GCSE Chemistry: Required practical handbook

Version 3.8

The methods provided in this *Required practical handbook* are suggested examples, designed to help your students fulfil the Apparatus and Techniques requirements outlined in the specifications. Written papers will include questions requiring knowledge gained from carrying out the specified practicals.

Please note: it is the Apparatus and Techniques requirements which are compulsory and must be fulfilled. Teachers are encouraged to adapt or develop activities, resources and contexts to suit their equipment and provide the appropriate level of engagement and challenge for their own students.

Contents

Introduction

Students need to undertake the required practical activities listed in the GCSE Chemistry specification (8462) so that they have the opportunity to experience all of the apparatus and techniques required by Ofqual.

In this guide, we suggest methods and activities for carrying out the required practical activities to help you plan the best experience for your students.

All of the activities we describe have been written and trialled by practising teachers and use apparatus and materials that are commonly available in most schools.

Why do practical work?

Practical work is at the heart of science – that's why we have placed it at the heart of each of our GCSE science specifications.

There are three separate, but interconnected, reasons for doing practical work in schools.

1. To support and consolidate scientific concepts. Doing practical work enables students to make sense of new information and observations, and provides them with insights into the development of scientific thinking.

2. To develop investigative skills. These transferable skills include:
    - devising and investigating testable questions
    - identifying and controlling variables
    - analysing, interpreting and evaluating data.

3. To build and master practical skills such as:
    - using specialist equipment to take measurements
    - handling and manipulating equipment with confidence and fluency
    - recognising hazards and planning how to minimise risk.

This guide signposts opportunities for developing these working scientifically skills (WS). Working scientifically is explained in more detail in the GCSE Chemistry specification on page 9.

Helping you to plan

This guide includes:

- teachers' notes providing information and tips on setting up and running practicals
- technical information providing guidance for technicians preparing for the practicals
- student sheets providing a method for students to carry out the practical.

Consider the particular focus of each practical lesson. By focusing on the reasons for carrying out a particular practical, you will help your students to:

- understand the subject better
- develop the skills of a scientist
- master the manipulative skills required for further study or jobs in STEM subjects.

There are blank spaces in the student sheets for students to write down the learning outcomes for each required practical activity.

At least 15% of the marks in the written exams will draw on the knowledge and understanding students have gained by carrying out the Required practical activities. It is therefore essential that you plan your practical activities with reference to the specification and make students aware of the key content that they need to learn.

You can find examples of the type of practical questions students can expect in our guide *Practicals in exams.*

We have designed the methods in this guide specifically to help your students fulfil the Apparatus and techniques requirements outlined in the specification. We encourage you to adapt or develop these activities, resources and contexts to suit your circumstances and to tailor the level of engagement and challenge to your students. To help you do this, we've provided the guide in an editable format.

The practical science statement

Unlike the A-levels, there will be no practical endorsement. Instead, we will provide the head of each school or college with a Practical science statement to sign, confirming that reasonable steps have been taken to ensure that each student has:

- completed the required practical activities detailed in the specification
- made a contemporaneous record of such work undertaken during the activities and the knowledge, skills and understanding derived from those activities.

The head of centre will need to return the signed statement to us by the date we will publish on our website, on our practicals page. We will also contact schools and colleges directly with the deadline date and send timely reminders if we don't receive the form. Failure to send this form

counts as malpractice/maladministration, and may result in formal action or warning for the school or college.

Not having done some of the practicals, despite the school's best efforts, will not stop a student from entering for the GCSE. However, it may affect their grade, because there may be questions in the exams that they won't be able to answer.

Apparatus and techniques

The following table lists the chemistry Apparatus and techniques (AT). Students must be given the opportunity to experience all of these during their GCSE Chemistry course, regardless of the awarding body whose specification they study. The list includes opportunities for choice and use of appropriate laboratory apparatus for a variety of experimental problem-solving and/or enquiry-based activities.

Use and production of appropriate scientific diagrams to set up and record apparatus and procedures used in practical work is common to all science subjects and should be included wherever appropriate.

AT 1–7 are common with both of our GCSE Combined Science specifications. AT 8 is for GCSE Chemistry only.

Where possible, we have added links to the Apparatus and techniques in our A-level Chemistry course, to show how the skills progress from GCSE to A-level.

	Apparatus and techniques
AT 1	Use of appropriate apparatus to make and record a range of measurements accurately, including mass, time, temperature, and volume of liquids and gases (links to A-level AT a).
AT 2	Safe use of appropriate heating devices and techniques including use of a Bunsen burner and a water bath or electric heater (links to A-level AT b).
AT 3	Use of appropriate apparatus and techniques for conducting and monitoring chemical reactions, including appropriate reagents and/or techniques for the measurement of pH indifferent situations (links to A-level AT a and d).
AT 4	Safe use of a range of equipment to purify and/or separate chemical mixtures including evaporation, filtration, crystallisation, chromatography and distillation (links to A-level AT d and g).
AT 5	Making and recording of appropriate observations during chemical reactions including changes in temperature and the measurement of rates of reaction by a variety of methods such as production of gas and colour change (links to A-level AT a and l).

AT 6	Safe use and careful handling of gases, liquids and solids, including careful mixing of reagents under controlled conditions, using appropriate apparatus to explore chemical changes and/or products (links to A-level AT a and k).
AT 7	Use of appropriate apparatus and techniques to draw, set up and use electrochemical cells for separation and production of elements and compounds (links to A-level AT d and j).
AT 8	Use of appropriate qualitative reagents and techniques to analyse and identify unknown samples or products including gas tests, flame tests, precipitation reactions, and the determination of concentrations of strong acids and strong alkalis (links to A-level AT d).

Suggested practical apparatus list

Through their study of the new GCSE Sciences students must be given the opportunity to experience a wide range of apparatus. Hands-on experience will help them acquire the practical skills defined by the DfE in their Apparatus and Techniques criteria. We have designed all the activities to use standard equipment and materials that can be found in most school laboratories. The lists are not exhaustive, and we encourage teachers to modify the activities to suit their students' needs and learning objectives, and the resources available in their school/college.

Lab equipment

- 100 cm^3 beakers
- 100 cm^3 conical flasks
- 100 cm^3 measuring cylinders
- 10 cm^3 measuring cylinders
- 250 cm^3 beakers
- 250 cm^3 conical flasks
- 25 cm^3 volumetric pipettes and pipette fillers
- 50 cm^3 burettes
- 50cm^3 measuring cylinders
- blue litmus paper
- Bunsen burners
- carbon rod electrodes with support bungs
- chromatography paper
- clamp stands, clamps and bosses
- crocodile/4 mm plug leads

- crystallising dishes
- delivery tubes with bungs
- evaporating basins
- expanded polystyrene cups and lids
- filter funnels and filter paper
- gauze mats
- glass capillary tubes
- glass stirring rods
- heatproof mats
- nichrome wires mounted in handles
- petri dish lids (to fit 100 cm^3 beaker)
- power supplies (variable)
- small funnels
- spatulas
- stopwatches
- teat pipettes
- test tube racks
- test tubes
- thermometers (stirring)
- tripods
- tweezers
- white tiles

Specialist supplies

- barium chloride solution (0.1 M)
- calcium chloride solution (0.4 M)
- copper (II) chloride solution (0.4 M)
- copper (II) chloride solution (0.5 M)
- copper (II) oxide powder
- copper (II) sulfate solution (0.5 M)
- hydrochloric acid (0.4 M)
- hydrochloric acid (2.0 M)
- limewater

- lithium chloride solution (0.4 M)
- magnesium ribbon
- methyl orange indicator
- nitric acid (0.4 M)
- potassium chloride solution (0.4 M)
- silver nitrate solution (0.05 M)
- sodium bromide solution (0.4 M)
- sodium carbonate solution (0.4 M)
- sodium chloride solution (0.4 M)
- sodium chloride solution (0.5 M)
- sodium hydroxide solution (0.1 M)
- sodium hydroxide solution (2.0 M)
- sodium iodide solution (0.4 M)
- sodium sulfate solution (0.4 M)
- sodium sulfate solution (0.5 M)
- sodium thiosulfate solution (0.2 M)
- sulfuric acid (0.08 M)
- sulfuric acid (1.0 M)

Risk assessment

Safety is an overriding requirement for all practical work. Although all of the suggested practical activities have been suggested by teachers who have successfully carried them out in the lab, schools and colleges are responsible for ensuring that appropriate safety procedures are followed whenever their students undertake practical work, and should undertake full risk assessments.

Required practicals summary

The practicals that have been selected will be familiar, using apparatus and materials that are readily available in most schools. This table summarises the eight practicals required for Chemsitry GCSE.

A student who has undertaken all of the practicals will have had the opportunity to experience all of the apparatus and techniques required for the specification. Opportunities for developing mathematical skills and working scientifically skills have also been signposted.

