
4. To be able to calculate which reagent is limiting in a reaction

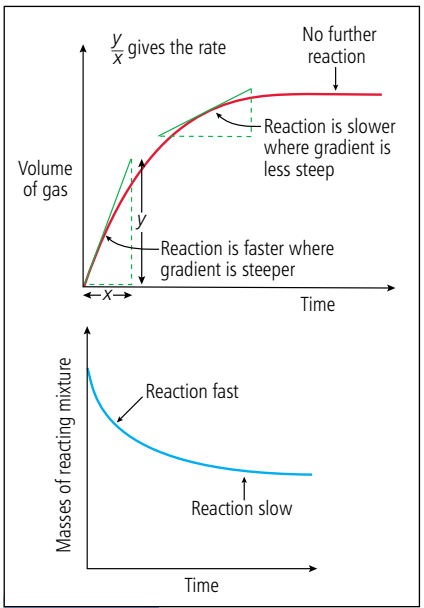


Figure 8.2.1

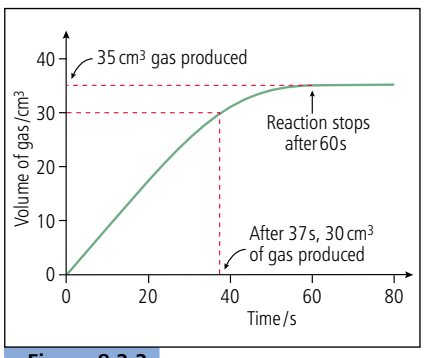


Figure 8.2.2

Constants and variables

Many factors such as temperature, concentration of reagent and particle size can affect the rate of reaction. How can you compare the results of a series of experiments in a fair way? You need to keep some things the same (controlled variables) and only change the one that you are interested in (the continuous variable). If you want to find out how the concentration of hydrochloric acid affects the rate of reaction of the acid with calcium carbonate you have to keep the temperature and particle size of the calcium carbonate the same in each experiment. You only change the concentration of the hydrochloric acid and record the time taken to get a certain volume of gas. Since **you** decide to when to take the time, the time is called the independent variable. And the volume of carbon dioxide produced is called the dependent variable because it depends on the time you selected.

Calculating rate of reaction

In a reaction such as

$$Mg + 2HCl \longrightarrow MgCl_2 + H_2$$

the time taken for the magnesium to disappear completely can be used as a measure of the rate of reaction. The reaction rate can be worked out by using the equation:

$$\text{rate of reaction} = \frac{\text{amount of product formed or reactant used up}}{\text{time}}$$

A more accurate definition of rate of reaction is

$$\text{rate} = \frac{\text{change in concentration of reactant or product}}{\text{time}}$$

However, we often need to know how the reaction rate changes as the reaction proceeds. If we look at how the volume of gas given off in a reaction changes with time we see that the reaction is fastest near the start but then gets slower and slower until it finally stops. The gradient (slope) of the graph gives us the reaction rate at any particular time.

If we look at a graph of loss of mass of the reaction mixture against time we can see a similar thing happening.

From these graphs we can find out:

- how long it takes for a reaction to produce a given volume of gas
- the volume of gas produced in a given time.

Extension

Limiting reactants

When carrying out an experiment we sometimes use an excess of one of the reactants. The reactant that is not in excess is called the limiting reactant. The reaction stops when the limiting reactant is completely used up. You can work out which reactant is limiting by calculating which reactant has the least number of moles for reaction. You must also take into account the mole ratio of the reactants in the equation.

Example: In the reaction $Mg + 2HCl \rightarrow MgCl_2 + H_2$

If 2.4 g of magnesium react with 50 cm^3 of 2 mol/dm^3 hydrochloric acid

moles of Mg = 2.4/24 = 0.1 mol;
moles of HCl = 2 x 50/1000 = 0.1 mol

The limiting reactant is hydrochloric acid because if we look at the equation: for every mole of magnesium used we need 2 moles of hydrochloric acid. So there is still 0.1/2 = 0.05 mol of magnesium left when the hydrochloric acid has been used up.

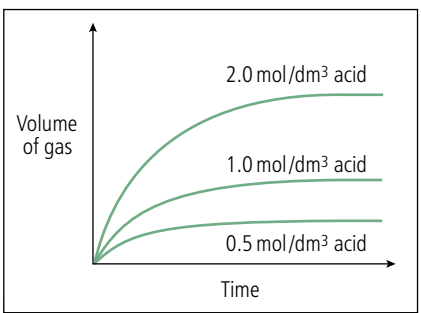


Figure 8.2.3

The graph shows how the volume of gas changes when hydrochloric acid is the limiting reactant at several different concentrations.

