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OCR AS/A level Chemistry A

Second Edition

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Module 3
The periodic table and energy

Module 4
Core organic chemistry

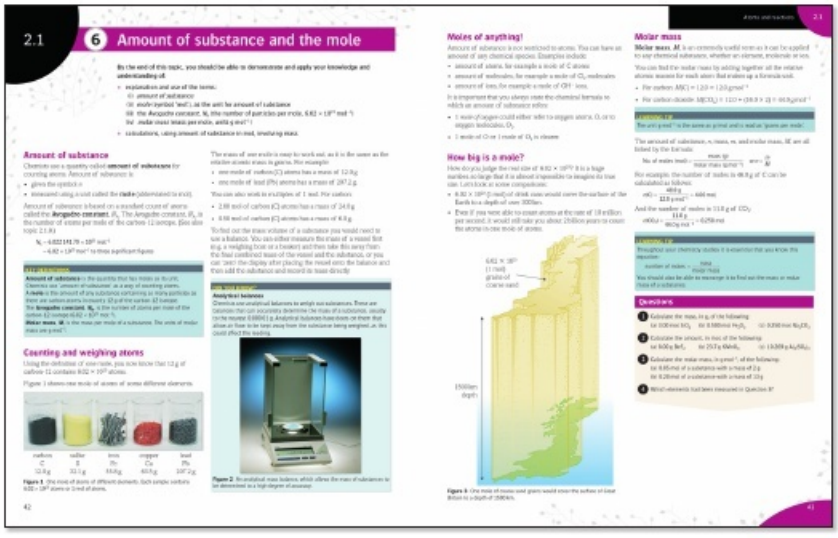
How to use this book

Welcome to your OCR AS/A level Chemistry A student book. In this book you will find a number of features designed to support your learning.

Chapter openers

Each chapter starts by setting the context for that chapter's learning:

- Links to other areas of Chemistry are shown, including previous knowledge that is built on in the chapter and future learning that you will cover later in your course.
- The **All the maths I need** checklist helps you to know what maths skills will be required.



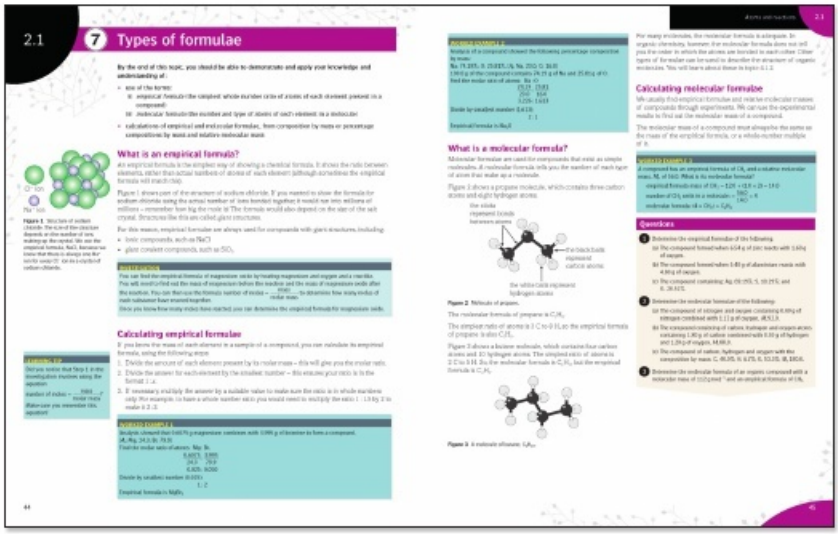
Main content

The main part of the chapter covers all of the points from the specification you need to learn. The text is supported by diagrams and photos that will help you understand the concepts.