Making salts	**Spec ref.**	**Skills**
Preparation of a pure, dry sample of a soluble salt from an insoluble oxide or carbonate, using a Bunsen burner to heat dilute acid and a water bath or electric heater to evaporate the solution.	Chemistry 4.4.2.3 Trilogy 5.4.2.3 Synergy 4.7.3.2	AT 2– Safe use of appropriate heating devices and techniques including use of a Bunsen burner and a water bath or electric heater. AT 3 – Use of appropriate apparatus and techniques for conducting chemical reactions, including appropriate reagents. AT 4 – Safe use of a range of equipment to purify and/or separate chemical mixtures including evaporation, filtration, crystallisation. AT 6 – Safe use and careful handling of liquids and solids, including careful mixing of reagents under controlled conditions. WS 2.3, WS 2.4
Neutralisation (Chemistry only)	**Spec ref.**	**Skills**
Determination of the reacting volumes of solutions of a strong acid and a strong alkali by titration. **Higher Tier only** Determination of the concentration of one of the solutions in mol/dm^3 and g/dm^3 from the reacting volumes and the known concentration of the other solution.	Chemistry 4.4.2.4	AT 1- Use of appropriate apparatus to make and record a range of measurements accurately, including volume of liquids. AT 8 - The determination of concentrations of strong acids and strong alkalis. MS 1a, MS 1c, MS 2a, WS 2.4, WS 2.6

Electrolysis	**Spec ref.**	**Skills**
Investigate what happens when aqueous solutions are electrolysed using inert electrodes. This should be an investigation involvingdeveloping a hypothesis.	Chemistry 4.4.3.4 Trilogy 5.4.3.4 Synergy 4.7.5.3	AT 3 - Use of appropriate apparatus and techniques for conducting and monitoring chemical reactions. AT 7 – Use of appropriate apparatus and techniques to draw, set up and use electrochemical cells for separation and production of elements and compounds. AT 8 - Use of appropriate qualitative reagents and techniques to analyse and identify unknown samples or products including gas tests for hydrogen, oxygen and chlorine (Chemistry only). WS 2.1, WS 2.2, WS 2.3, WS 2.4,WS 2.6
Temperature changes	**Spec ref.**	**Skills**
Investigate the variables that affect temperature changes in reacting solutions, eg acid plus metals, acid plus carbonates, neutralisations, displacement of metals.	Chemistry 4.5.1.1 Trilogy 5.5.1.1 Synergy 4.7.3.3	AT 1 – Use of appropriate apparatus to make and record a range of measurements accurately, including mass, temperature, and volume of liquids. AT 3 - Use of appropriate apparatus and techniques for conducting and monitoring chemical reactions. AT 5 - Making and recording of appropriate observations during chemical reactions including changes in temperature. AT 6 - Safe use and careful handling of gases, liquids and solids, including careful mixing of reagents under controlled conditions, using appropriate apparatus to explore chemical changes. MS 1a, MS 2a, MS 2b, MS 4a, MS 4c WS 2.1, WS 2.2, WS 2.3, WS 2.4, WS 2.6, WS 2.7
Rates of reaction	**Spec ref.**	**Skills**
Investigate how changes in concentration affect the rates of reactions by a method involving measuring the volume of a gas produced and a method involving a change in colour or turbidity. This should be an	Chemistry 4.6.1.2 Trilogy 5.6.1.2 Synergy 4.7.4.3	AT 1 – Use of appropriate apparatus to make and record a range of measurements accurately, including mass, temperature and volume of liquids. AT 3 - Use of appropriate apparatus and techniques for conducting and monitoring chemical reactions. AT 5 - Making and recording of appropriate observations during chemical reactions including changes in temperature. AT 6 - Safe use and careful handling of gases, liquids and solids, including careful mixing of reagents under

investigation involving developing a hypothesis.		controlled conditions, using appropriate apparatus to explore chemical changes. MS 1a, MS 1c, MS 1d, MS 2a, MS 2b, MS 4a, MS 4b, MS 4c, MS 4d, MS 4e WS 2.1, WS 2.2, WS 2.3, WS 2.4, WS 2.6, WS2.7
Chromatography	**Spec ref.**	**Skills**
Investigate how paper chromatography can be used to separate and tell the difference between coloured substances. Students should calculate Rf values.	Chemistry 4.8.1.3 Trilogy 5.8.1.3 Synergy 4.2.2.4	AT 1 - Use of appropriate apparatus to make and record a range of measurements accurately. AT 4 – Safe use of a range of equipments to purify and/or separate chemical mixtures including chromatography. WS 2.4, WS 2.6
Identifying ions (Chemistry only)	**Spec ref.**	**Skills**
Use of chemical tests to identify the ions in unknown single ionic compounds covering the ions from sections 4.8.3.1 to 4.8.3.5	Chemistry 4.8.3.7	AT 1 - Safe use of a Bunsen burner. AT 8 - Use of appropriate qualitative reagents and techniques to analyse and identify unknown samples or products including gas tests, flame tests, precipitation reactions. WS 2.4, WS 2.6
Water purification	**Spec ref.**	**Skills**
Analysis and purification of water samples from different sources, including pH, dissolved solids and distillation.	Chemistry 4.10.1.2 Trilogy 5.10.1.2 Synergy 4.4.1.8	AT 2 - Safe use of appropriate heating devices and techniques including use of a Bunsen burner and a water bath or electric heater. AT 3 - Use of appropriate apparatus and techniques for the measurement of pH in different situations. AT 4 - Safe use of a range of equipment to purify and/or separate chemical mixtures including evaporation, distillation. WS 2.3, WS 2.4, WS 2.5, WS 2.6, WS 2.7

GCSE Chemistry required practical activity: Making salts

Teachers' notes

Required practical activity	Apparatus and techniques
Preparation of a pure, dry sample of a soluble salt from an insoluble oxide or carbonate, using a Bunsen burner to heat dilute acid and a water bath or electric heater to evaporate the solution.	AT 2, AT 3, AT 4, AT 6

Preparation of pure dry copper sulfate crystals

Materials

In addition to access to general laboratory equipment, each group needs:

- $40cm^3$ 1.0M dilute sulfuric acid
- copper (II) oxide powder.

Technical information

If crystallising dishes are not available, petri dishes (without lids) make good substitutes. If small conical flasks are not available, a second small beaker is an acceptable replacement.

To prepare 1.0M dilute sulfuric acid, consult CLEAPSS Recipe Book 98 and Guide L195.

$40cm^3$ of dilute acid will react with approximately 3.2g copper (II) oxide powder, but more than this will be used due to the excess added.

Additional information

Students should be warned not to boil the acid. If students add copper (II) oxide to hot acid in large portions, the resulting frothing may go over the top of the beaker. Students should be reminded of the importance of good filtering technique (e.g. correct paper folding, liquid level not above top edge of filter paper). Students will also need to be reminded not to allow the water bath to boil dry.

The procedure may require two 60 minute lessons to complete. If so, it is suggested that the filtrate is retained at the end of the first lesson for evaporation during the second.

Students must not be allowed to take their crystals home. The waste crystals can be recycled to make up new copper (II) sulfate stock solutions.

Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- Safety goggles should be worn throughout.
- 1.0M dilute sulfuric acid (IRRITANT) is covered by Hazcard 98A.
- copper (II) oxide (HARMFUL) is covered by Hazcard 26.
- copper (II) sulfate (HARMFUL) is covered by Hazcard 27C.

Trialling

The practical should be trialled before use with students.

GCSE Chemistry required practical activity: Making salts

Student sheet

Required practical activity	Apparatus and techniques
Preparation of a pure, dry sample of a soluble salt from an insoluble oxide or carbonate, using a Bunsen burner to heat dilute acid and a water bath or electric heater to evaporate the solution.	AT 2, AT 3, AT 4, AT 6

Preparation of pure dry copper sulfate crystals

You will react an acid and an insoluble base to prepare an aqueous solution of a salt. The unreacted base from the reaction will need to be filtered. You will evaporate the filtrate to leave a concentrated solution of the salt, which will crystallise as it cools and evaporates further. When dry the crystals will have a high purity.

Learning outcomes
1 **2** **3** **Teachers to add these with particular reference to working scientifically**

Risk assessment

- Safety goggles must be worn throughout.

Method

You are provided with the following:

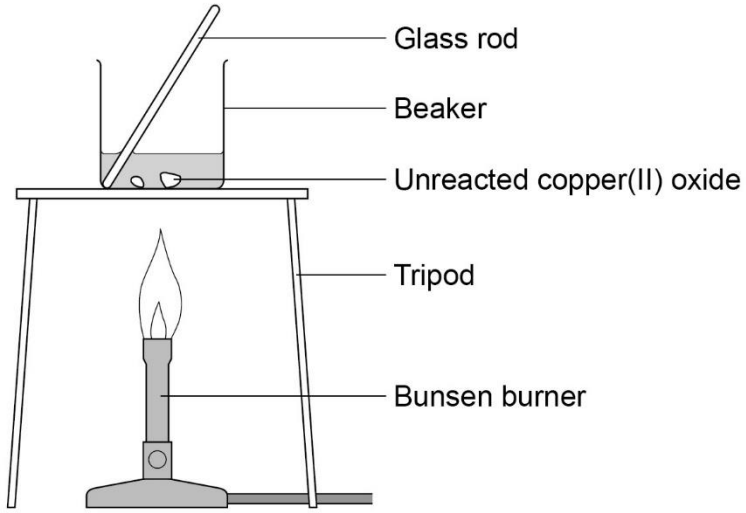
- 40 cm^3 1.0 M dilute sulfuric acid
- copper (II) oxide powder
- spatula
- glass rod
- 100 cm^3 beaker
- Bunsen burner
- tripod
- gauze
- heatproof mat
- filter funnel and paper
- clamp stand
- conical flask
- 250 cm^3 beaker
- evaporating basin
- crystallising dish

Read these instructions carefully before you start work.

1. Measure 40 cm^3 sulfuric acid into the 100 cm^3 beaker.

   The volume does not need to be very accurate, so you can use the graduations on the beaker.

2. Set up the tripod, gauze and heatproof mat. Heat the acid **gently** using the Bunsen burner until it is almost boiling. Turn off the Bunsen burner.



3. Use the spatula to add **small** amounts of copper (II) oxide powder. Stir with the glass rod.

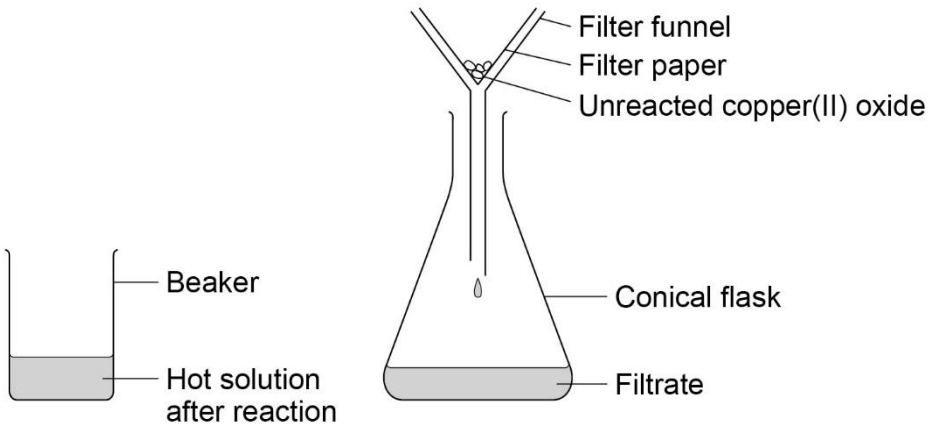
   Continue to add copper (II) oxide if it keeps disappearing when stirred. When the copper (II) oxide disappears the solution is clear blue.

