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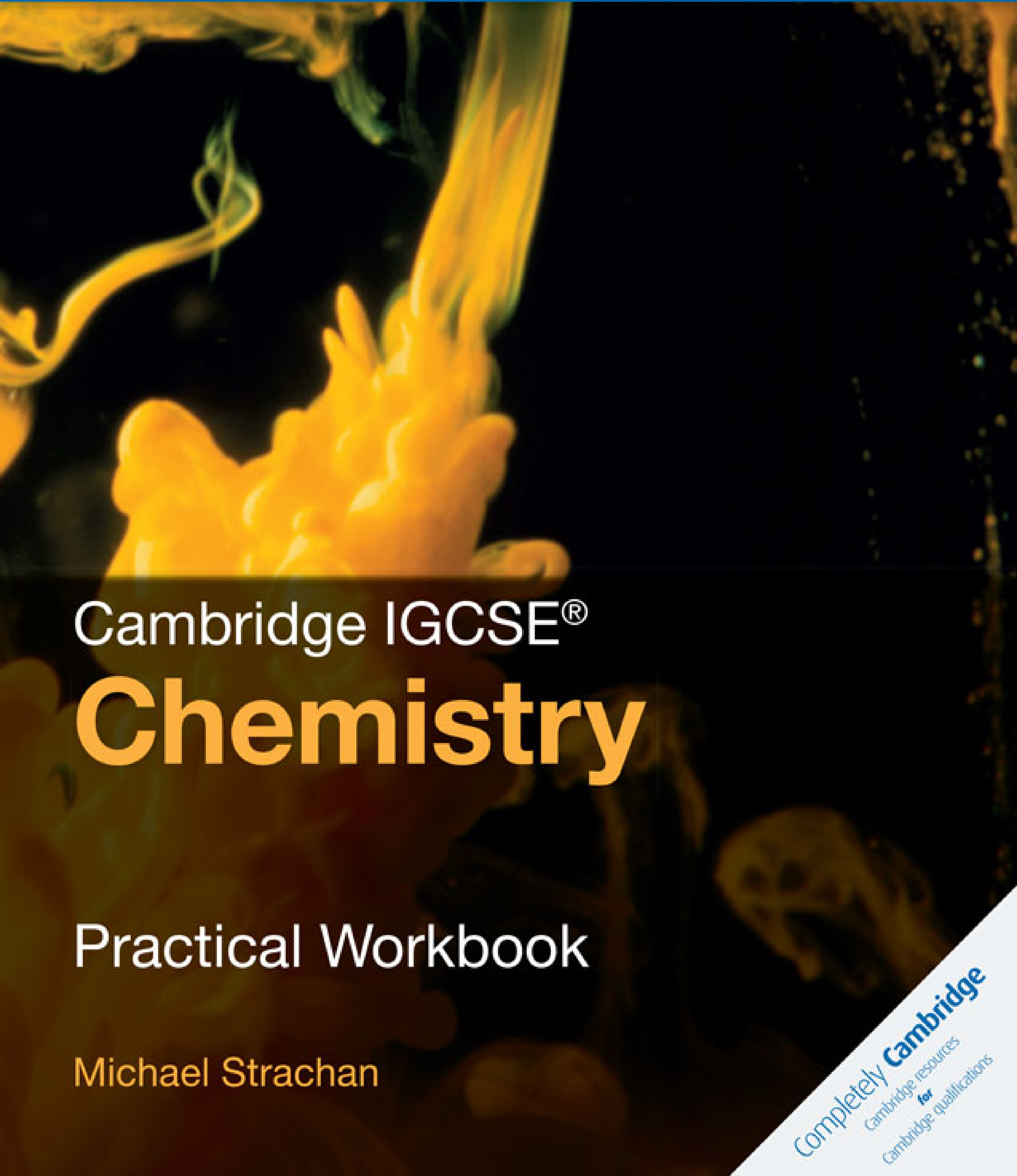

Cambridge IGCSE®

Chemistry

Practical Workbook

Michael Strachan

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Practical Workbook

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Cambridge University Press

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Contents

Introduction

None of the pioneering work done in the scientific field of chemistry would ever have occurred without the laboratory and the art of experimentation. Nearly all of the great discoveries that form the foundations of our knowledge came from people completing practical investigations in laboratories not too different from the ones you will be using to complete your studies. Great chemists such as Lavoisier and Priestley would recognise some of the principles contained in this book, though they would note the modern approaches used to investigate them.

Practical skills form the backbone of any chemistry course and it is hoped that, by using this book, you will gain confidence in this exciting and essential area of study. This book has been written for the Cambridge IGCSE Chemistry student. The various investigations and accompanying questions will help you to build and refine your abilities. You will gain enthusiasm in tackling laboratory work and will learn to demonstrate a wide range of practical skills. Aside from the necessary preparation for both the practical paper and the alternative to practical paper, it is hoped that these interesting and enjoyable investigations will kindle a deep love of practical chemistry in you. Great care has been taken to ensure that this book contains work that is safe and accessible for you to complete. Before attempting any of these activities, make sure that you have read the safety section and are following the safety regulations of the place where you study. Answers to the exercises in this Workbook can be found in the Teacher's guide. Ask your teacher to provide access to the answers.

Safety section

Despite using Bunsen burners and chemicals on a regular basis, the science laboratory is one of the safest classrooms in a school. This is due to the emphasis on safety and the following of precautions set out by regular risk assessment and procedures.

It is important that you follow the safety rules set out by your teacher. Your teacher will know the names of materials and the hazards associated with them as part of their risk assessment for performing the investigations. They will share this information with you as part of their safety briefing or demonstration of the investigation.

The safety precautions in each of the investigations of this book are guidance that you should follow to ensure your safety and that of other students around you. You should aim to use the safety rules as further direction to help to prepare for examination when planning your own investigations in the alternative to practical papers.

The following precautions will help to ensure your safety when carrying out most investigations in this workbook.

- Wear safety goggles to protect your eyes.
- Tie back hair and any loose items of clothing.
- Tidy away personal belongings to avoid tripping over them.
- Wear gloves and protective clothing as described by the book or your teacher.
- Turn the Bunsen burner to the cool, yellow flame when not in use.
- Observe hazard symbols and chemical information provided with all substances and solutions.