Within each topic, you will find the following features:

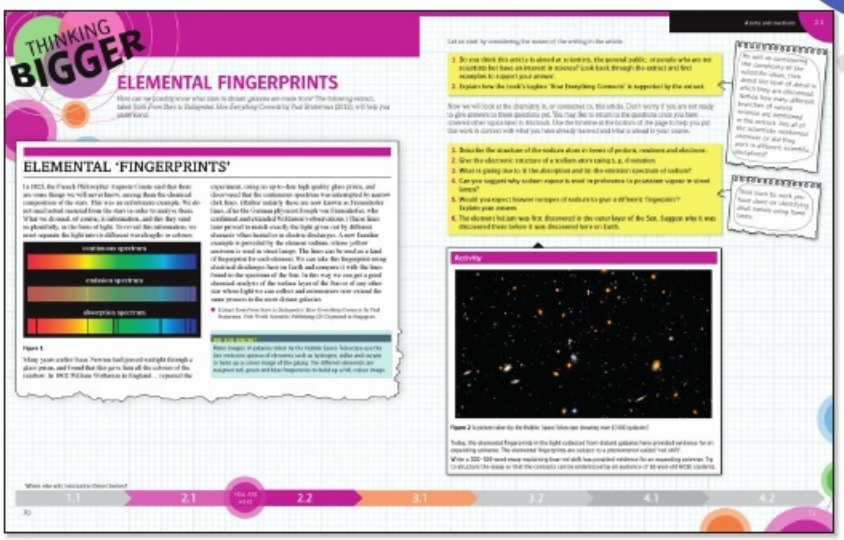
- **Learning objectives** at the beginning of each topic highlight what you need to know and understand.
- **Key terms** are shown in bold and defined within the relevant topic for easy reference.
- **Worked examples** show you how to work through questions, and how your calculations should be set out.
- **Investigations** provide a summary of practical experiments that explore key concepts.
- **Learning tips** help you focus your learning and avoid common errors.
- **Did you know?** boxes feature interesting facts to help you remember the key concepts.

At the end of each topic, you will find **questions** that cover what you have just learned. You can use these questions to help you check whether you have understood what you have just read, and to identify anything that you need to look at again.



Thinking Bigger

At the end of each chapter there is an opportunity to read and work with real-life research and writing about science. These sections will help you to expand your knowledge and develop your own research and writing techniques. The questions and tasks will help you to apply your knowledge to new contexts and to bring together different aspects of your learning from across the whole course. The timeline at the bottom of the spread highlights which other chapters of your book the material relates to.

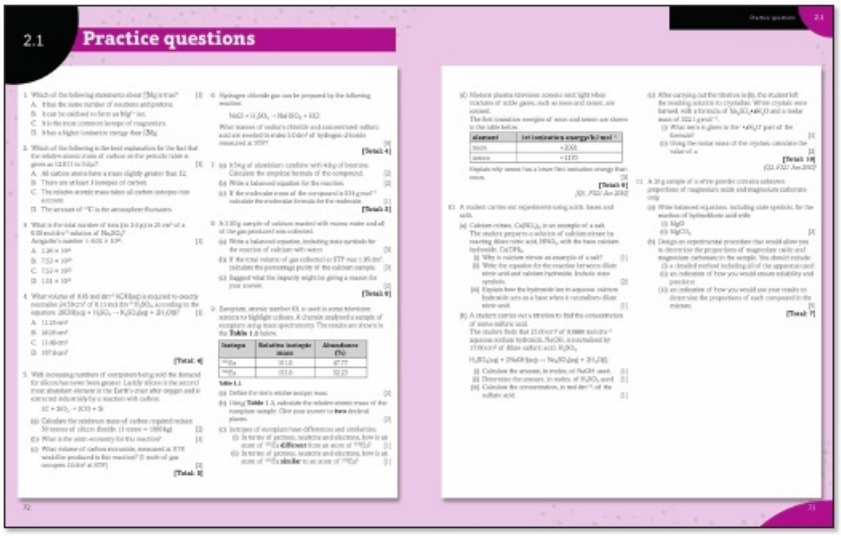


These spreads will give you opportunities to:

- read real-life material that's relevant to your course
- analyse how scientists write
- think critically and consider relevant issues
- develop your own writing
- understand how different aspects of your learning piece together.