4. Stop adding the copper (II) oxide when some of it remains after stirring.

   Allow apparatus to cool completely.

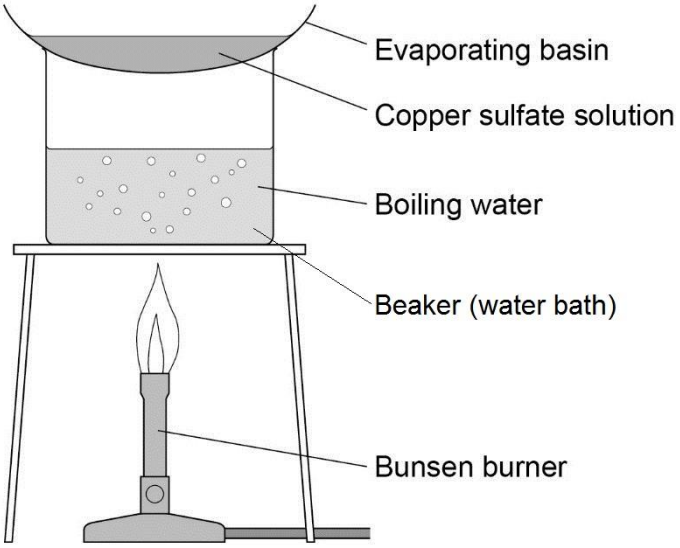
5. Set up the filter funnel and paper over the conical flask. Use the clamp stand to hold the funnel.

   Filter the contents of the beaker from step **3**.



6. When filtration is complete, pour the contents of the conical flask into the evaporating basin.

   Evaporate this gently using a water bath (250 cm^3 beaker with boiling water) on the tripod and gauze (see diagram). Stop heating once crystals start to form.



7. Transfer the remaining solution to the crystallising dish. Leave this in a cool place for **at least 24 hours**.

8. Remove the crystals from the concentrated solution with a spatula. **Gently** pat the crystals dry between two pieces of filter paper.

   These are pure dry crystals of copper (II) sulfate.

GCSE Chemistry required practical activity: Neutralisation

Teachers' notes

Required practical activity	Apparatus and techniques
Determination of the reacting volumes of solutions of a strong acid and a strong alkali by titration. **Higher Tier only** Determination of the concentration of one of the solutions in mol/dm3 and g/dm3 from the reacting volumes and the known concentration of the other solution.	AT 1, AT 8

Investigation to find the volume of dilute sulfuric acid needed to neutralise a known volume of sodium hydroxide solution. (FT)

Investigation to find the concentration of a dilute sulfuric acid solution, using a sodium hydroxide solution of known concentration. (HT)

Materials

In addition to access to general laboratory equipment, each group needs:

- 25cm^3 volumetric pipette
- Pipette filler
- 50cm^3 burette
- White tile
- 0.1M sodium hydroxide solution (concentration shown on label for HT)
- 0.08M sulfuric acid (concentration NOT shown on label for HT)
- Methyl orange indicator.

Technical information

To prepare 0.08M dilute sulfuric acid, consult CLEAPSS Recipe Book 98 and Guide L195.

To prepare 0.1M sodium hydroxide solution, consult CLEAPSS Recipe Book 85 and Guide L195.

To prepare methyl orange indicator, consult CLEAPSS Recipe Book 46.

$25cm^3$ 0.1M NaOH is neutralised by $15.6cm^3$ 0.08M H_2SO_4. Therefore, it should be possible to complete all three titrations using one fill of a standard $50cm^3$ burette. However, the student sheet assumes for simplicity that the burette is refilled each time to $0cm^3$. Some teachers may wish to use burette reading subtractions with able groups. In this case the table will need to be expanded to hold start and finish volumes as well as volume of acid required.

Similarly, some traditional procedures, such as rinsing glassware, eye level meniscus reading, preliminary (rough) titrations and pipette draining have been omitted from the student sheet.

Teachers may want to mention these to able groups.

It will be necessary to demonstrate the use of the particular type of pipette filler available in the centre.

Additional information

This can be done without burettes, using measuring cylinders and a dropper (plastic dropping pipette). This works well with students, and gives reasonable accuracy.

For example, using two 25 cm^3 measuring cylinders:

1. Put 25 cm^3 dilute acid into one measuring cylinder.
2. Use second measuring cylinder to measure 20 cm^3 alkali and pour into a conical flask.
3. Add a drop or two of a suitable indicator to the alkali.
4. Use a dropper to transfer acid from the first cylinder to alkali in the flask, initially one dropper full at a time, but then dropwise near the end point. Swirl after each addition of acid.
5. Return any unused acid from the dropper to the measuring cylinder.
6. Read the final volume of acid in the measuring cylinder.

Sodium hydroxide solution is particularly hazardous to the eyes.

Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- Safety goggles must be worn throughout.
- 0.08M dilute sulfuric acid is covered by Hazcard 98A.
- 0.1M sodium hydroxide solution (IRRITANT) is covered by Hazcard 91.
- Acid-base indicators (TOXIC) are covered by Hazcard 32.

Trialling

The practical should be trialled before use with students.

GCSE Chemistry required practical activity: Neutralisation

Student sheet – Foundation Tier

Required practical activity	Apparatus and techniques
Determination of the reacting volumes of solutions of a strong acid and a strong alkali by titration.	AT 1, AT 8

Investigation to find the volume of dilute sulfuric acid needed to neutralise a known volume of sodium hydroxide solution

You will find the volume of dilute sulfuric acid needed to neutralise 25 cm^3 of sodium hydroxide solution. Observing the colour change in an acid-base indicator is used to do this.

Learning outcomes
1
2
3
Teachers to add these with particular reference to working scientifically

Risk assessment

- Safety goggles must be worn throughout**.**

Method

You are provided with the following:

- 25cm^3 volumetric pipette and pipette filler
- Burette, small funnel and clamp stand
- 250cm^3 conical flask
- White tile
- Dilute sulfuric acid
- Sodium hydroxide solution
- Methyl orange indicator.

Read these instructions carefully before you start work.

1. Use the pipette and pipette filler to put exactly 25 cm^3 sodium hydroxide solution into the conical flask. Your teacher will show you how to do this.

   Stand the flask on a white tile.

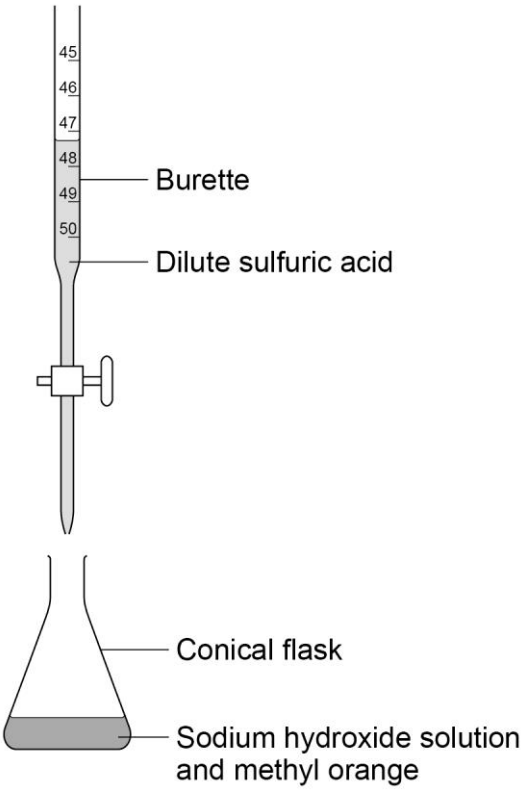
2. Clamp the burette vertically in the clamp stand about halfway up its length.

   There should be just enough room underneath for the conical flask and tile.

3. Close the burette tap.

   Use the small funnel to carefully fill the burette with dilute sulfuric acid to the 0 cm^3 line.

   You should do this at a low level so that you are not pouring acid from above head height. For example, put the clamp stand temporarily on a lab stool or the floor.



4. Put 5–10 drops of methyl orange indicator into the conical flask. Swirl to mix and place under the burette with the tile.

5. Carefully open the tap so that sulfuric acid flows into the flask at a drop by drop rate.

   Constantly swirl the flask when adding the acid. Look for a colour change from yellow to red in the indicator.

6. There will be signs that the colour change is close to being permanent. When this happens use the tap to slow the drops down.

   You need to be able to shut the tap immediately after a single drop of acid causes the colour to become permanently red.

7. Read the burette scale carefully and record the volume of acid you added. You can use a table such as the one below.

Volume of dilute sulfuric acid needed to neutralise 25cm^3 sodium hydroxide solution (cm^3)			
Trial 1	**Trial 2**	**Trial 3**	**Mean**

8. Repeat steps **1–7** twice more and record the results in the table.

9. Calculate the mean value for the volume of acid needed to neutralise 25 cm^3 of the sodium hydroxide solution. Record this value in the final space in the table.

GCSE Chemistry required practical activity: Neutralisation

Student sheet – Higher Tier

Required practical activity	Apparatus and techniques
Higher Tier only Determination of the concentration of one of the solutions in mol/dm3 and g/dm3 from the reacting volumes and the known concentration of the other solution.	AT 1, AT 8

Investigation to find the concentration of a dilute sulfuric acid solution using a sodium hydroxide solution of known concentration

You will find the volume of dilute sulfuric acid needed to neutralise 25 cm^3 of 0.5 mol/dm^3 sodium hydroxide solution. Observing the colour change in an acid-base indicator is used to do this.