Many of the investigations require some sort of teamwork or group work. It is the responsibility of your group to make sure that you plan how to be safe as diligently as you plan the rest of the investigation.

In Chemistry particular attention should be paid to the types of Bunsen burner flame needed as well as the concentrations and volumes of chemicals used.

Skills grid

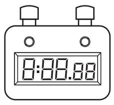
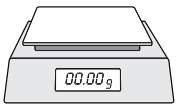
Assessment objective 3 (AO3) 'Experimental skills and investigations' of the Cambridge International Examinations syllabus is about your ability to work as a scientist. Each aspect of the AO3 has been broken down for you below with a reference to the chapters in this title that cover it. This will enable you to identify where you have practiced each skill and also allow you to revise each one before the exam.

Chapter	1	2	3	4	5	6	7	8	9	10	11	12
AO3: Experimental skills and investigations												
1.1 demonstrate knowledge of how to safely use techniques		X	X	X	X	X		X		X	X	
1.2 demonstrate knowledge of how to use apparatus and materials		X	X	X	X	X	X	X	X	X	X	
1.3 demonstrate knowledge of how to follow a sequence of instructions where appropriate	X	X	X	X	X	X	X	X	X	X	X	X
2. plan experiments and investigations		X	X					X	X	X	X	
3.1 make and record observations			X	X	X	X	X	X	X	X	X	X
3.2 make and record measurements	X	X	X	X	X	X	X	X			X	
3.3 make and record estimates		X		X	X		X					
4.1 interpret experimental observations and data	X	X	X	X	X	X	X	X	X	X	X	X
4.2 evaluate experimental observations and data					X	X	X	X	X		X	
5.1 evaluate methods	X			X	X	X	X	X	X			
5.2 suggest possible improvements to methods	X	X	X	X	X	X			X		X	

Quick skills section

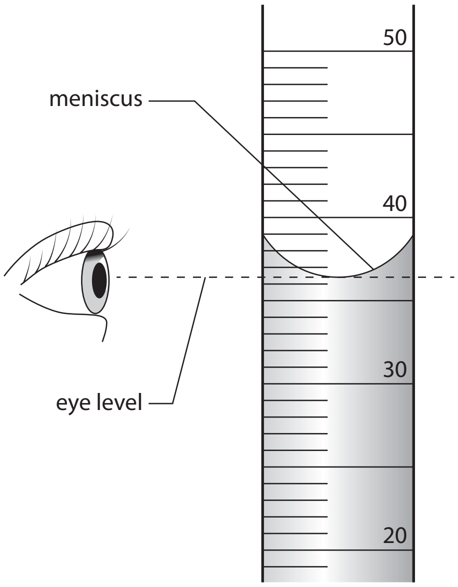
Apparatus

You will need to be able to identify, use and draw a variety of scientific apparatus. Complete the table below by adding the diagram and uses for each piece of apparatus. The first two have been completed for you.

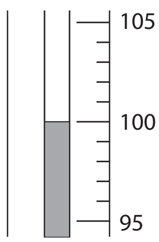
Apparatus	Diagram	Uses
timer		To measure the time taken for something to happen. Usually measured in seconds.
balance		To measure the mass of a substance. Usually measured in grams.
thermometer		
measuring cylinder		
beaker		
pipette		
burette		
conical flask		
Bunsen burner		
tripod		
test-tube / boiling tube		

Measuring

Being able to take accurate measurements is an essential skill for all chemistry students. As part of the Cambridge IGCSE course you will be expected to be able to take accurate measurements using a variety of different apparatus. When using measuring cylinders you will need to look for the meniscus, which is the bottom of the curve formed by the liquid.



Thermometers are a very common tool for measuring temperature in chemistry experiments so you will need to be able to take readings reliably. Not all of the points of the scale on a thermometer will be marked but you will still need to be able to determine the temperature. To do this you will need to work out the value of each graduation. In the diagram below there are four marks between 95 and 100. Each of these marks indicates 1°C.



Recording

When working on investigations the ability to record data accurately is very important. Sometimes a table will be supplied; however, you need to be able to draw your own table with the correct headings and units.

The first task is to identify the independent and dependent variables for the investigation you are doing. The independent variable is the one that you are changing to see if this affects the dependent variable. The dependent variable is the one that you will measure and record the results of in the table. The names of these two variables and their units need to go into the top two boxes in your results table. The independent variable goes in the left hand box and the dependent variable goes in the right hand box. Separate the name of the variables and units using a forward slash, e.g. time / seconds. Remember that the column headings need to be physical quantities (time, mass, temperature, etc.).

Next count how many different values you have for the independent variable. This is how many rows you will need to add below the column headings. Finally add the values for the independent variable into the left hand column. Your table is now ready for you to add the results from your investigation into the right hand column.

Independent variable / units	Dependent variable / units

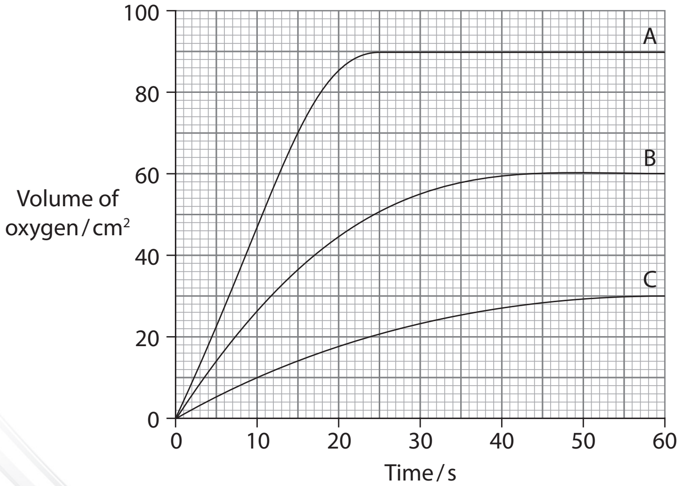
The number of significant figures that you use in your answer should match the number used in any data you have been given. You may not be awarded credit if you use an inappropriate number of significant figures in your answers to questions. If you are recording raw data from an investigation, always try to use the maximum number of significant figures available.