Practice questions

At the end of each chapter, there are **practice questions** to test how fully you have understood the learning.



Getting the most from your ActiveBook

Your ActiveBook is the perfect way to personalise your learning as you progress through your OCR AS/A level Chemistry A course. You can:

- access your content online, anytime, anywhere
- use the inbuilt highlighting and annotation tools to personalise the content and make it really relevant to you
- search the content quickly.

Highlight tool

Use this to pick out key terms or topics so you are ready and prepared for revision.

Annotations tool

Use this to add your own notes, for example, links to your wider reading, such as websites or other files. Or make a note to remind yourself about work that you need to do.

MODULE 1

Practical skills in chemistry

CHAPTER 1.1

PRACTICAL SKILLS ASSESSED IN A WRITTEN EXAMINATION

Introduction

The philosophers in Ancient Greece would ponder the world around them and generate ideas to explain their observations. Some were correct, like the idea of the atom, and others were not, like the hypothesis that the world was flat. It wasn't until the age of the alchemists that logical planned practical investigations into the material world were made. These forerunners of modern day chemists would mix chemicals, heat, cool and observe – all in their practical search for gold. This experimentation gave a lot of advances to the sciences and medicine, including discovering many elements, such as phosphorus. So, experiments are an important part of science.

Practical science allows researchers to test theories, explore the world and make new discoveries. To make sure that scientists don't miss anything a clear repeatable approach is used in practical work. This involves setting an aim, which is then used to plan and carry out an investigation. Having the skills to logically plan out an experiment and interpret the results while modifying techniques underpins our understanding of many areas of chemistry.

All the maths you need

To unlock the puzzles of this chapter you need the following maths:

- Use the correct units to quantify a variable
- Display data in different formats such as tables, charts and graphs
- Be able to calculate averages (mean)
- Be able to calculate the gradient of a trend line on a graph
- Identify anomalies in a data set
- Be able to represent numbers in standard form
- Be able to represent numbers in appropriate significant figures

What have I studied before?