The sulfuric acid has an unknown concentration. You also calculate the concentration of the sulfuric acid used in mol/dm^3 and g/dm^3.

Learning outcomes
1 **2** **3** **Teachers to add these with particular reference to working scientifically**

Risk assessment

- Safety goggles should be worn throughout.

Method

You are provided with the following:

- 25 cm^3 volumetric pipette and pipette filler
- burette
- small funnel
- clamp stand
- 250 cm^3 conical flask
- white tile
- dilute sulfuric acid of unknown concentration
- 0.1 mol/dm^3 sodium hydroxide solution
- methyl orange indicator.

Read these instructions carefully before you start work.

1. Use the pipette and pipette filler to put exactly 25 cm^3 sodium hydroxide solution into the conical flask. Your teacher will show you how to do this.

   Stand the flask on a white tile.

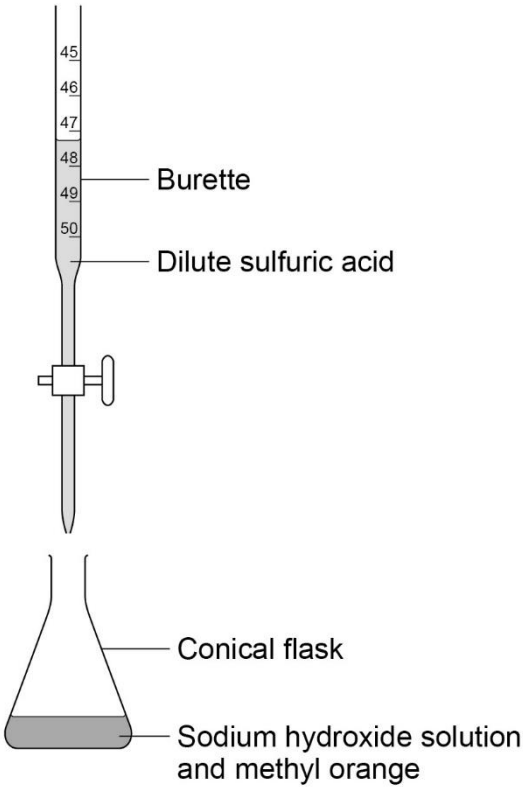
2. Clamp the burette vertically in the clamp stand about halfway up its length.

   There should be just enough room underneath for the conical flask and tile.

3. Close the burette tap.

   Use the small funnel to carefully fill the burette with dilute sulfuric acid to the 0 cm^3 line.

   You should do this at a low level so that you are not pouring acid from above head height. For example put the clamp stand temporarily on a lab stool or the floor.



4. Put 5–10 drops of methyl orange indicator into the conical flask. Swirl to mix and place under the burette with the tile.

5. Carefully open the tap so that sulfuric acid flows into the flask at a drop by drop rate.

Constantly swirl the flask when adding the acid. Look for a colour change from yellow to red in the indicator.

6. There will be signs that the colour change is close to being permanent. When this happens use the tap to slow the drops down.

   You need be able to shut the tap immediately after a single drop of acid causes the colour to become permanently red.

7. Read the burette scale carefully and record the volume of acid you added. You can use a table such as the one below.

Volume of dilute sulfuric acid needed to neutralise 25cm^3 sodium hydroxide solution (cm^3)			
Trial 1	**Trial 2**	**Trial 3**	**Mean**

8. Repeat steps **1–7** twice more and record the results in the table.

9. Calculate the mean value for the volume of acid needed to neutralise 25 cm^3 of the sodium hydroxide solution. Record this value in the final space in the table.

   Use your mean result to calculate the concentration of the acid in mol/dm^3 and g/dm^3 using the following calculation steps.

Calculations

Step 1

Concentration (mol/dm^3) = number of moles ÷ volume of solution (dm^3)

Moles of sodium hydroxide in 25 cm^3 = concentration × volume = 0.1 mol/dm^3 × (25 ÷ 1000) dm^3

= _____ moles

Step 2

Equation: $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

This shows that **two** moles of sodium hydroxide neutralise **one** mole of sulfuric acid.

So moles of sulfuric acid used = (answer from step **1**) ÷ 2

= _____ moles

Step 3

Concentration of sulfuric acid (mol/dm^3) = moles ÷ mean volume of acid

= (answer from step **2**) ÷ (mean volume from table ÷ 1000)

= _____ mol/dm^3

Step 4

Number of moles = mass of substance (g) ÷ M_r of substance

A_r (H) = 1; A_r (O) = 16; A_r (S) = 3

M_r (H_2SO_4) = _____

Concentration of sulfuric acid (g/dm^3) = (answer from step **3**) x M_r (H_2SO_4)

= _____ g/dm^3

GCSE Chemistry required practical activity: Electrolysis

Teachers' notes

Required practical activity	Apparatus and techniques
Investigate what happens when aqueous solutions are electrolysed using inert electrodes. This should be an investigation involving developing a hypothesis.	AT 3, AT 7, AT 8

Investigating the elements formed at each electrode when different salt solutions are electrolysed

Materials

In addition to access to general laboratory equipment, each group needs:

- 0.5M copper (II) chloride solution
- 0.5M sodium chloride solution
- 0.5M copper (II) sulfate solution
- 0.5M sodium sulfate solution
- petri dish lid with bored holes
- two carbon rod electrodes with support bungs
- two crocodile/4mm plug leads
- low voltage power supply
- blue litmus paper
- tweezers.

Technical information

To prepare 0.5M copper (II) chloride solution and 0.5M copper (II) sulfate solution, consult CLEAPSS Recipe Book 31 and Guide L195.

To prepare 0.5M sodium chloride solution, consult CLEAPSS Recipe Book 82 and Guide L195.

Preparation of sodium sulfate solution is not covered by the Recipe Book.

Small petri dish lids fit 100cm^3 beakers well and can be drilled out at 180^o spacing to take the two electrodes. If the carbon rods are then fitted with holed bungs that are positioned to rest on the lid above the holes, the rods will be stabilised well and the risk of short circuits will be much reduced. Proprietary electrolysis cells are available and can be substituted if available.

Additional information

Chlorine is produced during the first two electrolyses. Students should be warned not to inhale it, and the laboratory should be well ventilated. Limiting the p.d. to 4v and the electrolysis times to 5 minutes will minimize the risk of chlorine exposure.

Much longer times will be needed to collect enough oxygen and hydrogen for testing. If a Hofmann voltameter is available, it could be set up with sodium sulfate (or sulfuric acid) at the beginning of the lesson. This will usually produce enough oxygen and hydrogen for testing by the end of the lesson.

Much frustration can be avoided if the crocodile leads are tested for electrical continuity before this activity.

Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- Safety goggles must be worn throughout.
- 0.5M copper (II) chloride solution is covered by Hazcard 27A.
- 0.5M copper (II) sulfate solution is covered by Hazcard 27C.
- 0.5M sodium chloride solution is covered by Hazcard 47B.
- 0.5M sodium sulfate solution is covered by Hazcard 98B.
- Chlorine is covered by Hazcard 22A.

Trialling

The practical should be trialled before use with students.

GCSE Chemistry required practical activity: Electrolysis

Student sheet

Required practical activity	Apparatus and techniques
Investigate what happens when aqueous solutions are electrolysed using inert electrodes. This should be an investigation involving developing a hypothesis.	AT 3, AT 7, AT 8

Investigating the elements formed at each electrode when different salt solutions are electrolysed

You will use a low voltage power supply and carbon rod electrodes to pass a current through four different salt solutions. You will identify the element formed at the positive and negative electrode in each case.

Learning outcomes
1 **2** **3** **Teachers to add these with particular reference to working scientifically**

Risk assessment

- Safety goggles should be worn throughout.

Method

You are provided with the following:

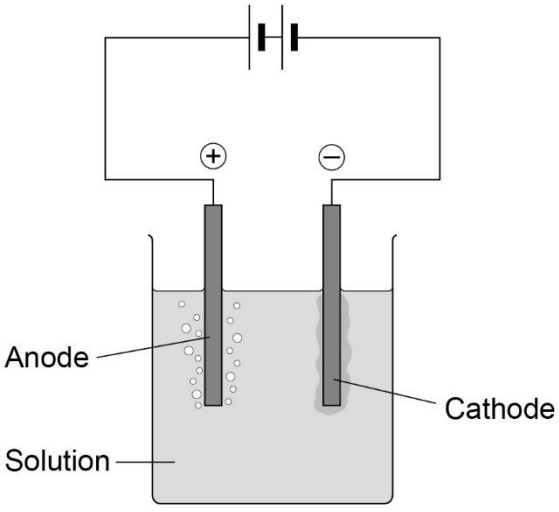
- copper (II) chloride solution
- copper (II) sulfate solution
- sodium chloride solution
- sodium sulfate solution
- 100 cm^3 beaker
- petri dish lid
- two carbon rod electrodes
- two crocodile/4 mm plug leads
- low voltage power supply
- blue litmus paper
- tweezers.

Read these instructions carefully before you start work.

1. Pour copper (II) chloride solution into the beaker to about 50 cm^3.

2. Add the lid and insert carbon rods through the holes. **The rods must not touch each other**.

   Attach crocodile leads to the rods. Connect the rods to the **dc (red and black)** terminals of a low voltage power supply.



3. Select 4 V on the power supply and switch on.

4. Look at both electrodes. Is there bubbling at neither, one or both electrodes?

5. Use tweezers to hold a piece of blue litmus paper in the solution next to the positive electrode (the one connected to the red terminal). You will need to lift the lid temporarily to do this.

   Write your observations in the first blank row of the table below. What is this element?