DID YOU KNOW?

The time taken for one form of aspartic acid to change into a different form of aspartic acid in fossil bones is 1 00 000 years!

EXAMINER SAYS...

Make sure that you know how to interpret the different parts of a graph of volume of gas released or loss in mass of the reactants against time.

EXAMINER SAYS...

You should also be able to calculate the rate of reaction form these graphs.

SUMMARY QUESTIONS

1 Sketch a graph to show how the mass off the reaction mixture changes with time for the reaction:

$$MgCO_3 + 2HCl \rightarrow MgCl_2 + CO_2 + H_2O$$

On your graph show (i) where the reaction had just stopped (ii) where the reaction is fastest (iii) where the reaction is very slow

2 a student adds some pieces of calcium carbonate to some acid. At the start of the reaction many bubbles are seen. After 10 minutes some calcium carbonate is still present but the bubbles have stopped. Which reactant is in excess? Explain your answer.

3 Copy and complete using words from the list:

fast limiting slows stops

When excess calcium carbonate reacts with hydrochloric acid, the reaction is very _____ at first but then _____ down until it _____ completely. The reaction stops because the _____ reactant has been completely used up.

KEY POINTS

1 Rate of reaction is calculated by dividing change in the amount of reactant or product by time.

2 As a reaction proceeds the rate of reaction decreases as one or more of the reactants gets used up

3 A reaction stops when the limiting reactant is completely used up.

Extension

8.3 Surfaces and reaction speed

LEARNING OUTCOMES

- Describe the effect of particle size and catalysts on the speeds of reactions
- Explain why fine powders can cause explosions e.g. in flour mills and in mines

EXAMINER SAYS...

It is a common error to think that larger particles have a larger surface area than smaller ones. Think of a large cube cut up – by cutting, you are exposing more surfaces.

Surface area and rate of reaction

If you want to make a fire quickly, you are more likely to succeed if you try to light small, thin pieces of wood rather than large pieces. We see a similar effect when solids react with solutions. A large lump of marble reacts slowly with hydrochloric acid but powdered marble reacts very quickly. Why is this?

The rate of reaction depends on how often the particles of acid collide with the particles on the surface of the marble. The greater the surface area of the marble, the more particles there are available to react. If we cut up the marble into smaller pieces, the surface area and the number of particles of marble which can react are both increased.

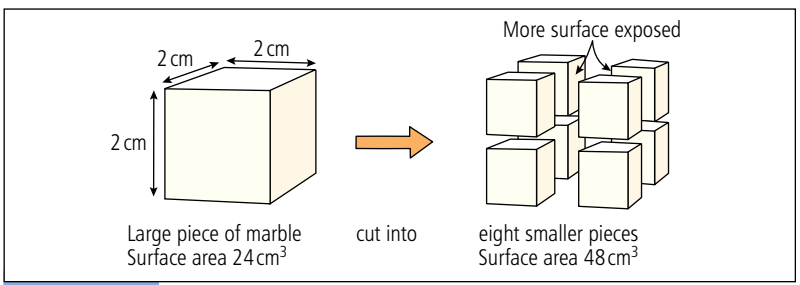


Figure 8.3.1

PRACTICAL

Investigating the effect of surface area

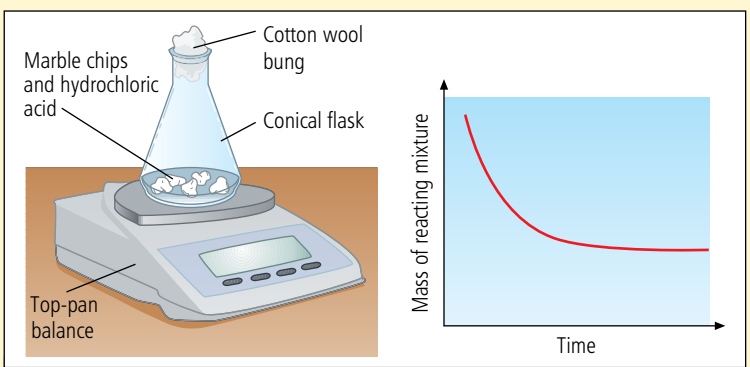


Figure 8.3.2

Marble is a form of calcium carbonate. You can investigate the effect of increasing surface area by reacting different sized marble chips with hydrochloric acid. You can carry out the reaction either by measuring the loss in mass as carbon dioxide is released or by recording the volume of carbon dioxide given off.