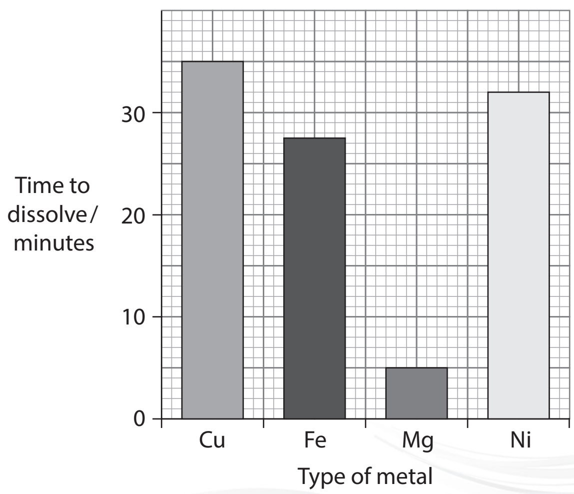
The first significant figure is the first non-zero digit in the number. The number 456 is: 500 to 1 significant figure; 460 to 2 significant figures; 456 to 3 significant figures; 456.0 to 4 significant figures, etc. Digits of 5 or greater are rounded up; and digits of 4 and below are rounded down. It is important that numbers are not rounded up during calculations until you have your final answer, otherwise the final answer may be affected.

Graphing

When drawing a graph it is useful to follow a set procedure every time to ensure that when you are finished the graph is complete.

Axes: You must label the axes with your independent and dependent variables. The independent variable is used to label the *x*-axis (horizontal axis) and the dependent variable is used to label the *y*-axis (vertical axis). Remember to also add the units for each of the variables. An easy way to ensure that you get this correct is to copy the column headings from the table of data you are using to draw the graph.



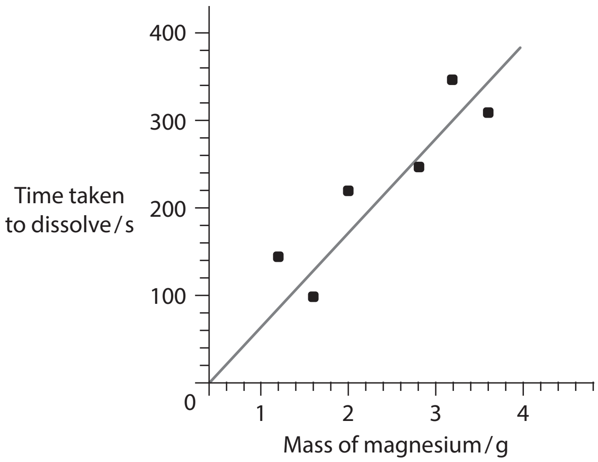


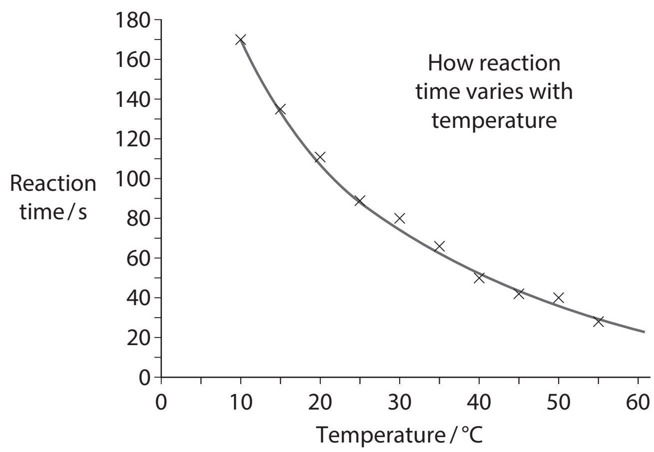
Tip: At the top of any table of data you have to use write the letters X and Y next to the independent and dependent variable to remind you which axis each goes on.

The second stage of drawing a graph is adding a scale. You must select a scale that allows you to use more than half of the graph grid in both directions. Choose a sensible ratio to allow you to easily plot your points (e.g. each 1cm on the graph grid represents 1, 2, 5, 10, 50 or 100 units of the variable). If you choose to use other numbers for your scale it becomes much more difficult to plot your graph.

Now you are ready to plot the points of data on the graph grid. You can use either crosses (x) or a point enclosed inside a circle (•) to plot your points but take your time to make sure these are plotted accurately. Remember to use a sharp pencil as large dots make it difficult to see the place the point is plotted and may make it difficult for the accuracy of the plot to be decided.

Finally a best-fit line needs to be added. This must be a single thin line or smooth curve. It does not need to go through all of the points but it should have roughly half the number of points on each side of the line or curve. Remember to ignore any anomalous data when you draw your best-fit line. Some good examples of best-fit lines that you should use are shown below:





Variables

The independent and dependent variables have already been discussed but there is a third type of variable that you will need to be familiar with – controlled variables. These are variables that are kept the same during an investigation to make sure that they do not affect the results. If these variables are not kept the same then we cannot be sure that it is our independent variable having an effect on the results.

Example

Two students are investigating how changing the temperature affects the rate that gas is produced when adding magnesium to an acid. They do not control the volume of acid or the mass of magnesium used each time. This means that there is no pattern in their results, as if they use more acid magnesium more gas is produced regardless of the temperature used.

Reliability, accuracy and precision

A common task in this book will be to suggest how to improve the method used in an investigation to improve its reliability/accuracy/precision. Before we come to how these improvements can be made it is important that you have a solid understanding of what each of these words mean.

Reliability refers to the likelihood of getting the same results if you did the investigation again and being sure that the results are not just down to chance. Reliability is now often called repeatability for this reason. If you can repeat an investigation several times and get the same result each time, it is said to be reliable.

The reliability can be improved by:

- Controlling other variables well so they do not affect the results
- Repeating the experiment until no anomalous result are achieved
- Increasing precision

Precision indicates the spread of results from the mean.