Solution	Positive electrode (anode)		Negative electrode (cathode)	
	Observations	**Element formed**	**Observations**	**Element formed**
Copper (II) chloride				
Copper (II) sulfate				
Sodium chloride				
Sodium sulfate				

6. After no more than five minutes, switch off the power supply.

   Examine the negative electrode (the one connected to the black terminal). Is there evidence of a metal coating on it? What could it be?

   Record your results in the table.

7. Clean the equipment carefully.

   Repeat steps **1–6** using solutions of:

   - copper (II) sulfate
   - sodium chloride
   - sodium sulfate.

Additional information

Gas produced at the positive electrode which does **not** bleach blue litmus paper, is oxygen. The amounts produced are usually too small to identify by testing.

If a gas is produced at the negative electrode, it is hydrogen. The amounts produced are usually too small to identify by testing.

GCSE Chemistry required practical activity: Temperature changes

Teachers' notes

Required practical activity	Apparatus and techniques
Investigate the variables that affect temperature changes in reacting solutions such as, eg acid plus metals, acid plus carbonates, neutralisations, displacement of metals.	AT 1, AT 3, AT 5, AT 6

Investigation of the temperature changes which take place when an acid is neutralised by an alkali

Materials

In addition to access to general laboratory equipment, each group needs:

- 2 M dilute hydrochloric acid
- 2 M sodium hydroxide solution
- expanded polystyrene cups and lids with thermometer holes
- 0-110ºC thermometers.

Technical information

To prepare 2 M dilute hydrochloric acid, consult CLEAPSS Recipe Book 43 and Guide L195.

To prepare 2 M sodium hydroxide solution, consult CLEAPSS Recipe Book 85 and Guide L195.

30 cm thermometers are preferable to 15 cm as they are easier to read over the small temperature increases expected and additionally the bulk of the thermometer scale will be above the hole in the lid.

Lids for polystyrene cups can be purchased and perforated; otherwise wooden lids can easily be constructed.

Additional information

Students may need to be reminded to keep thermometer bulbs fully immersed whilst making measurements.

Additional guidance may need to be provided to students regarding the drawing of the two lines of best fit so that they intersect.

The solutions used are quite concentrated in order to produce reasonable temperature changes. 2M sodium hydroxide is particularly hazardous to the eyes. The risk assessment should take account of the ability and behaviour of the group and concentrations lowered if necessary. For example, 10 cm^3 portions of 1M sodium hydroxide could be substituted.

Alternatively students could investigate the change in temperature when a metal is added to an acid. They could do this by adding finely divided magnesium, zinc, iron and copper to dilute hydrochloric acid in an expanded polystyrene cup and then measure maximum temperature change for each metal.

Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- Safety goggles must be worn throughout.
- 2 M dilute hydrochloric acid (IRRITANT) is covered by Hazcard 47A.
- 2 M sodium hydroxide solution (CORROSIVE) is covered by Hazcard 91.

Trialling

The practical should be trialled before use with students.

GCSE Chemistry required practical activity: Temperature changes

Student sheet

Required practical activity	Apparatus and techniques
Investigate the variables that affect temperature changes in reacting solutions such as, eg acid plus metals, acid plus carbonates, neutralisations, displacement of metals.	AT 1, AT 3, AT 5, AT 6

Investigation of the temperature changes which take place when an acid is neutralised by an alkali

You will monitor the temperature rise as small volumes of sodium hydroxide solution are added to dilute hydrochloric acid. The acid will be contained in an insulated cup.

Plot a graph of your results. Determine how much sodium hydroxide was needed to fully react with the acid.

Learning outcomes
1 **2** **3** **Teachers to add these with particular reference to working scientifically**

Risk assessment

- Safety goggles should be worn throughout.

Method

You are provided with the following:

- 2 M dilute hydrochloric acid
- 2 M sodium hydroxide solution
- expanded polystyrene cup and lid
- 250 cm^3 beaker
- 10 cm^3 measuring cylinder
- 50 cm^3 measuring cylinder
- thermometer.

Read these instructions carefully before you start work.

1. Use the 50 cm^3 measuring cylinder to put 30 cm^3 dilute hydrochloric acid into the polystyrene cup.

2. Stand the cup inside the beaker. This will make it more stable.

3. Use the thermometer to measure the temperature of the acid. Record it in the first blank column of the table such as the one below.

4. Put 5 cm^3 sodium hydroxide solution into the 10 cm^3 measuring cylinder.

5. Pour the sodium hydroxide into the cup. Fit the lid and gently stir the solution with the thermometer through the hole.

   When the reading on the thermometer **stops changing**, write the temperature in the next space in the table.

6. Repeat steps **4** and **5** to add further 5 cm^3 amounts of sodium hydroxide to the cup. A total of 40 cm^3 needs to be added.

   The last few additions should produce a temperature fall rather than a rise.

7. Repeat steps **1–6** and record the results in the second blank column of the table.

8. Calculate the **mean** maximum temperature reached for each of the sodium hydroxide volumes. Record these means in the third blank column.

Total volume of sodium hydroxide added in cm^3	Maximum temperature in ^oC		
	First trial	Second trial	Mean
0			
5			
10			
15			
20			
25			
30			
35			
40			

9. Plot a graph with:

   - 'Mean maximum temperature in ^oC' on the y-axis
   - 'Total volume of sodium hydroxide added in cm^3' on the x-axis.

   Draw two straight lines of best fit:

   - one through the points which are increasing
   - one through the points which are decreasing.

   Ensure the two lines are extended so they cross each other.

10. Use the graph to estimate how much sodium hydroxide solution was needed to neutralise 25 cm^3 dilute hydrochloric acid.

GCSE Chemistry required practical activity: Rates of reaction

Teachers' notes

Required practical activity	Apparatus and techniques
Investigate how changes in concentration affect the rates of reactions by a method involving measuring the volume of a gas produced and a method involving a change in colour or turbidity. This should be an investigation involving developing a hypothesis.	AT 1, AT 3, AT 5, AT 6

Investigation into how the concentration of a solution affects the rate of a chemical reaction

There are two parts to this practical which investigate how the rate of reaction can be measured using colour change and the volume of gas produced.

Activity 1: Colour change

Materials

In addition to access to general laboratory equipment, each group needs:

- 40g/dm^3 sodium thiosulfate solution
- 2.0 M dilute hydrochloric acid
- conical flask (100 cm^3)
- printed black paper cross
- stopclock.

Technical information

To prepare 40g/dm^3 sodium thiosulfate solution, consult CLEAPSS Recipe Book 87 and Guide L195. The concentration is specified in g/dm^3 rather than mol/dm^3 to simplify graph plotting for students. However, if it is desired that a Higher Tier group work in mole/dm^3 then the base thiosulfate solution should be 0.2 M. The diluted solutions prepared by students will then be 0.16, 0.12, 0.08 and 0.04 mol/dm^3

To prepare 2.0 M dilute hydrochloric acid, consult CLEAPSS Recipe Book 43 and Guide L195.

Printed crosses may give a greater likelihood of students obtaining reproducible results between groups.

Additional information

This required practical should form the basis of a complete investigation and will probably require two 60 minute laboratory lessons to complete.

Sulfur dioxide is released during the reaction which can exacerbate breathing difficulties in people with pre-existing conditions such as asthma. The laboratory should be well ventilated. Consult CLEAPPS Guide L195 for additional safety information.

Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- Safety goggles should be worn throughout.
- 40g/dm3 sodium thiosulfate (LOW RISK) is covered by Hazcard 95C.
- 2.0 M dilute hydrochloric acid (IRRITANT) is covered by Hazcard 47A.
- Sulfur dioxide (TOXIC) is covered by Hazcard 97.

Trialling

The practical should be trialled before use with students.

Activity 2: Volume of gas

Materials

In addition to access to general laboratory equipment, each group needs:

- magnesium ribbon cut into 3 cm lengths
- dilute hydrochloric acid, 1.0 M
- safety goggles
- each group of students will need:
- conical flask (100 cm^3)
- single-holed rubber bung and delivery tube to fit conical flask
- trough or plastic washing-up bowl
- measuring cylinders (100 cm^3)
- clamp stand, boss and clamp

- stopclock
- graph paper.

Technical information

The magnesium ribbon needs to be cleaned by rubbing lengths of the ribbon with fine sandpaper to remove the layer of oxidation. To prepare Hydrochloric acid, HCl (aq) - see CLEAPSS Hazcard 47a and CLEAPSS Recipe Book 43. The bungs in the flasks need to be rubber, since corks are too porous and will leak.

Additional Information

Gas syringes can be used instead of troughs of water and measuring cylinders. But these are expensive and are probably best used by the teacher as a demonstration. Syringes should not be allowed to become wet, or the plungers will stick.

Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- Safety goggles should be worn throughout.
- 2.0 M dilute hydrochloric acid (IRRITANT) is covered by Hazcard 47A.
- Magnesium ribbon, Mg(s) - see CLEAPSS Hazcard 59A.
- 3 Hydrogen gas, H2(g) (EXTREMELY FLAMMABLE) - see CLEAPSS Hazcard 48. Ensure that all naked flames are extinguished.

Trialling

The practical should be trialled before use with students.

GCSE Chemistry required practical activity: Rates of reaction

Student sheet

Required practical activity	Apparatus and techniques
Investigate how changes in concentration affect the rates of reactions by a method involving measuring the volume of a gas produced and a method involving a change in colour or turbidity. This should be an investigation involving developing a hypothesis.	AT 1, AT 3, AT 5, AT 6

Investigation into how the concentration of a solution affects the rate of a chemical reaction

There are two parts to this practical which investigate how the rate of reaction can be measured.

Activity 1: Observing colour change

You will react sodium thiosulfate with hydrochloric acid. You will then find out how the rate of reaction changes as the thiosulfate solution becomes more dilute.

Activity 2: Measuring the volume of gas produced

You will react magnesium ribbon and hydrochloric acid. You will then find out how the rate of reaction is affected by the concentration of the acid.