Explosive reactions

Many industrial processes cause fine powders to get into the air. These powders are highly combustible. They burn very readily in air because of their very large surface area. A lit match or a spark from a machine can cause them to explode. Examples are flour from flour mills, wood dust from sawmills and coal dust in coal mines. In coal mines there is another hazard. The methane gas which is often present can form an explosive mixture with air.

PRACTICAL

Explosive milk!

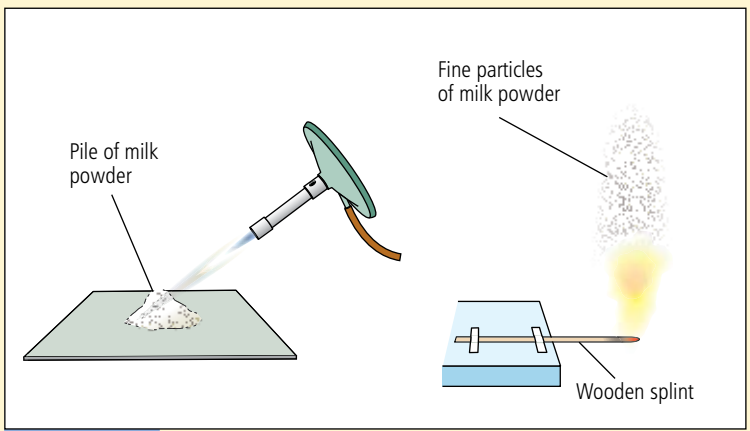


Figure 8.3.3

If you try to set fire to a pile of milk powder, it will just go black on the surface. If you sprinkle the milk powder onto a burning splint the flame will suddenly flare up as the milk powder 'explodes'.

Catalysis

A **catalyst** is a substance which speeds up a chemical reaction. The catalyst is not used up in the reaction – it remains the same substance as it was at the start of the reaction.

A catalyst works by allowing the reactants to get close together on its surface so that less energy is needed to get the reaction to occur. Catalysts are generally used in the form of pellets or wire gauzes. This gives them a large surface area for reaction.

We only need tiny amounts of catalyst to speed up the reaction but they are often expensive. However they can be used over and over again. They are important in speeding up the reactions in many important industrial chemical processes. In this way chemicals can be produced quicker and at a lower temperature compared with the uncatalysed reaction.

All living things contain particular types of catalysts called enzymes. These speed up all the chemical reactions in the body (see Unit 20.4).

DID YOU KNOW?

The earliest recorded explosion in a flour mill was in Italy in 1785.

Catalytic converters are important in reducing pollutant gases from cars.

SUMMARY QUESTIONS

1 Copy and complete using the words below:

again increases rate unchanged

A catalyst is a substance which _____ the _____ of a chemical reaction. The catalyst is _____ at the end of the reaction, so it can be used _____.

2 Factories which cut metals often have special fans to remove metal dust. Explain why metal dust in the atmosphere can be dangerous.

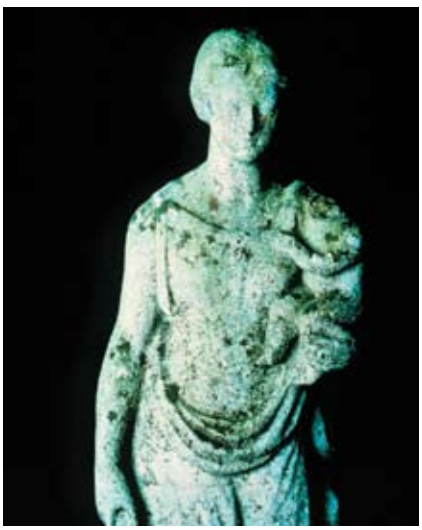
3 The inside of a catalytic converter in a car has thousands of tiny beads coated with the catalyst. Explain why these beads are used rather than having large lumps of catalyst.

8.4 Concentration and rate of reaction

LEARNING OUTCOMES

- Describe how concentration affects rate of reaction
- Describe and explain how concentration affects the rate of reaction in terms of collisions between reacting particles

Extension



Limestone statues are damaged by acid rain. This damage increases as the concentration of the acids in rainwater increases.

DID YOU KNOW?

Cars with steel bodies are likely to rust faster if you live near the sea because there is a higher concentration of salt in the atmosphere and rainwater.

How concentration affects the rate of reaction

The Taj Mahal, a beautiful building in India, is being eroded away! Over recent years the concentration of acids in rainwater all over the world has been steadily increasing. The acids in the air react with the marble and damage the surface of the building. The higher the concentration of acid in the air, the quicker a building made of marble or limestone will react.