The precision can be improved by:

- Using apparatus that has smaller scale divisions

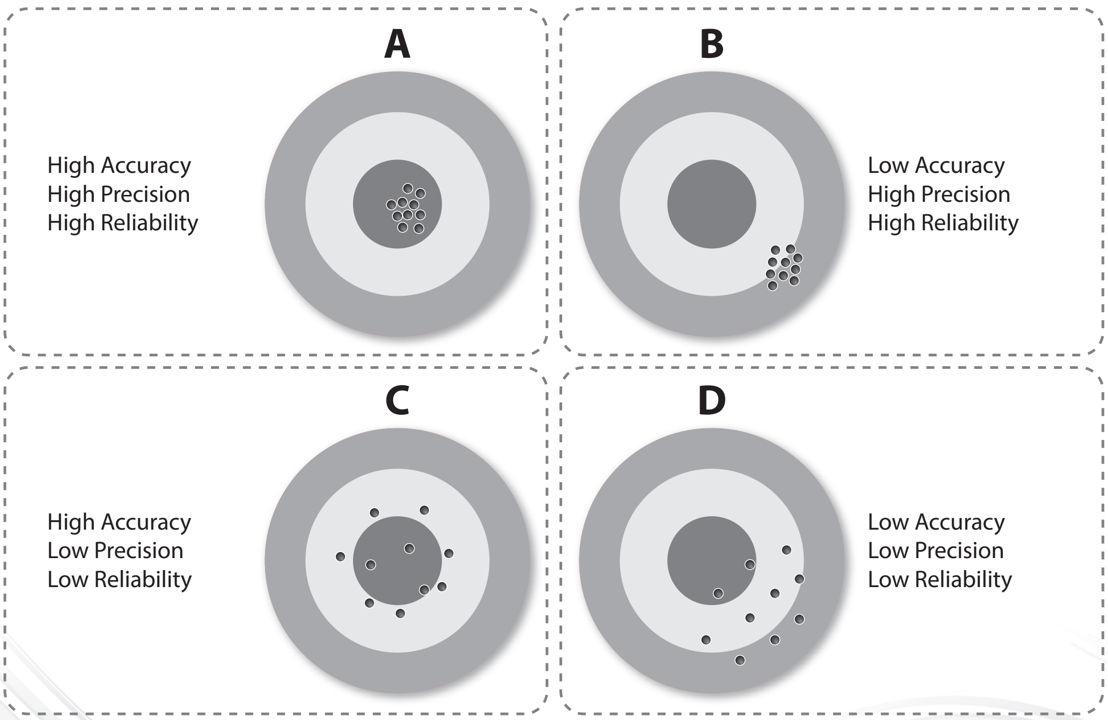
Accuracy is a measure of how close the measured value is to the true value. The accuracy of the results depends on the measuring apparatus used and the skill of the person taking the measurements.

The accuracy can be improved by:

- Improving the design of an investigation to reduce errors
- Using more precise apparatus
- Repeating the measurement and calculating the mean

You can observe how these terms are used in the figure below.

Reliability v Precision v Accuracy



Designing an investigation

When asked to design an investigation you must think carefully about what level of detail to include. You must identify what your independent variable is and which values you are planning to use for it. The dependent variable must also be identified along with how you are going to measure it. The next thing you need to do is to suggest how you will control other variables. Finally, outline the method in a series of numbered steps that is detailed enough for someone else to follow. Remember to include repeat readings to help improve reliability.

1 Planet Earth

In this chapter, you will complete investigations on:

- ◆ **1.1** Estimating the percentage of oxygen in the air
- ◆ **1.2** The effects of acid rain on metal
- ◆ **1.3** The effect of carbon dioxide on the atmosphere

Practical investigation 1.1 Estimating the percentage of oxygen in the air

Objective

Oxygen is one of the gases that make up Earth's atmosphere. It is an important element and is involved in many reactions necessary for life. In this investigation you will estimate what percentage of the atmosphere is made up of oxygen. To do this you will use the rusting of iron. This is an oxidation reaction in which the oxygen from the atmosphere reacts with iron to form rust. As the oxygen is removed from the air in the tube to form iron oxide, the same volume of water is drawn up the tube. By measuring how far water is drawn up inside a boiling tube it will be possible to calculate the percentage of oxygen in the air. By the end of this investigation you should be able to state the composition of clean, dry air.

Equipment

- Iron wool
- boiling tube
- rubber bung
- beaker (250 cm^3)
- measuring cylinder (25 cm^3)
- glass rod
- permanent marker pen

Method

1 Place a piece of iron wool into the bottom of the boiling tube. It needs to be large enough so that is does not move when the boiling tube is inverted (turned upside down). You can use the glass rod to help you push the iron wool to the bottom.
2 Pour water into the boiling tube until it is half full so that the iron wool is completely covered then place the rubber bung on the boiling tube.
3 Fill the beaker with approximately 150 cm^3 of water.
4 Invert the boiling tube and place it into the beaker, holding the bung while you do this to avoid the bung falling out.
5 Carefully remove the bung from the boiling tube (Figure 1.1).

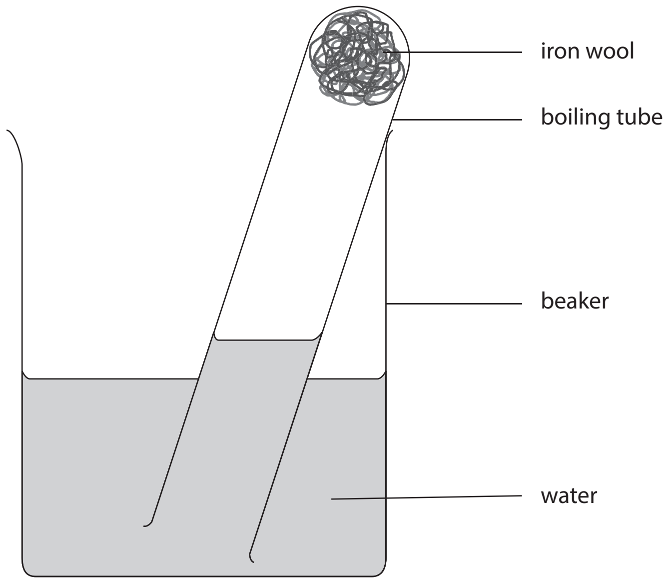


Figure 1.1

6 Using the marker pen, draw a line to mark how far the column of air is on the boiling tube. Label this line with the word 'start'.
7 Leave the experiment for a week.
8 Using the marker pen, a draw a line to mark the new position of the column of air. Label this line with the word 'finish'.
9 Carefully remove the boiling tube from the beaker.
10 Fill the boiling tube with water up to the line you labelled 'start'. Now pour the water into a measuring cylinder. Record this value in the table below.
11 Empty the measuring cylinder then fill the boiling tube with water to the line labelled 'finish'.
12 Now pour the water into a measuring cylinder. Record this value in the table. Also record any observations.