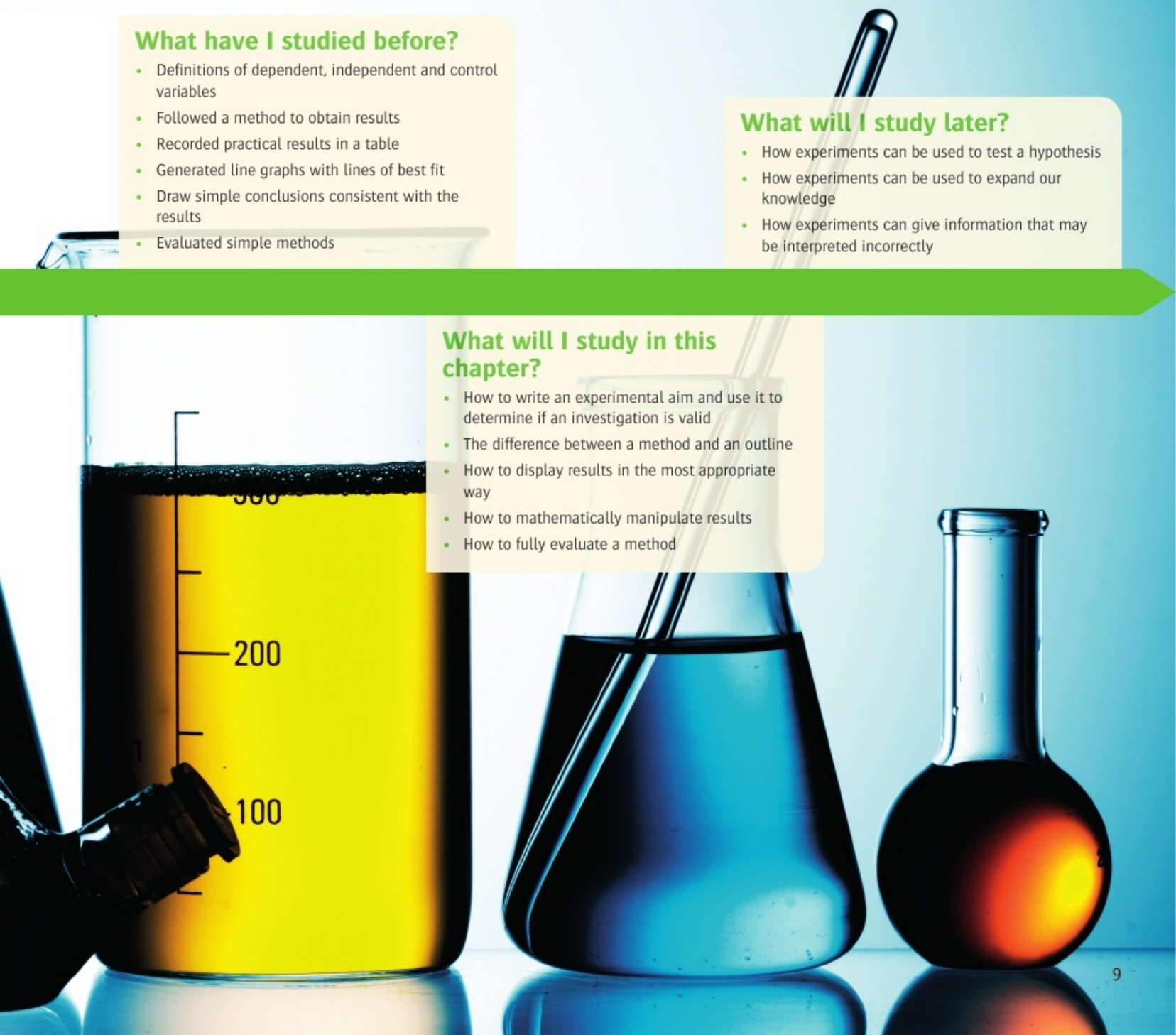
- Definitions of dependent, independent and control variables
- Followed a method to obtain results
- Recorded practical results in a table
- Generated line graphs with lines of best fit
- Draw simple conclusions consistent with the results
- Evaluated simple methods

What will I study later?

- How experiments can be used to test a hypothesis
- How experiments can be used to expand our knowledge
- How experiments can give information that may be interpreted incorrectly

What will I study in this chapter?

- How to write an experimental aim and use it to determine if an investigation is valid
- The difference between a method and an outline
- How to display results in the most appropriate way
- How to mathematically manipulate results
- How to fully evaluate a method



1 Experimental design

By the end of this topic, you should be able to demonstrate and apply your knowledge and understanding of:

* experimental design, including to solve problems set in a practical context

Types of research

Scientists investigate using two techniques:

- Primary research – new data is collected and conclusions are then drawn.
- Secondary research – data from other studies is used in different ways to draw conclusions.

DID YOU KNOW?

Scientists share their ideas by publishing their findings in periodicals called journals. Their investigations are written up into a document called a paper. Each paper outlines the scientist's research and their conclusions. Papers are often used by other scientists in their secondary research. Most scientific conclusions are generated from a mixture of primary and secondary research.

Figure 1 Scientists create an aim for their research and can then apply for funding.

Before a scientist starts a piece of research, they set out their aim. This is either a question that they want to answer or a hypothesis that they want to test. When they are planning their research, they must ensure that the method generates results that can achieve the aim. Suitable results that can test the aim are described as **valid**.

Once the aim has been agreed, a scientist will create a **hypothesis**. This is a prediction using their scientific knowledge and trusted information from text books, colleagues and papers. The scientist then decides on their method for testing their ideas.

Surveys

A survey is a type of primary research. It sets out limits to observe something that is already happening.

For example, if you took a daily photograph of a piece of copper attached to the roof of a building for one year, this would be a survey of how the metal tarnished. In A level Chemistry we rarely use surveys.