PRACTICAL

How changing the concentration of acid affects reaction rate

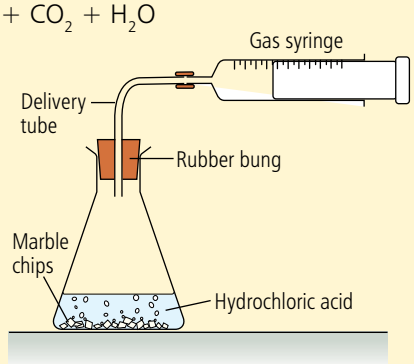
The rate of reaction of marble chips (calcium carbonate) is carried out with hydrochloric acid of different concentrations.

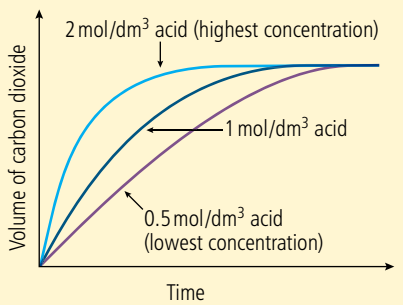
$$CaCO_3 + 2HCl \longrightarrow CaCl_2 + CO_2 + H_2O$$

We can follow the reaction by measuring the increase in volume of carbon dioxide given off or by measuring the decrease in mass of the reaction mixture. The temperature, mass and size of marble chips are kept the same as well as the volume of hydrochloric acid used. The concentration of hydrochloric acid is varied but it is always in excess.

For each concentration of hydrochloric acid used, record the volume of gas at time intervals.

A graph of the results is shown.





You can see that as the concentration of acid increases, the rate of reaction increases. The final volume of carbon dioxide released is the same in each experiment because hydrochloric acid was in excess.

Extension

Using the collision theory

A concentrated solution has more particles of solute per unit volume than a dilute solution. In the reaction between calcium carbonate and hydrochloric acid, the important solute particles are the hydrogen ions in the hydrochloric acid (see Unit 10.4).

A reaction occurs when particles with enough energy collide. The more concentrated the hydrochloric acid, the more hydrogen ions there are in a given volume to collide and react with the carbonate particles in the calcium carbonate. The rate of reaction depends on the number of successful collisions per second. If there are more collisions per second, the rate of reaction is faster.

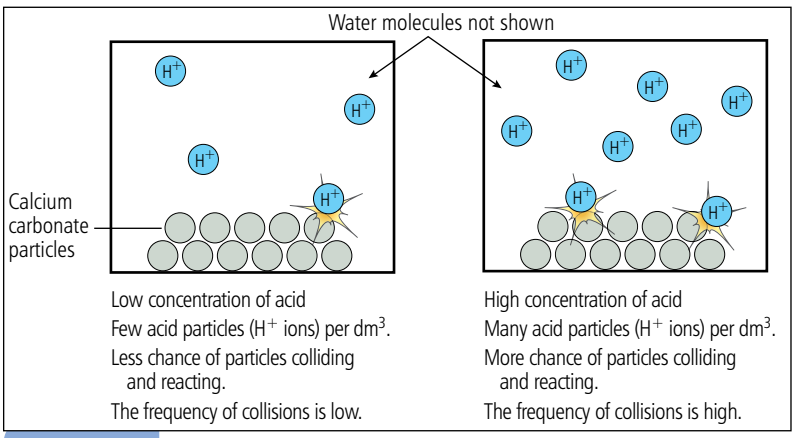


Figure 8.4.3

In a reaction involving gases, increasing the pressure has a similar effect to the increase in concentration. Increasing the pressure pushes the particles closer together so that they collide with a greater frequency and the rate of reaction increases.

EXAMINER SAYS...

Remember that increasing the concentration of a reactant has no effect on the force with which the particles hit each other.

EXAMINER SAYS...

When explaining the effect of concentration on reaction rate don't just refer to more collisions of the particles. It is the more frequent collision of the particles which is important.

SUMMARY QUESTIONS

1 Copy and complete using words from the list below:

concentration increases rate

The _____ of a chemical reaction _____ when the _____ of one or more of the reactants increases.

2 a When barium carbonate reacts with hydrochloric acid, carbon dioxide gas is given off. Sketch a graph to show how the mass of the reaction mixture changes using dilute hydrochloric acid.

b On the same graph axes sketch the line you would expect for the same experiment but using hydrochloric acid of half the concentration.

Extension

3 Copy and complete using words from the list below:

collide collision concentrated frequently unit

The effect of increasing reactant concentration on the rate of reaction can be explained by the _____ theory. When the reactants are more _____ there are more reactant particles present per _____ volume so they _____ more _____.