Safety considerations

None

Recording data

Because the water will have the same volume as the air inside the tube, by measuring the volume of water you will also be measuring the volume of air that was inside the tube.

Volume to start line / cm^3	Volume to finish line / cm^3

Observations of the iron wool inside the tube:

....

....

Handling data

You now need to calculate the difference between the two volumes. To do this you must subtract the volume of water to the finish line from the volume of water to the start line.

Difference in volume = ...

Now you need to calculate the % difference. To do this you must first divide the difference in volume that you calculated above by the value for the volume of water to the start line.

Difference in volume / Volume at start = ...

Now multiply this value by 100 to get the percentage = ...%

Analysis

1 Use the words below to fill in the gaps in the paragraph, and your own results to complete the conclusion.

difference	iron oxide	rusting	water	iron	volume	oxygen

The reaction that took place was called .... This is the name for the oxidation of .... Oxygen from the atmosphere reacted with the iron wool to form a new compound called .... or rust. At the start of the investigation the air in the tube contained .... but by the end this had all gone as it had reacted with the iron. As the oxygen had been removed from the air the .... of gas inside the tube was lower. This meant that .... from the beaker moved up inside the boiling tube. By measuring the .... in the volume of gas from start to finish, it was possible to calculate the volume of oxygen that had been removed from the air in the tube. This was then calculated to be ....%.

Evaluation

2 Apart from the decrease in the volume of gas inside the tube, what other evidence was there for a reaction having taken place?

....

....

3 Why did the experiment have to be left for a week?

....

....

4 What other apparatus could you have used to measure more precisely the volume of oxygen being used up?

....

....

5 Use your textbook or the internet to find out the real percentage of oxygen in the air. Look at your estimate. Suggest why your estimated value was higher or lower than the real percentage of oxygen in the air.

....

....

....

....

6 Use the knowledge you have gained from this investigation and your general chemistry knowledge to suggest a method for estimating the percentage of carbon dioxide in the air.

....

....

....

....

....

Practical investigation 1.2 The effects of acid rain on metal

Objective

Acid rain caused by burning fossil fuels which contain sulfur compounds is a problem that increases the corrosion of metals. In this investigation, you will determine which metals are most affected by acid rain. Sulfur dioxide released by burning impure fossil fuels dissolves in water in the Earth's atmosphere to form acid rain. You will be using a sulfur dioxide solution to create a similar acidic atmosphere inside a container. By the end of this investigation you should be able to state how sulfur dioxide, from the combustion of fossil fuels which contain sulfur compounds, leads to acid rain.

Equipment

- Zinc foil
- tin foil
- iron sheet
- magnesium ribbon
- copper foil
- foam sheet
- plastic box with lid, beaker (100 cm^3)
- scissors, measuring cylinder (50 cm^3)
- marker pen
- sandpaper

Method

1. Place the foam sheet in the plastic box. You might need to use the scissors to cut it to the correct shape. Use the marker pen to mark the lid with the name of each metal. Make sure the labels are spaced out.
2. Carefully clean each piece of metal with the sandpaper and insert each piece into the foam so that it is standing upright. Ensure that each metal is next to the label you have written. Make sure each metal strip is secure and will not fall over.
3. Take the plastic box to the fume cupboard with the 100 cm^3 beaker.
4. Carefully measure 30 cm^3 of sulfur dioxide solution using the measuring cylinder and pour this into the 100 cm^3 beaker.
5. Place the beaker with the sulfur dioxide solution into the plastic box and seal the lid tightly.
6. Leave the plastic box inside the fume cupboard and return periodically to observe the effects of the sulfur dioxide on the metals.

Safety considerations

Wear eye protection throughout. Make sure that you do not remove the acid solution or the plastic boxes from the fume cupboard. Do not open the plastic box once you have placed the beaker of acid inside.

Recording data

In the space below you must design a results table that includes space for the names of each metal and space to record your observations of the effect of the sulfur dioxide solution. Ask your teacher how many times you will observe the results. If you need a reminder of how to draw a results table, have a look at the 'Quick skills guide' at the start of this book.

Analysis

1 From your observations, which of the metals were most corroded by the acid rain?

....

....

2 Which of the metals corroded first?

....

3 Why do you think that this metal corroded first?

....

....

4 Were there any metals that did not corrode?

....

5 Why do you think that these metals did not corrode?

....

....

6 List three ways that metals that corrode when exposed to acid rain could be protected?

....

....

....

7 Suggest two ways that a reactive metal used as a building material could be protected in an area that has a lot of acid rain.

....

....

....

Evaluation

8 Suggest why it was necessary to clean the metals with sandpaper at the start of the investigation.

....

....

9 Why was it possible to see corrosion on many of the metals in this investigation in only a few days when building materials can last for many years in areas where there is acid rain?

....

....

....

10 How could you have designed a control for this investigation?

....

....

....

Practical investigation 1.3 The effect of carbon dioxide on the atmosphere

Objective

Some gases in the atmosphere cause energy from the Sun to be trapped in the Earth's atmosphere rather than being allowed to pass out into space. If the level of these gases in the atmosphere increases, the temperature of the Earth will increase. This is called global warming. In this investigation, you will see if changing the level of carbon dioxide has an effect on the amount of heat energy stored in the gases inside a bottle. By the end of this investigation you should be able to state that carbon dioxide is a greenhouse gas and explain how it may contribute to climate change.

Equipment

- Two large clear plastic drinks bottles (at least 1.5 dm^3)
- two thermometers, two rubber bungs with holes for thermometers (or modelling clay)
- lamp, meter rule, measuring cylinder (1000 cm^3 or 500 cm^3)
- two antacid tablets, marker pen

Method

1. Using the measuring cylinder, measure 750 cm^3 of water into each of the bottles. Label one 'Carbon dioxide' and the other 'Normal air'.
2. Insert the thermometers into the bungs or use the modelling clay to create a lid for each bottle with the thermometer suspended inside.
3. Measure the temperature of the air in both bottles.
4. Add the antacid tablets to the water in the 'Carbon dioxide' bottle and close the bottle immediately with the bung or modelling clay. It is important that both bottles are sealed well so that they are airtight.
5. Place the lamp 40 cm from the bottles and switch it on.
6. After 45 minutes, record the temperature in each bottle again.