Learning outcomes
1 **2** **3** **4** **Teachers to add these with particular reference to working scientifically**

Risk assessment

- Safety goggles should be worn throughout.

Method

Activity 1: Observing colour change

You are provided with the following:

- 40 g/dm^3 sodium thiosulfate solution
- 2.0 M dilute hydrochloric acid
- 10 cm^3 measuring cylinder
- 100 cm^3 measuring cylinder
- 100 cm^3 conical flask
- printed black paper cross
- stopclock.

Read these instructions carefully before you start work.

1. Use a measuring cylinder to put 10 cm^3 sodium thiosulfate solution into the conical flask.

   Use the measuring cylinder to then add 40 cm^3 water. This dilutes the sodium thiosulfate solution to a concentration of 8 g/dm^3.

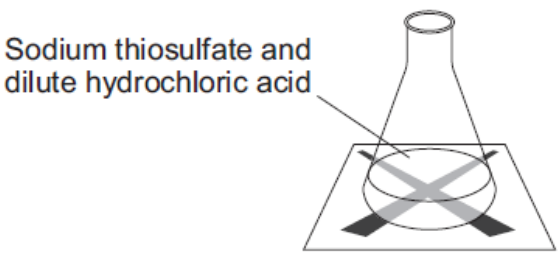
   Put the conical flask on the black cross.

2. Put 10 cm^3 of dilute hydrochloric acid into the 10 cm^3 measuring cylinder.

3. Put this acid into the flask. At the same time swirl the flask gently and start the stopclock.

4. Look down through the top of the flask. Stop the clock when you can no longer see the cross.

   Take care to avoid breathing in any sulfur dioxide fumes.



5. Write the time it takes for the cross to disappear in the first blank column of the table such as the one below. Record the time **in seconds**.

   You will need to multiply any minutes by 60 and then add the extra seconds.

Concentration of sodium thiosulfate in g/dm^3	**Time taken for cross to disappear in seconds**			
	First trial	**Second trial**	**Third trial**	**Mean**
8				
16				
24				
32				
40				

6. Repeat steps **1–5** four times, **but in step 1 use:**
   - 20 cm^3 sodium thiosulfate + 30 cm^3 water (concentration 16 g/dm^3)
   - 30 cm^3 sodium thiosulfate + 20 cm^3 water (concentration 24 g/dm^3)
   - 40 cm^3 sodium thiosulfate + 10 cm^3 water (concentration 32 g/dm^3)
   - 50 cm^3 sodium thiosulfate + no water (concentration 40 g/dm^3)

7. Then repeat the **whole investigation** (steps **1–5**) twice more.

   Record the results in the second and third blank columns of the table.

8. Calculate the **mean** time for each of the sodium thiosulfate concentrations. Leave out anomalous values from your calculations.

   Record the means in the fourth blank column.

9. Plot a graph with:
   - 'mean time taken for cross to disappear in seconds' on the y-axis
   - 'Sodium thiosulfate concentration in g/dm^3' on the x-axis

   Draw a smooth curved line of best fit.

   What can you say about the effect of the independent variable (concentration) on the dependent variable (time taken for the cross to disappear)? What were your control variables?

Compare your results with those of others in the class. Is there evidence that this investigation is reproducible?

Activity 2: Measuring the volume of gas produced

You are provided with the following:

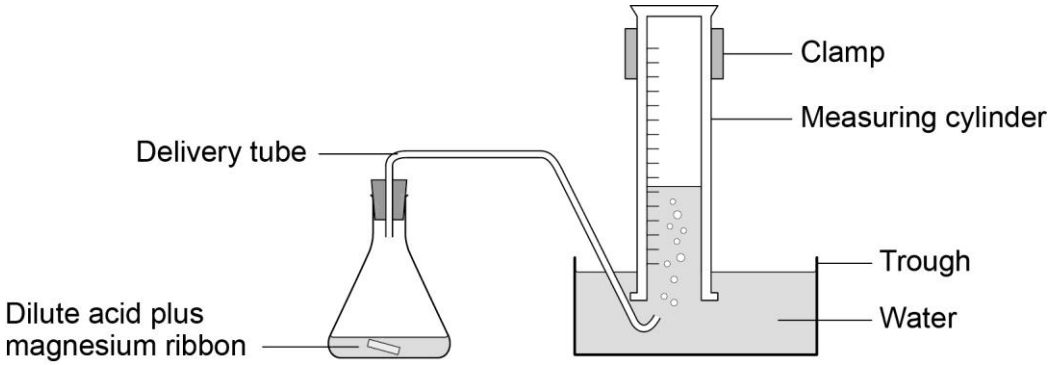
- safety goggles
- conical flask (100 cm^3)
- single-holed rubber bung and delivery tube to fit conical flask
- trough or plastic washing-up bowl
- two measuring cylinders (100 cm^3)
- clamp stand, boss and clamp
- stop clock
- graph paper
- magnesium ribbon cut into 3 cm lengths
- dilute hydrochloric acid, (2.0 M, and 1.0 M).

Read these instructions carefully before you start work.

1. Measure 50 cm^3 of 2.0 M hydrochloric acid using one of the measuring cylinders. Pour the acid into the 100 cm^3 conical flask.

2. Set up the apparatus as shown in the diagram.

   Half fill the trough or bowl with water.



3. Fill the other measuring cylinder with water. Make sure it stays filled with water when you turn it upside down.

4. When you are ready, add a 3 cm strip of magnesium ribbon to the flask, put the bung back into the flask as quickly as you can, and start the stopclock.

5. Record the volume of hydrogen gas given off at suitable intervals (eg 10 seconds) in a table such as the one below.

   Continue timing until no more gas appears to be given off.

Time in seconds	**Volume of gas produced for 2.0 M hydrochloric acid in cm^3**
10	
20	
30	
40	
50	
60	
70	
80	
90	
100	

6. Repeat steps **1-5** using 1.0 M hydrochloric acid.

7. Plot a graph with:

   - 'Volume of gas produced in cm^3 (for 2.0 M hydrochloric acid)' on the y-axis
   - 'Time in seconds' on the x-axis

   Draw a smooth curved line of best fit.

8. Plot a curve for 1.0 M hydrochloric acid on the same graph.

9. Use this graph to compare the rates of reaction of 1.0 M and 2.0 M hydrochloric acid with magnesium

10. Compare your results with the data collected in **Activity 1.**

11. Use kinetic theory to explain your findings.

GCSE Chemistry required practical activity: Chromatography

Teachers' notes

Required practical activity	Apparatus and techniques
Investigate how paper chromatography can be used to separate and tell the difference between coloured substances. Students should calculate Rf values.	AT 1, AT 4

Investigation into the use of paper chromatography to separate and identify a mixture of food colourings

Materials

In addition to access to general laboratory equipment, each group needs:

- four known food colourings labelled **A–D**
- unknown food colouring labelled **U**
- rectangle of chromatography paper
- capillary melting point tubes.

Technical information

There are several brands of food colouring available. It will be necessary to experiment to obtain a type which gives good results. The unknown mixture should contain two of the known food colouring and a third colour **not** from **A–D**. Best results will be obtained if **A–D** are single dyes and not mixtures themselves.

Additional information

It is suggested that chromatography paper is pre-cut for student use so that it will not touch the beaker walls (if it does, capillary rise at the edges will distort the solvent front).

Melting point tubes take up food dye by capillary attraction and are a convenient way of making small reproducible spots.

Wet chromatography paper is difficult to take measurements from. Because of the drying time involved it may be necessary to make measurements and do calculations during the following lesson.
Students should be told to resist the temptation to move or touch the beaker once the experiment is under way.

A lid is sometimes suggested for good results, especially when the solvent is volatile, but is not essential with water. However, to illustrate good practice, if desired, a petri dish or lid makes a suitable lid. Cut-outs in the wall can be made at 180^{o} to each other to clear the ends of the glass rod.

Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- Safety goggles must be worn throughout.
- There are no significant safety issues.
- Care should be taken with sharp broken melting point tubes.

Trialling

The practical should be trialled before use with students.

GCSE Chemistry required practical activity: Chromatography

Student sheet

Required practical activity	Apparatus and techniques
Investigate how paper chromatography can be used to separate and tell the difference between coloured substances. Students should calculate Rf values.	AT 1, AT 4

Investigation into the use of paper chromatography to separate and identify a mixture of food colourings

You will use paper chromatography to separate the different colours present in an unknown mixture of food colourings. You will then measure the distance travelled by each colour and the solvents to calculate R_f values.

Learning outcomes
1
2
3
Teachers to add these with particular reference to working scientifically

Risk assessment

- Safety goggles should be worn throughout.

Method

You are provided with the following:

- 250 cm^3 beaker
- glass rod
- a rectangle of chromatography paper
- four known food colourings labelled **A**-**D**
- an **unknown mixture** of food colourings labelled **U**
- glass capillary tubes.

Read these instructions carefully before you start work.

1. Use a ruler to draw a horizontal pencil line 2 cm from a short edge of the chromatography paper.

   Mark five pencil spots at equal intervals across the line. Keep at least 1 cm away from each end.

2. Use a glass capillary tube to put a small spot of each of the known colourings on four of the pencil spots. Then use the glass capillary tube to put a small spot of the unknown mixture on the 5th pencil spot.

   Try to make sure each spot is no more than 5 mm in diameter.

   Label each spot **in pencil**.