4 Use ideas from the collision theory to suggest why a reaction slows down as time goes on.

KEY POINTS

1 Increasing the concentration of reactants increases the rate of reaction.

2 Increasing the concentration of reactants increases the frequency of collision of the particles and so increases reaction rate.

8.5 Temperature and rate of reaction

LEARNING OUTCOMES

- Describe how temperature affects the rate of reaction

Extension

- Describe and explain how temperature affects the speed of reaction in terms of collisions between reactant particles

Moving faster means it's more likely that you'll bump into someone else – and the bump will be harder too!

DID YOU KNOW?

Food cooks quicker at a higher temperature because the particles have more energy and there are more collisions per second between the molecules in the food.

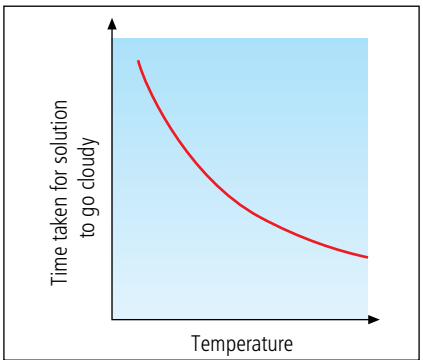


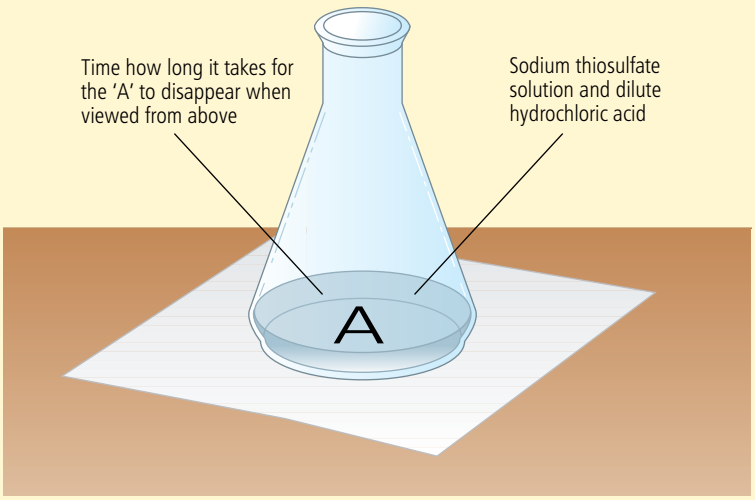
Figure 8.5.2

How temperature affects rate of reaction

We can change the rate of a chemical reaction by heating or cooling the reaction mixture. Food goes mouldy quicker when left out of the refrigerator. This is because the reactions which make food rot are faster at higher temperatures. Some surgical operations are carried out below room temperature to slow down the chemical reactions in the body.

PRACTICAL

Investigating the effect of temperature on reaction rate



When we react sodium thiosulfate with hydrochloric acid a precipitate of sulfur is formed.

You place the flask of sodium thiosulfate on top of the cross on the paper. You add hydrochloric acid and record the time taken for the letter X to 'disappear'. Repeat the experiment at different temperatures using the same amounts of acid and thiosulfate heated up separately before mixing them together.

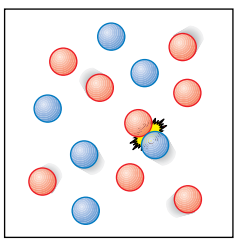
You can plot a graph of the time taken for the X to 'disappear' against temperature. The shorter the time taken for the X to 'disappear', the faster the reaction is. This is because rate of reaction is proportional to amount of product formed (or reactant used) divided by time. If you look at the graph carefully, you can see that for every 10 °C rise in temperature, the rate of reaction approximately doubles.

Extension

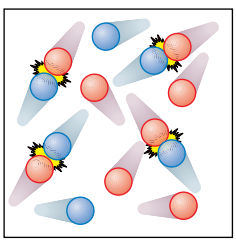
Using the collision theory

There are two reasons we can use to explain why increasing the temperature increases the rate of reaction. The second of these is the most important.

1. When we heat up a reaction mixture, the particles gain energy. When particles gain energy they move faster and collide more often. The frequency of collisions is increased. This results in an increased rate of reaction.
2. In order to react, particles must collide with a minimum amount of energy. This is called the activation energy. As the temperature gets higher more and more particles have this minimum amount of energy to react when they collide. In other words, as the temperature is increased there is more chance of a collision between the reactant particles being successful. We say that the number of effective collisions increases as the temperature increases.



Lower temperature.
Particles have less energy.
They move more slowly and collide less frequently.
The collisions are not very effective.