Safety considerations

The lamp may become hot as it will be on for a long time. Take care with thermometers as they can break very easily.

Recording data

Bottle	Temperature at the start / °C	Temperature at the end / °C
carbon dioxide		
normal air		

Handling data

Use the data from your results to plot a bar chart.

Analysis

1 For each of the two bottles, calculate the temperature change from the start to the end of the experiment.

Bottle	Temperature change from start to end/°C
carbon dioxide	
normal air	

2 Look at your results. What can you conclude from your investigation about the effect of carbon dioxide on the temperature of the gas inside the bottle?

Evaluation

3 List at least three variables in this experiment that you controlled.

....

....

4 How could you test the gas produced by antacid tablets to make sure it is carbon dioxide?

....

....

5 Why is it important that both bottles are the same distance from the lamp?

....

....

6 What would be the effect on the temperature of a bottle that was placed closer to the lamp?

....

....

7 How could you redesign this experiment to determine whether increasing carbon dioxide concentration increased the change in temperature?

....

....

....

....

Exam-style questions

1 Ravi and Jose are investigating the percentage of oxygen found in the air. They have left some wet iron wool in an inverted boiling tube like the one shown in Figure 1.2. Ravi is not sure that the reaction is complete; he thinks that there is still oxygen in the tube.

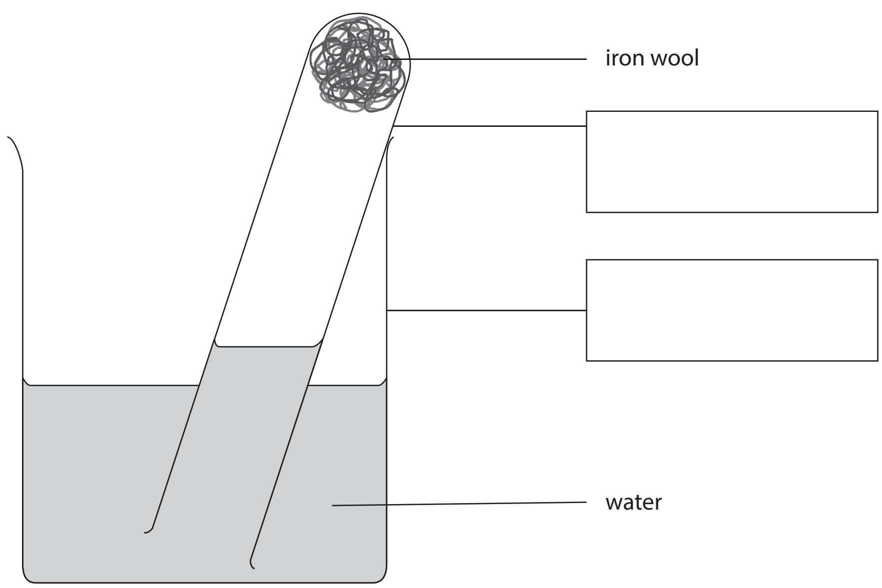


Figure 1.2

a What can he do to make sure the reaction is over? [1]

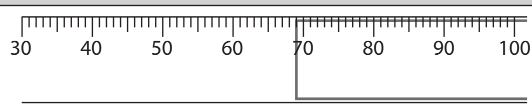
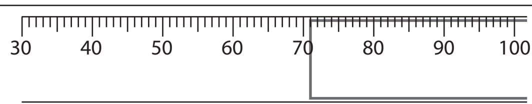
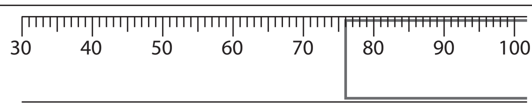
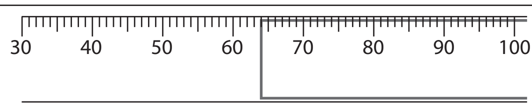
....

....

b Complete the boxes to name the apparatus shown in the diagram. [2]

To get more accurate data, Ravi and Joe repeated the experiment using a different set of apparatus. This time they placed the wet iron wool into a conical flask and attached it to a gas syringe open to 100 cm^3 to measure the decrease in volume.

c Use the gas syringe diagrams below to complete the table of results and calculate the decrease in the volume of gas. [8]

Repeat	Gas syringe diagram	Reading / cm^3	Decrease in volume / cm^3
1			
2			
3			
4			

d Calculate the mean decrease in the volume of gas. [2]

....

e As a control experiment, Ravi and Joe attached the gas syringe to a conical flask with dry iron wool and left it for three days. What do you think the decrease in volume of gas was? [2]

....

Total [15]

2 Mark and Tony are discussing the results of their investigation into the effect of acid rain on different metals. In their investigation, they used different metals and observed the effect of corrosion. Look at their results below.

Name of metal	Level of corrosion after 14 days
silver	none
lead	some corrosion
aluminium	very corroded

From the results, Mark concludes that silver should be used as a building material in areas where there is a lot of acid rain. Tony disagrees and says he can think of two reasons why using silver as a building material is a bad idea.

a Suggest two reasons Tony could use to support his argument. [2]

....

....

....

b From the results, suggest which of the metals is most reactive. [1]

....

c Predict how much corrosion would be observed if the experiment was repeated using magnesium. [1]

....

d Suggest how you could measure the pH of the acid rain that was used. [1]

....

....

Many lakes in Norway are affected by acid rain and so the government is monitoring the pH of many lakes. Bjorg and Peter are sent a sample of water from a nearby lake to test using a pH meter. They recorded the pH of the samples sent every day for 14 days in a table:

Day	pH of sample
1	6.5
2	6.4
3	6.5
4	6.6
5	5.5
6	5.5
7	5.6
8	5.7
9	5.8
10	6.9
11	7.0
12	7.0
13	6.9
14	6.9

e Plot the results for the experiment on the grid. [5]

f Using the results and your graph, suggest which day it rained. [1]

As part of the work to prevent damage caused by acid rain, the government of Norway is adding lime to the lake to reduce the acidity.

g Using the results and your graph, suggest which day lime was added to the lake and give a reason for your answer. [2]

Total [13]

3 Metals are a commonly used building material and so are very vulnerable to the damage that is caused by acid rain. However, it is possible to protect metals from this corrosion. Design an investigation to safely determine the best method of protecting metal from acid rain. Use the equipment list below. Remember to think about variables that you will control (keep the same).