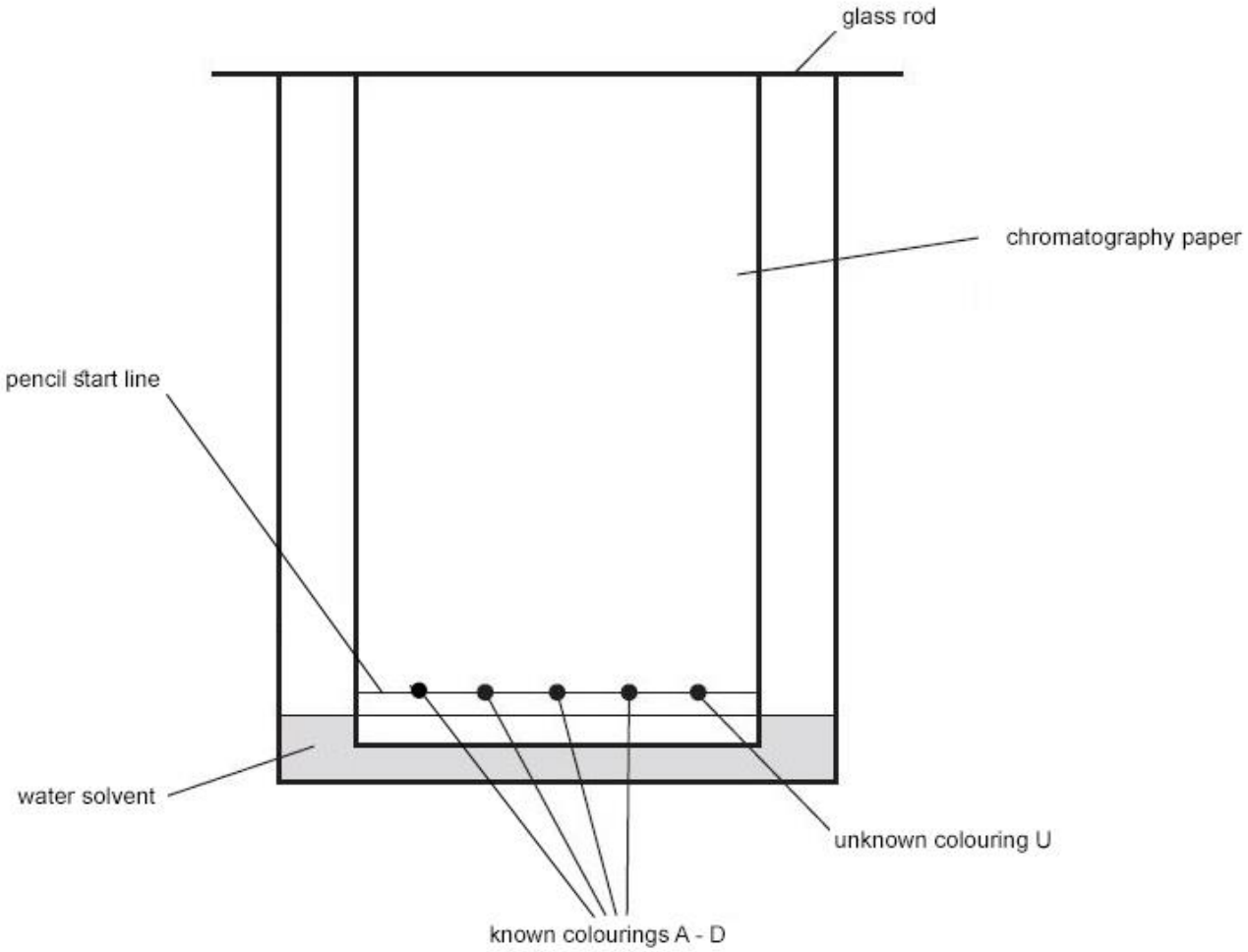
3. Pour water into the beaker to a depth of **no more than 1 cm**.

4. Tape the edge of the chromatography paper to the glass rod. The paper needs to be taped at the end furthest from the spots.

   Rest the rod on the top edge of the beaker. The bottom edge of the paper should dip into the water.

   Ensure that the:

   - **pencil line is above the water surface**
   - **sides of the paper do not touch the beaker wall.**



5. Wait for the water solvent to travel at least three quarters of the way up the paper. Do **not** disturb the beaker during this time.

   Carefully remove the paper. Draw another pencil line on the dry part of the paper as close to the wet edge as possible.

6. Hang the paper up to dry thoroughly.

7. Measure the distance in mm between the two pencil lines. This is the distance travelled by the water solvent.

   Measure and record the same distance for each food colouring in the table below.

Food colouring	Distance travelled in mm		Rf value
	Solvent	Spot	
A			
B			
C			
D			

7. For each of the four known colours, measure the distance in mm from the bottom line to the centre of each spot. Write each measurement in the table.

8. Use the following equation to calculate the R_f value for each of the known colours.

$$R_f = \frac{\text{distance moved by substance}}{\text{distance moved by solvent}}$$

   Write the calculated values in the table.

9. Match the spots in mixture **U** with those from **A–D**. Use the colour and distance travelled to help you.

   Which of colourings **A–D** are in mixture **U**?

   Are there any other colourings in mixture **U** which do **not** match **A–D**?

GCSE Chemistry required practical activity: Identifying Ions

Teachers' notes

Required practical activity	Apparatus and techniques
Use of chemical tests to identify the ions in unknown single ionic compounds covering the ions from sections 4.8.3.1 to 4.8.3.5.	AT 1, AT 8

Identify the ions in a single ionic compound using chemical tests

Materials

In addition to access to general laboratory equipment, each group needs:

- nichrome wire mounted in handle
- limewater
- 0.4 M dilute hydrochloric acid
- 0.1 M barium chloride solution
- 0.4 M dilute nitric acid
- 0.05 M silver nitrate solution
- 0.4 M known labelled cation salt solutions: LiCl, NaCl, KCl, $CaCl_2$, $CuCl_2$
- 0.4 M known labelled anion salt solutions: Na_2CO_3, Na_2SO_4, NaCl, NaBr, NaI
- 0.4 M salt solution labelled 'unknown'.

Technical information

The unknown salt solution could be any soluble compound containing the anions and cations tested for. It is suggested that potassium sulfate will give good results as the unknown. It has the additional advantage that the halide test need not be done again if time is short, saving silver nitrate.

Nichrome wires can be mounted in lengths of glass capillary tube to form a handle. If nichrome wires are not available, soaked splints can be **briefly** heated to give acceptable results.

To prepare 0.4 M dilute hydrochloric acid, consult CLEAPSS Recipe Book 43 and Guide L195.
To prepare 0.1 M barium chloride solution, consult CLEAPSS Recipe Book 10 and Guide L195.
To prepare 0.4 M dilute nitric acid, consult CLEAPSS Recipe Book 61 and Guide L195.
To prepare 0.05 M silver nitrate solution, consult CLEAPSS Recipe Book 77 and Guide L195.

Additional information

Students will need practice and/or demonstration to show how to transfer small amounts of CO_2 to limewater using a pipette. Several withdrawals of CO_2 will be needed before the limewater turns cloudy.

Students will need to be told to label the test tubes in the rack clearly to avoid confusion.

The distinction between the three halide precipitates (white, cream and yellow) is slight. Students should be encouraged to compare these, side-by-side.

It is important to keep nichrome wires clean. They can be rubbed with fine emery paper to achieve this. Students at GCSE level should **not** be provided with concentrated hydrochloric acid in watch glasses to clean the wires in the traditional way. Contaminated wires or solutions can result in the intense sodium flame emission masking the other ions.

Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- Safety goggles should be worn throughout.
- 0.4 M dilute hydrochloric acid (LOW RISK at this concentration) is covered by Hazcard 47A.
- 0.1 M barium chloride solution (HARMFUL) is covered by Hazcard 10A.
- 0.4 M dilute nitric acid (IRRITANT) is covered by Hazcard 67.
- 0.05 M silver nitrate (LOW RISK at this concentration) is covered by Hazcard 87.
- The risks associated with the salt solutions and limewater should also be taken into consideration.

Trialling

The practical should be trialled before use with students.

GCSE Chemistry required practical activity: Identifying Ions

Student sheet

Required practical activity	Apparatus and techniques
Use of chemical tests to identify the ions in unknown single ionic compounds covering the ions from sections 4.8.3.1 to 4.8.3.5.	AT 1, AT 8

Identify the ions in a single ionic compound using chemical tests

You will analyse a range of known ionic compounds.

The methods you will use are:

- flame testing
- addition of acids
- addition of barium chloride
- addition of silver nitrate.

You will then apply the knowledge you gain to identify the ions in an unknown compound.

Learning outcomes
1 **2** **3** **Teachers to add these with particular reference to working scientifically**

Risk assessment

- Safety goggles should be worn throughout.

Method

You are provided with the following:

- Bunsen burner
- test tubes and test tube rack
- teat pipette
- nichrome wire mounted in handle
- limewater
- 0.4 M dilute hydrochloric acid
- 0.1 M barium chloride solution
- 0.4 M dilute nitric acid
- 0.05 M silver nitrate solution
- known labelled solutions: chlorides of lithium, sodium, potassium, calcium and copper
- known labelled solutions: sodium salts containing carbonate, sulfate, chloride, bromide and iodide
- salt solution labelled ‘unknown’.

Read these instructions carefully before you start work.

Flame Tests

1. Pour around 1 cm depth of each of the **labelled chloride solution**s into five test tubes in the rack.

2. Dip the nichrome wire into the first solution. Then hold the tip of the wire in a blue Bunsen burner flame.

3. Record your observation in **Table 1** (at end of this worksheet).

4. Clean the wire carefully.

5. Repeat steps **2–4** for each of the other four solutions.

6. Empty and clean the test tubes.

Carbonate test

1. Pour around 1 cm depth of each of the **labelled sodium solutions** into five test tubes in the rack.

2. Place 2 cm depth of limewater in a sixth test tube.

3. Add 1 cm depth of **dilute hydrochloric acid** to each sodium salt in turn.

   Only if you see bubbles, **quickly** use the teat pipette to transfer the gas produced to the limewater. Your teacher may show you how to do this.

   You will need to take several pipettes of the gas to get a change in the limewater.

4. Record your results in the first blank row of **Table 2** (at end of this worksheet).

5. Empty and clean the test tubes.

Sulfate test

1. Pour around 1 cm depth of each of the **labelled sodium solutions** into five test tubes in the rack.

2. Add a few drops of **dilute hydrochloric acid** to each solution. Then add 1 cm depth of **barium chloride** solution.