Higher temperature.
Particles have more energy.
They move faster and collide more frequently.
The collisions are very effective.

Figure 8.5.3

EXAMINER SAYS...

1 When writing answers to questions about rates of reaction it is important to use words like faster or slower not just fast or slow.

EXAMINER SAYS...

Note that as the temperature increases, each particle collides with a greater force. It is also more accurate to write that 'there are more frequent collisions' than just 'more collisions'.

SUMMARY QUESTIONS

1 Copy and complete using words from the list below:

longer rate slower time

The _____ the _____ taken for a reaction to be complete the _____ the _____ of reaction.

2 A student followed the rate of reaction of calcium carbonate with hydrochloric acid at different temperatures. At each temperature she recorded the volume of gas produced 30 seconds from the start of the reaction. Sketch a graph to show how the volume of gas changes with temperature.

Extension

3 Copy and complete using words from the list below:

effective energy faster increases minimum more

When the temperature of a reaction mixture is increased the particles move _____ because the _____ of the particles increases. At a higher temperature there are also _____ particles with the _____ amount of energy to react when they collide. So the collisions are more _____ and the rate of reaction _____.

KEY POINTS

1 The higher the temperature the greater the rate of reaction.

2 The rate of reaction increases with increase in temperature because particles have more energy so they move faster and collide more frequently. The collisions that take place are also more energetic so are more likely to result in a reaction taking place.

Extension

8.6 Light sensitive reactions

Extension

LEARNING OBJECTIVES

1. To describe the effect of light on the rate of some reactions
2. To describe the use of silver salts in photography
3. To describe the process of photosynthesis in simple terms

A few chemical reactions are started by ultraviolet or visible light. These are called photochemical reactions. We rely on the photochemical reactions in plants to provide the oxygen we breathe and the food we eat as well as removing carbon dioxide from the atmosphere. The photochemical reaction in plants is called photosynthesis. Not all photochemical reactions are useful. Compounds called CFCs are broken down by ultraviolet light and the products are responsible for the depletion of the ozone layer around the Earth.

Photosynthesis

Plants use the energy from sunlight to make glucose. This process is called photosynthesis.

$$\underset{\text{carbon dioxide}}{6CO_2} + \underset{\text{water}}{6H_2O} \rightarrow \underset{\text{glucose}}{C_6H_{12}O_6} + \underset{\text{oxygen}}{6O_2}$$

The glucose is turned into macromolecules called starch and cellulose (see Unit 20.3)

Photosynthesis is catalysed by the green pigments in plants called chlorophylls.

EXAMINER SAYS...

It is important to realise that light only affects a few reactions. The only ones you have to know about are photosynthesis, the conversion of silver bromide to silver and the reaction of halogens with chlorine (see Unit 18.1)

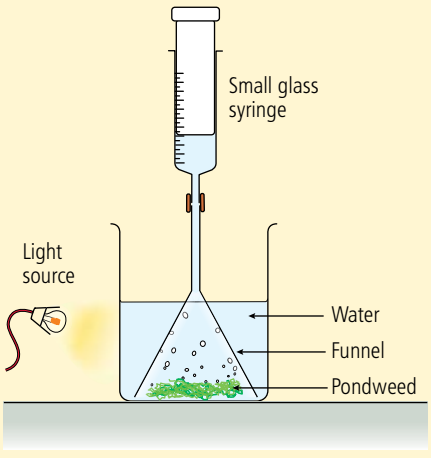
Photo:
Two plants grown with and without light

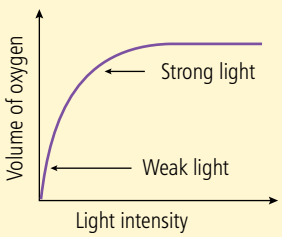
The plant on the left looks unhealthy because it has not had enough light

PRACTICAL

How light affects the rate of photosynthesis

When light shines on the pondweed, bubbles of oxygen slowly form on the leaves and then rise into the syringe. You can record the volume of oxygen collected over several days. Then you can repeat the experiment using stronger (more intense) light. The graph shows how the rate of photosynthesis changes with light intensity. The graph levels off because carbon dioxide becomes limiting.