Equipment:

- metal strips
- grease
- paint
- paintbrush
- cling film
- sulfuric acid solution
- foam, plastic box [5]

Total [5]

2 The nature of matter

In this chapter, you will complete investigations on:

- ◆ **2.1** Changing physical state
- ◆ **2.2** Filtration, distillation and evaporation
- ◆ **2.3** Chromatography

Practical investigation 2.1 Changing physical state

Objective

In chemistry, there are three states of matter: solid, liquid and gas. By changing the temperature of an element it is possible for us to change the state that it exists in. For example, if we heat water to 100 °C, it will begin to boil and change into a gas. Likewise, if we cool water to 0 °C, it will freeze and turn into ice. When changing states, energy is required to break the intermolecular forces between molecules. In this experiment, we will examine what happens to the temperature of water as it is heated from ice until it becomes steam. By the end of this investigation you should be able to describe changes of state in terms of melting, boiling, evaporation, freezing and condensation.

Equipment

- Clamp stand with clamp and boss
- heat-resistant mat
- Bunsen burner, thermometer
- beaker (250 cm^3)
- ice
- timer
- pestle
- mortar
- tripod
- gauze
- stirring rod

Method

1 Add seven ice cubes to the mortar and crush them with the pestle until you are left with only small pieces. Do this carefully so that the ice cubes do not come out of the mortar.
2 Place the crushed ice in the beaker until it is half full.
3 Set up the Bunsen burner on the heat-resistant mat.
4 Place the beaker on the tripod and gauze. Use the clamp and clamp stand to hold the thermometer in the beaker. You can use the diagram in Figure 2.1 to help you.
5 Measure the temperature of the ice in the beaker and record the result in the results table.
6 Start the timer. Begin to heat the beaker of water with the Bunsen burner on a gentle blue flame.
7 Record the temperature every minute. Use the stirring rod to make sure the ice melts evenly.
8 Once the water is boiling (bubbles forming within the liquid), only take one more reading.

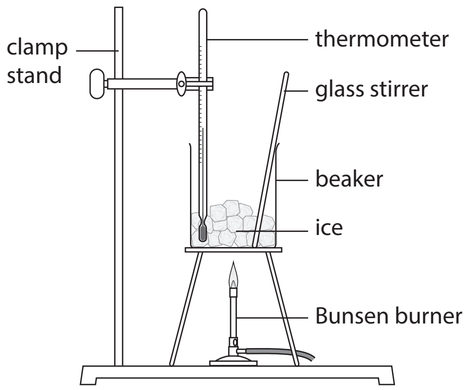


Figure 2.1

Safety considerations

Wear eye protection throughout. You will need to stand for the practical because hot liquids will be used. Remember to take care when handling hot glassware and also to be careful when the water is boiling as the steam will be very hot.

Recording data

1 Record your results in the results table below. The units are missing and need to be added.

Time /	Temperature /
0	
1	
2	
3	
4	
5	
6	
7	
8	

Handling data

2 Plot the results of your experiment on the graph paper below. Think about whether you will need to plot a line graph or a bar graph.

Analysis

3 Use the words given to complete the conclusion paragraph below.

molecules   intermolecular   melting   temperature   boiling   liquid   gas   heating

At first, the .... inside the beaker did not change. This is because the energy being added by .... was being used to break the intermolecular forces between the water .... This is called .... Once all of the solid water had turned into .... water, the temperature began to increase. It stopped increasing once the water reached its .... point. The energy being added was now used to break the .... forces between the water molecules in the liquid state. This meant that the water could turn into a ....

4 Look at the graph in Figure 2.2.

Match the correct letter to each of the following words or terms:

a melting point ……………

b boiling point ……………

c solid ……………

d liquid ……………

e gas ……………

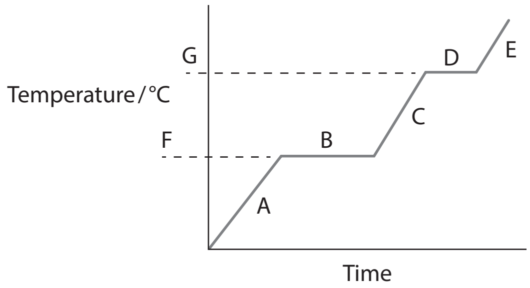


Figure 2.2

Evaluation

5 Think about your experiment. How could you have made the results more accurate?

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

6 How would adding an impurity, such as salt, to the ice in this experiment affect the results? Sketch a graph to support your ideas.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

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……………………………………………………………………………………………………

Practical investigation 2.2 Filtration, distillation and evaporation

Objective

Often in chemistry we find that substances we want to use are in mixtures rather than in a pure state. It is important that we are able to separate these mixtures regardless of whether the substances mixed are solids or liquids. At a very basic level we might need to separate water from a salt solution to obtain drinking water, for example. At a more complex level we might want to separate the different hydrocarbons found in crude oil. In this investigation, you will begin with a mixture of four substances that have been mixed together. You will need to use a variety of different separating techniques to obtain samples of each substance. Your teacher will supply you with a sample of water that will have iron filings, sand and salt in it. You will need to think carefully about which techniques you will use to separate each substance from the others and also which order to complete the separations, as this is very important. By the end of this investigation you should be able to suggest suitable purification techniques, given information about the substances involved.

Equipment

- Filter paper
- clamp stand with clamp and boss
- funnel
- spatula
- two beakers (250 cm^3)
- magnet
- small plastic bag
- boiling tube with bung and delivery tube or Liebig condenser (if available)
- ice
- evaporating basin
- sample to be separated (of sand, salt, iron filings and 150 cm^3 of water)

Method

1 For each of the combinations below, suggest the most suitable technique for separating the substances.

a To obtain salt from a salt water solution

....

b To obtain iron filings from sand

....

c To obtain water from a salt water solution

....

d To obtain iron filings and sand from a water suspension

....

2 Now think about the order in which you will need to use each technique. Write the sequence of techniques in order.

a ....

b ....

c ....

d ....