3. Record your observations in the second blank row of **Table 2**.

4. Empty and clean the test tubes.

Halide test

1. Pour around 1 cm depth of each of the **labelled sodium solutions** into five test tubes in the rack.

2. Add a few drops of **dilute nitric acid** to each solution. Then add 1 cm depth of **silver nitrate** solution.

3. Record your observations in the third blank row of **Table 2**.

Unknown

1. Repeat the flame, carbonate, sulfate and halide tests on the unknown salt solution.

2. Use your results from:
    - **Table 1** to identify the positive metal ion in the unknown compound
    - **Table 2** to identify the negative non-metal ion.

Table 1

Possible flame colours are:

- green
- crimson
- lilac
- yellow
- red.

Metal ion	**Lithium**	**Sodium**	**Potassium**	**Calcium**	**Copper**
Flame colour					

Table 2

Possible outcomes are:

carbon dioxide release

or

white, cream or yellow precipitates

or

no reaction

Non-metal ion	**Carbonate**	**Sulfate**	**Chloride**	**Bromide**	**Iodide**
Carbonate test					
Sulfate test					
Halide test					

GCSE Chemistry required practical activity: Water purification

Teachers' notes

Required practical activity	Apparatus and Techniques
Analysis and purification of water samples from different sources, including pH, dissolved solids and distillation.	AT 2, AT 3, AT 4

Analysis and Distillation of water from different sources

Materials

In addition to access to general laboratory equipment, each group needs:

- 50 cm^3 sample of 'sea water'
- 10 cm^3 sample of 'spring water'
- 10 cm^3 sample of 'rain water'
- a few ice cubes
- universal indicator solution or paper.
- access to balance(s) with resolution to 0.01 g.

Technical information

Although only a small quantity of water needs to be distilled, enough needs to be present in the flask to avoid it boiling dry and cracking.

Ersatz sea water can be produced by dissolving 25 g sodium chloride in 1 dm^3 water. The pH will need to be adjusted so that it produces a turquoise colour with universal indicator, indicating a pH of 8.0 – 8.5. This can be achieved by adding sodium carbonate solution in small volumes and monitoring with a pH probe until the desired pH is reached.

Ersatz spring water can be simulated using 0.1 M magnesium sulfate solution. This should have a pH of 5.5 – 6.5 and should turn universal indicator yellow-green.

To prepare 0.1 M magnesium sulfate solution, consult CLEAPSS Recipe Book 55.

Ersatz rainwater could be distilled water acidified to produce an orange-yellow effect with universal indicator and a pH of 5.0 – 5.5. This can be done by bubbling carbon dioxide through the water whilst monitoring with a pH probe.

Additional information

Students should be warned about the need to avoid the water bath boiling dry.

Students will need to be cautioned to remove the heat source during distillation if it seems likely the sea water will boil over through the delivery tube. They should also be told to keep the delivery tube at least 2cm from the bottom of the collecting test tube, otherwise the distillate level may rise above it, creating the possibility of suck-back when heating is discontinued.

The complete procedure will probably take two 60 minute lessons to allow for setting up, cooling and clearing away.

If preferred, the weighing of the evaporated residues can be replaced by a qualitative observation of the presence or otherwise of dissolved solids and relative amounts.

Risk assessment

Risk assessment and risk management are the responsibility of the centre. Eye protection should be worn throughout.

0.1 M magnesium sulfate solution (LOW RISK at this concentration) is covered by Hazcard 59B.

Trialling

The practical should be trialled before use with students.

Supplementary demonstration

Outline method	Suggested apparatus	Suggested reagents
Testing pH of water samples using pH probe. Distillation of seawater to obtain water using Liebig condenser. Place solution in clamped side arm distillation flask over tripod, gauze and Bunsen burner or electric heating mantle. Fit thermometer and Liebig condenser and distil into conical flask.	pH probe, Tripod, gauze, clamp stand, heatproof mat, Bunsen burner OR electric heating mantle, side arm distillation flask, thermometer in bung, Liebig condenser, conical flask.	Sea water, spring water, rain water.

GCSE Chemistry required practical activity: Water purification

Student sheet

Required practical activity	Apparatus and Techniques
Analysis and purification of water samples from different sources, including pH, dissolved solids and distillation.	AT 2, AT 3, AT 4

Analysis and Distillation of water from different sources

In this investigation you will test three water samples from different sources for pH and the presence of dissolved solids. After distillation of the sea water, you will test the water again to check that dissolved solids have been removed, making the water fit to drink.

Learning Outcomes
1.
2.
Teachers to add these with particular reference to working scientifically

Method

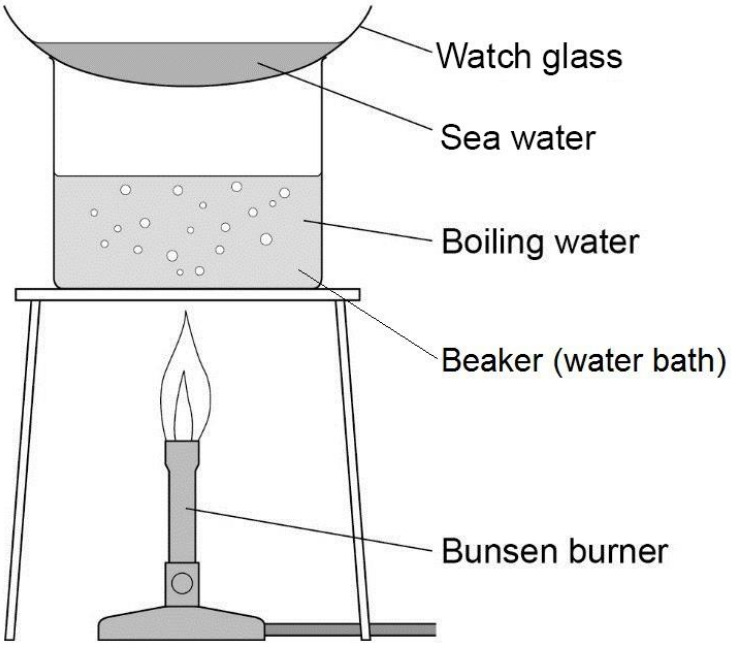
You are provided with the following:

- water samples
- universal indicator
- test tubes and rack
- Bunsen burner
- 10 cm^3 measuring cylinder
- tripod
- gauze
- heatproof mat
- 250 cm^3 beaker
- watch glass
- tongs
- clamp stand
- 250 cm^3 conical flask
- delivery tube with bung
- ice

You should read these instructions carefully before you start work.

1. Pour around 1 cm depth of the sea water into a test tube in the rack. Add a few drops of universal indicator solution. Using a pH colour chart, match the colour and record the pH of the water in the results table. Repeat this test for spring water and rain water and record the results.

2. Weigh a dry watch glass. Record its mass in the table. Pour 4 cm^3 sea water (less if your watch glass is small) into it and place it above a beaker acting as a water bath as shown in the diagram.

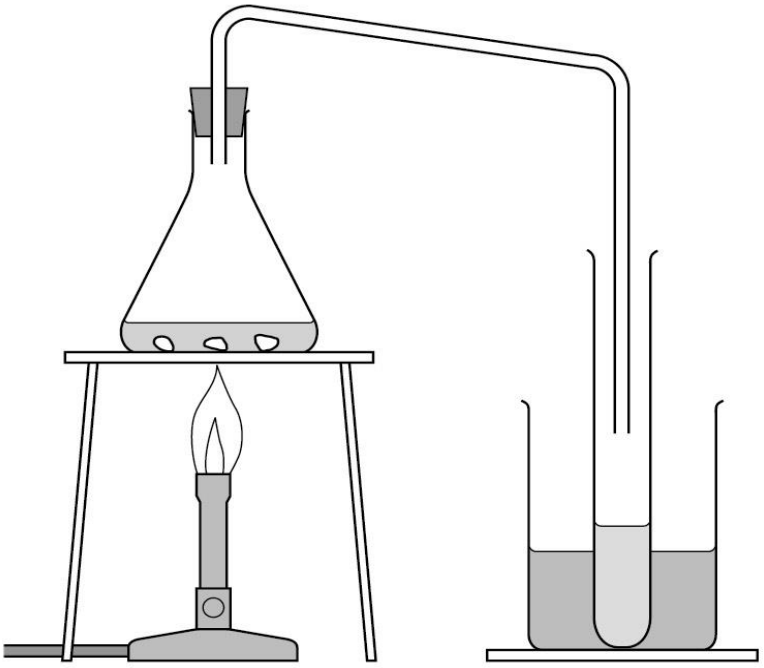


3. Allow all the water to evaporate from the watch glass. Do not let the water bath boil dry.

4. You should see dissolved solids on the glass. Remove the watch glass with tongs and allow to cool. Dry the bottom of the watch glass with a cloth and reweigh it. Record the new mass in the table. Subtract the mass of the watch glass alone and record the mass of the dissolved solids. Wash the watch glass and dry it.

5. Repeat steps 2 – 4 for the other water samples. You do not need to weigh the empty watch glass again as long as you use the same one each time.

Place the remaining sea water (around 40 cm^3) in the conical flask and set up the apparatus for distillation as shown in the diagram.



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6. Make sure the conical flask is held on the tripod and gauze using the clamp stand. Place a mixture of ice and water in the beaker surrounding the test tube.

7. Heat the sea water with the Bunsen burner until it starts to boil. Then reduce the heat so that the water boils gently. Distilled water will collect in the cooled test tube. Collect about 5 cm depth of water in this way, then stop heating.

8. Repeat the tests in steps 1 to 4 again using the distilled sea water, again recording your results in the table. How does the distilled water compare with the undistilled sea water?

Water	pH	Mass in grams		
		Watch glass	Watch glass and dissolved solids	Dissolved solids
Sea				
Spring				
Rain				
Distilled sea				