Photography

The surface of black and white photographic film contains tiny crystals of silver bromide mixed with gelatine. When light shines on the film the silver bromide is 'activated'. Some of the silver bromide decomposes (breaks down) to form silver.

$$\underset{\text{silver bromide (very pale cream)}}{2AgBr} \longrightarrow \underset{\text{silver (black)}}{2Ag} + Br_2$$

In this reaction the silver ions in the silver bromide accept electrons from the bromide ions and become silver atoms. This is a redox reaction (see Unit 9.3). The silver ions get reduced because they accept electrons and the bromide ions get oxidised because they lose electrons (see unit 9.3)

$$2Ag^+ + 2e^- \longrightarrow 2Ag \quad \text{(a reduction reaction)}$$

$$2Br^- \longrightarrow Br_2 + 2e^- \quad \text{(an oxidation reaction)}$$

The parts of the film exposed to stronger light appear black and the parts not exposed appear white. The greater the intensity (strength) of the light the faster the reaction. A positive print is made by shining light through the negative onto a piece of photographic paper behind.

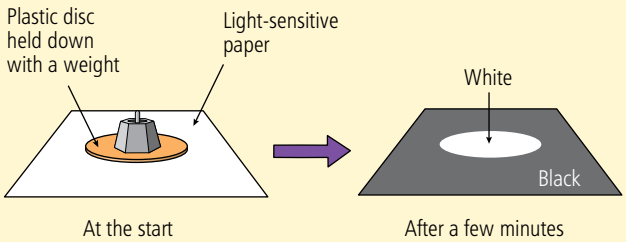
DID YOU KNOW?

Some spectacle lenses darken in bright light and get more transparent in dim light. This is because light reacts with the silver chloride in the lenses.

PRACTICAL

A light sensitive reaction

Place a plastic disc on a piece of light sensitive photographic paper in the dark. The paper and disc are then left in the light. After a short time the paper will turn black but if you remove the disc you can still see a circle of white paper. This shows that light is needed for the reaction to happen.



SUMMARY QUESTIONS

1 What do you understand by the following terms:
a Photosynthesis
b reduction
c photochemical reaction?

2 Copy and complete using words from the list.

black bromide crystals light particles silver

Photographic film contains tiny _____ of silver _____ When _____ shines on the film the _____ bromide breaks down to _____ of silver which are _____ in colour.

3 How does the rate of decomposition of silver bromide vary with the strength (intensity) of light?

KEY POINTS

1 The rate of some reactions is increased by increasing the intensity of light. These reactions are photochemical reactions.

2 Photosynthesis is a process by which plants change carbon dioxide and water to glucose and oxygen using chlorophyll as a catalyst

3 In the photographic reaction silver bromide is decomposed to silver and bromine.

SUMMARY QUESTIONS

1 Match the method for measuring reaction rate on the right with the type of reaction on the left:

a purple solution changes to a colourless solution	measure the volume of gas
hydrogen is released during a reaction	electrical conductivity
two solutions react slowly to form a precipitate	measure the light transmitted through a solution
there are more ions in the reactants than in the products	seeing how long it takes for a letter 'A' under a flask to disappear

2 Write definitions of the following:

(a) rate of reaction

(b) catalyst

(c) gradient

3 Sketch a graph to show how the mass changes in the reaction:

$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

4 Complete the following phrases:

(a) increasing the surface area of a solid _____ the rate of reaction.

(b) As a reaction proceeds the _____ of reaction _____.

5 What effect does each of the following have on the rate of reaction:

(a) diluting the reaction mixture

(b) using large lumps of solid rather than small

Extension

6 Use your knowledge of the kinetic particle theory to describe and explain how increasing the pressure affects the rate of the following reaction:

$2N_2O(g) \rightarrow 2N_2(g) + O_2(g)$

7 Write definitions of:

(a) limiting reactant

(b) photochemical reaction

(c) photosynthesis

8 Us the kinetic particle theory to suggest why food cooks more quickly when the temperature is higher.

EXAM-STYLE QUESTIONS

1 Which one of the following statements about catalysts is true?

A They are always non metals

B They do not take part in chemical reactions

C They have no effect on rate of reaction

D Their mass remains unchanged at the end of the reaction

(Paper 1) *[1]*

1 The table shows the volume of oxygen given off when hydrogen peroxide decomposes at 40 °C in the presence of a catalyst

Time / s	Volume of oxygen/ cm^3
0	0
5	22
10	34
20	48
30	56
40	59
50	60
60	60

a) Plot a graph of the results with time on the x axis and volume of oxygen on the y axis. *[3]*

b) On the same axes sketch a curve for the same reaction but carried out at a temperature of 50 °C. *[2]*

c) What results would you expect if the catalyst was not present? Explain your answer. *[2]*

(Paper 2)

2 A student compared how well different compounds catalysed the reaction between zinc and hydrochloric acid. The results are shown in the table.