3 You need to be able to describe methods of purification as part of the syllabus. For each of the techniques you have listed above, write a short method to explain how you will use the equipment to separate the mixtures.

Separating insoluble solids from liquids by filtration
a ....
b ....
c ....
d ....
e ....

4 For this section you will need to split the filtrate you have obtained into two samples: one for use in each of the two remaining techniques. Describe the methods you would use.

Separating water from a solution that contains a dissolved solid
a i ....
ii ....
iii ....
iv ....
v ....

Separating a soluble solid from water to obtain the solid
b i ....
ii ....
iii ....
iv ....
v ....

Separating two solids from one another
c i ....
ii ....
iii ....

Safety considerations

Wear eye protection throughout. You will need to stand for the practical because hot liquids are being used. Remember to take care when handling hot glassware and also to be careful when the water is boiling as the steam will be very hot.

Recording data

Standard diagrams are used to show the apparatus needed in chemistry experiments (see Figure 2.3 on the next page).

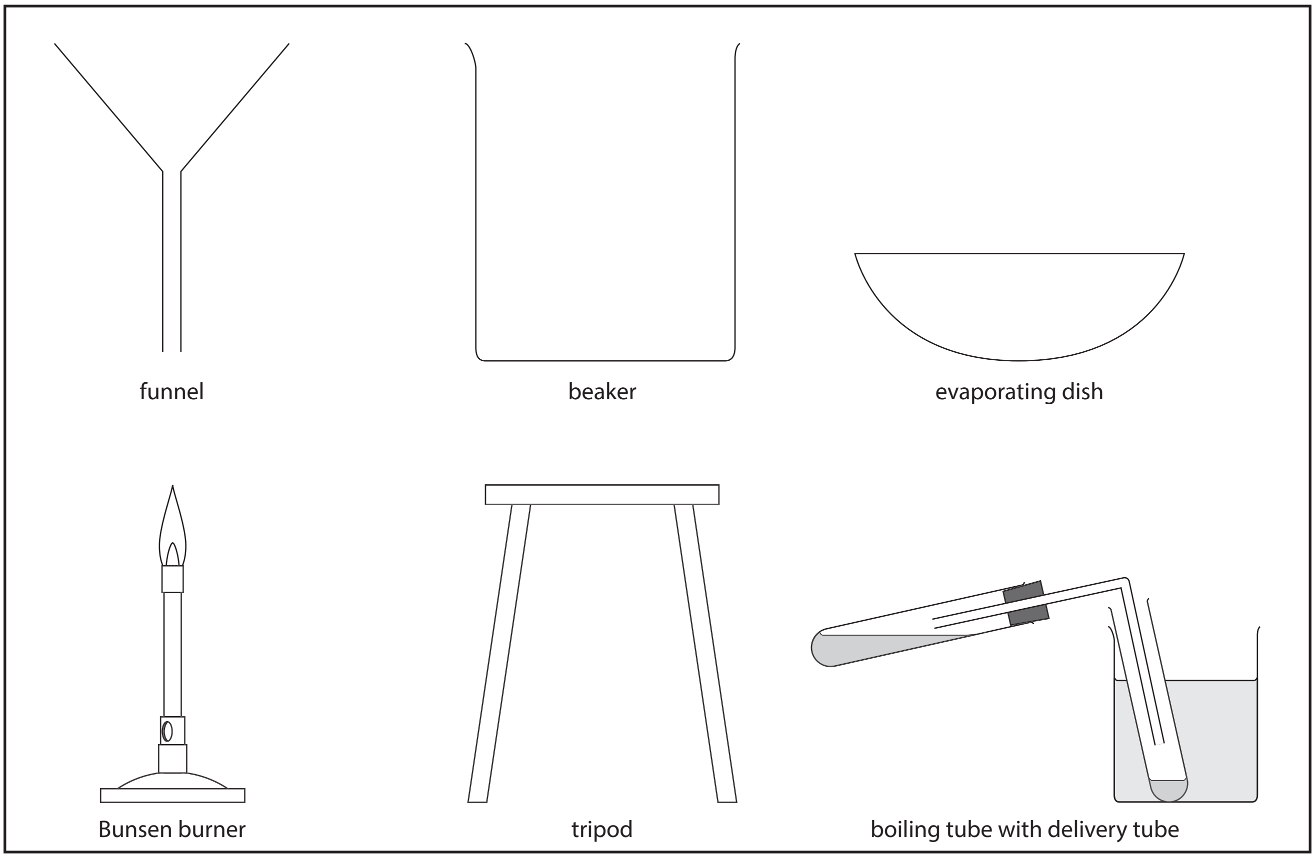

Figure 2.3

5 Refer to the illustration above and, in the spaces below on the opposite page, draw diagrams to show how you arranged your practical equipment.

a Filtration diagram

b Evaporation diagram

c Distillation diagram

Evaluation

6 How could we test the water to make sure that there was no salt in it? (Important: Remember that you cannot taste anything in a laboratory.)

....

....

Practical investigation 2.3 Chromatography

Objective

Sometimes more than one solid is dissolved in a solution and so it is difficult to separate these from one another, therefore we use a technique called chromatography. This technique is used extensively in forensic science and sports for drug testing. By the end of this investigation you should be able to demonstrate knowledge and understanding of paper chromatography so that you can interpret simple chromatograms including the use of R_f values.

Equipment

- Beaker (250 cm^3)
- chromatography paper/filter paper
- samples of food dye
- paper clip
- capillary tube

Method

1 Read the **incorrect** method that Atikah has written in the box below. There are six errors. Underline these errors and then rewrite the method in the space provided with your corrections.

Judy's method

1 *Take the filter paper and, using a ruler, measure 2 cm from the bottom. Use a pen to draw a line across the paper from one side to the other.*

2 *At 0.5 cm intervals label the filter paper with the full name of each sample of food dye that will be used.*

3 *Add a large sample of each of the types of food dye to the filter paper using a pipette.*

4 *Bend the filter paper into a circle and fix it in place with a paper clip.*

5 *Place the filter paper in the empty beaker so that it is touching the sides of the beaker.*

6 *Add water to the beaker until it is just above the line that you have drawn on the filter paper.*

7 *When the ink has climbed about three-quarters of the way up the paper, remove the paper and dry it.*