Experiments

An **experiment** is a type of primary research. It is an ordered set of practical steps that are used to test the hypothesis. The results can be used as evidence to support or disprove a theory.

An example of an experiment might be investigating how the chain length of straight-chain alkanes affects their melting point by directly measuring the melting points. A special apparatus can be used to accurately measure the melting points of organic chemicals. In A level Chemistry we use experiments a lot.

Figure 2 Melting point apparatus.

Meta study or meta analysis

A meta study is a type of secondary research. This uses the raw data from a variety of different studies to try to answer a new aim. This is a mathematical approach using statistics and is often used by social scientists. It is also being used increasingly in medical research, as it allows a large data group to be studied. However, the data may be unreliable and biased, which can cause errors in the conclusions.

In A level Chemistry we sometimes use data from a variety of sources to draw conclusions. For example, periodicity data (like melting points of period 3 elements) could come from a variety of sources.

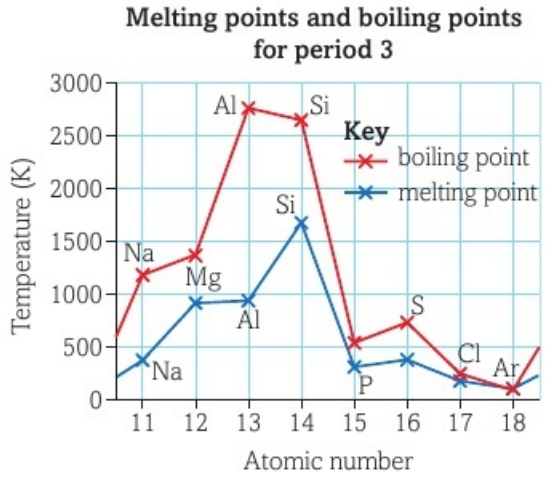


Figure 3 Melting point and boiling point line graphs of period 3 elements are the result of a meta study.

KEY DEFINITIONS

A **valid** experiment provides information to test the aim of the experiment.
A **hypothesis** is a prediction and explanation of the chemistry behind the prediction.
An **experiment** is an ordered set of practical steps, which are used to test the hypothesis.
Quantitative data is a quantity (number) of what is being observed.
Qualitative data is a description of what is being observed.
Resolution is the smallest change in the quantity being measured that can be observed.
Accuracy is how close to the true value a measurement is.

DID YOU KNOW?

The use of information technology is making it quicker to gather large amounts of data. As databases become easier to search, valid meta studies can be completed quickly, rather than many researchers repeating identical studies and generating the same conclusions.

Types of data

Results can be:

- **quantitative** – have a numerical value and require a measuring instrument in order to be observed
- **qualitative** – descriptions of what is observed.

Most experiments in A level Chemistry give quantitative data. The data can be manipulated using mathematical techniques to help see patterns and draw conclusions.

To observe quantitatively, you use measuring equipment like thermometers, burettes and top pan balances. These pieces of equipment allow for measurements to be made as they contain a scale, calibration mark or a digital display. Some equipment, like a thermometer, can be used to measure a range of different values. Others, like a bulb pipette, can only measure one quantity.

For qualitative data scientists need to use their senses. Researchers carry out the experiment and note down what they observe. This is usually what they see occurring, but observations can also involve smell, sound and, in a suitable environment, even taste.

Qualitative research is prone to bias, as the researcher often unconsciously screens what they think is important and notes those observations, rather than everything that occurs. This observational bias can be reduced by using modern technology, such as filming experiments. Then a group of researchers can review the clip, discuss their observations and draw a common conclusion.

LEARNING TIP

Surveys are used more in social sciences like psychology. In these areas, lots of factors are likely to affect an outcome. It is therefore difficult to select just one dependent variable to monitor and so design a valid experiment.

Choosing equipment

Quantitative data requires a measuring instrument to give a quantity to a variable. When choosing equipment, you should consider two factors:

- **Resolution** – this is the smallest change in the quantity being measured that can be observed. If you are measuring liquids, a measuring jug has less resolution than a measuring cylinder.
- **Accuracy** – this is how close to the true value a measurement is. When measuring the volume of a liquid, a bulb pipette will be the most accurate way of measuring a standard volume.