Compound	Time taken for all the zinc to react / s
No catalyst	500
Copper(II) sulfate	150
Copper(II) chloride	175
Manganese(IV) oxide	390
Sodium chloride	500
Sodium sulfate	500

a) What do you understand by the term catalyst? *[1]*

b) Which is the best catalyst for this reaction? *[1]*

c) What things must you keep constant in these experiments if it is to be a fair test? *[3]*

d) Which compounds are not catalysts? *[1]*

(Paper 2)

3 Magnesium ribbon reacts with hydrochloric acid. The equation is

$$Mg + 2HCl \longrightarrow MgCl_2 + H_2$$

a) Suggest two methods that you could use to follow the progress of this reaction *[4]*

b) For one of these methods describe how you can calculate the rate of reaction *[3]*

c) Explain using the kinetic particle theory how and why the rate of reaction changes when

(i) the concentration of hydrochloric acid is increased *[3]*

(ii) the temperature of the reaction mixture is lowered *[3]*

(iii) powdered magnesium is used rather than magnesium ribbon *[3]*

(Paper 3)

4 A student investigated the reaction between 40 g calcium carbonate and 30 cm^3 of 2.0 mol/dm^3 hydrochloric acid.

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

a) Draw a sketch graph to show how the loss in mass of the reaction mixture changes with time. *[2]*

b) By referring to the shape of your graph you have drawn in part (a) explain how the rate of reaction decreases with time. *[2]*

c) Use the idea about colliding particles to explain why the rate of reaction decreases with time. *[3]*

d) **(i)** Calculate the number of moles of calcium carbonate and hydrochloric acid at the start of the reaction. *[2]*

(ii) Was the hydrochloric acid or the calcium carbonate the limiting reactant? Explain your answer. *[2]*

e) In another experiment the student investigated how the rate of this reaction varies with temperature. The results are shown in the table.

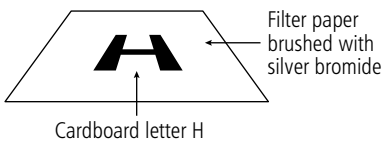
Temperature / °C	20	30	40	50
Time taken for a piece of calcium carbonate to dissolve / s	64	32	16	8

(i) Draw a suitable graph to display these results *[3]*

(ii) From your graph predict how many seconds it would take the piece of calcium carbonate to dissolve at 60 °C. *[1]*

(Paper 3)

5 Crystals of silver bromide were brushed onto a sheet of damp filter paper. A cardboard letter 'H' was placed on top of the paper.



The filter paper and cardboard 'H' was left in the light for time. After a few hours the filter

Paper around the 'H' had turned black but underneath the 'H' it was still white.

a) Explain these results. *[4]*

b) How can you make the filter paper go black quicker? *[1]*

c) Write an ionic equation to show what is happening to the silver ions when the light strikes the paper silver bromide on the paper. *[1]*

(Paper 3)

6 Zinc powder reacts with excess aqueous iodine to form zinc iodide.

Zn(s)	+	I_2(aq)	⟶	ZnI_2(aq)
grey solid		brown solution		colourless solution

a) Describe a suitable method for following this reaction. *[3]*

b) Which is the limiting reagent in the reaction? *[1]*

c) Use the kinetic particle theory to explain how and why the rate of reaction changes when large pieces of zinc are used in place of zinc powder. *[3]*

(Paper 3)

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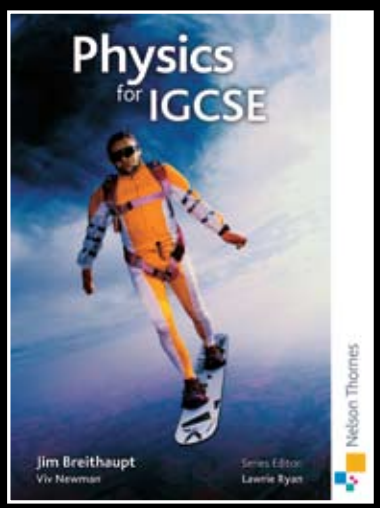

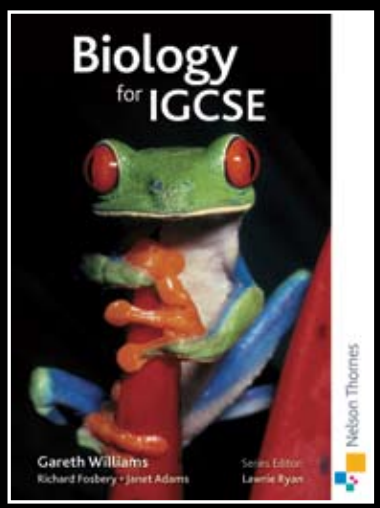

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