Figure 4 A bulb pipette has less resolution than a measuring jug but is more accurate at measuring 25 cm^3 of liquid at 25 °C.

Questions

1. What are the features of a valid aim?
2. Describe the similarities and differences between meta studies and experiments.
3. In an experiment, a student wanted to measure the mass of water to 1 g. Suggest how this can be done without using a balance.

2 Types of variable

By the end of this topic, you should be able to demonstrate and apply your knowledge and understanding of:

- identification of variables that must be controlled, where appropriate
- appropriate units for measurements

What are variables?

Variables are the factors that can affect the outcome of an experiment. In an aim, a scientist will often suggest a connection between two variables. All other variables must then be kept the same in order to discover whether these two variables are related.

Independent variable

An **independent variable** is the factor that you are interested in changing to see the effect it has on another factor. Independent variables are chosen before an experiment starts. They are listed in the first column of a results table and can be filled in before the experiment begins.

DID YOU KNOW?

An experiment is undertaken to discover how chemical structure affects melting point. The independent variable is the structure, as you choose the structures that you will investigate.

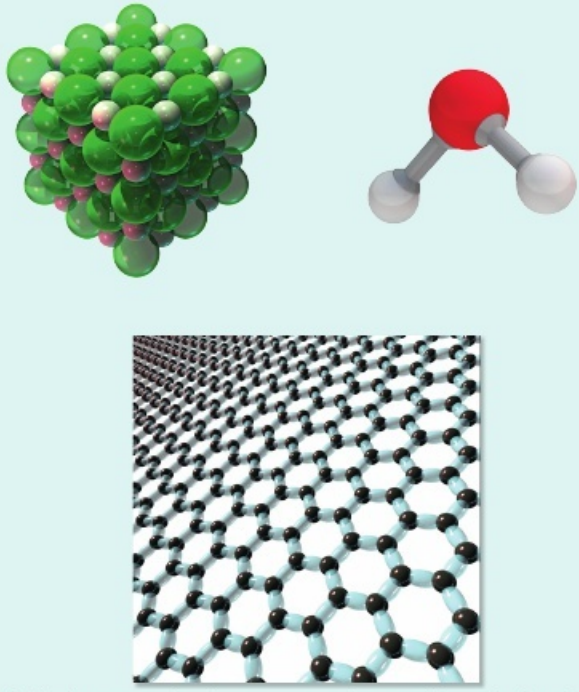


Figure 1 Find out more about how structure affects melting point in topic 3.1.7.

Dependent variable

A **dependent variable** is the factor that you measure or observe in an experiment. This data is added to the results table as the experiment progresses.

INVESTIGATION

In an experiment to measure the enthalpy change of a reaction, the dependent variable is the temperature change of the solution. This is monitored during the experiment and recorded.

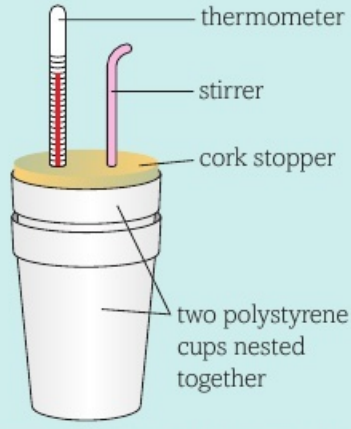


Figure 2 Find out more about coffee cup calorimetry in topic 3.2.4.

Control variable

A **control variable** is a factor that you must keep constant between each run of the experiment, so that results can be compared. Control variables must be considered before an experiment starts and measured each time a run happens. They are not recorded in a results table.

INVESTIGATION

In a titration experiment to measure the concentration of a solution of sodium hydroxide, the control variables include the concentration and type of acid. This allows concordant results to be generated.

Figure 3 Find out more about titrations in topic 2.1.17.