AQA
Realising potential

GCSE
CHEMISTRY
(8462)

Required practical handbook

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 to provide the appropriate level of engagement and challenge for their own students.

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Contents

Introduction

The purpose of this handbook

The required practical activities listed in the GCSE Chemistry specification (8462) have been written to ensure that students have the opportunity to experience all of the Apparatus and Techniques (AT) criteria required by Ofqual.

In this guide we **suggest** methods for carrying out the required practical activities to give ideas and guidance to help you plan the best experience for your students. **None of these methods are compulsory.** However, you must ensure that you carry out a sufficient variety of practical work to give your students the opportunity to experience all aspects of the AT criteria required by Ofqual. The methods we have suggested will enable you to do this, but we strongly encourage you to adapt them to fit the needs of your students and the resources you have available.

The methods we suggest are deliberately familiar, using apparatus and techniques that are readily available in most schools. All of the methods suggested have been written by practising teachers and trialled by specialist lab technicians, who have included sample results when appropriate.

Covering the AT criteria

Students must be given the opportunity to experience all of the chemistry AT criteria during their GCSE science course, regardless of the awarding body whose specification they study.

Individual practical activities will not necessarily cover all aspects of an AT statement, ie it is only by doing all of the required practical activities that all aspects of each AT statement will be covered. The teacher and technician notes indicate which aspects of an AT statement the method we suggest covers.

We are keen to encourage teachers to use alternative methods that support students to develop their understanding of the apparatus and techniques statements. More detailed advice, additional activities and alternative methods can be found on the CLEAPSS website.

Whichever method you use, it is your responsibility to check that you have covered all aspects of the apparatus and techniques criteria.

The GCSE practical science statement

There is no practical skills endorsement at GCSE level, unlike that at A-level. Instead, the head of each school or college will need to sign the AQA practical science statement to confirm that reasonable opportunities have been given 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. 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.

Teachers should agree with their head of school what evidence he or she requires to be confident in signing the declaration.

If a student is absent from a required practical activity and doesn't catch up with the work they have missed, it may compromise their overall grade as 15% of the available examination marks are practical work related.

Risk assessment

Schools and colleges are responsible for ensuring that appropriate safety procedures are followed, and should undertake full risk assessments.

Comprehensive information on safe use of practical apparatus, techniques and associated chemicals etc is available on the CLEAPSS website.

Suggested websites to support with practical work

Association for science education

Getting practical

Practical Chemistry

RSC

STEM

Student worksheets

Within the student worksheets we have included a number of tasks which will challenge students to think about their practical work and/or related theory. The questions are **not** example examination questions and are expected to be edited and expanded on by teachers.

Required practical activities per specification

The below table shows which required practical activities must be covered by each of the five GCSE science specifications.

Required practical activity	Synergy	Trilogy	Biology	Chemistry	Physics
Microscopy	✓	✓	✓		
Osmosis	✓	✓	✓		
Enzymes	✓	✓	✓		
Food tests	✓	✓	✓		
Photosynthesis	✓	✓	✓		
Reaction time	✓	✓	✓		
Field investigations	✓	✓	✓		
Plant responses			✓		
Decay			✓		
Microbiology			✓		
Making salts	✓	✓		✓	
Temperature changes	✓	✓		✓	
Rates of reaction	✓	✓		✓	
Chromatography	✓	✓		✓	
Water purification	✓	✓		✓	
Electrolysis	✓	✓		✓	
Neutralisation				✓	
Identifying ions				✓	
Specific heat capacity	✓	✓			✓
Resistance	✓	✓			✓
I-V characteristics	✓	✓			✓
Density	✓	✓			✓

Force and extension	✓	✓			✓
Acceleration	✓	✓			✓
Waves	✓	✓			✓
Radiation and absorption	✓	✓			✓
Thermal insulation					✓
Light					✓

Teacher and technician notes

Making salts

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.

	Trilogy	**Synergy**	**Chemistry**
RPA	8	17	1
Specification reference	5.4.2.3	4.7.3.2	4.4.2.3

By using this method your students will have the opportunity to develop the following aspects of the chemistry AT skills	
AT 2	safe use of appropriate heating devices and techniques including the use of a Bunsen burner and water bath or electric heater
AT 4	safe use of a range of equipment to purify and/or separate a chemical mixture including evaporation, filtration and crystallisation
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

Materials

For the basic method

- 1.0 mol/dm^3 dilute sulfuric acid
- copper (II) oxide powder
- a spatula
- a glass rod
- a measuring cylinder
- two beakers: one 100 cm^3 and one 250 cm^3
- Bunsen burner
- tripod
- gauze
- heatproof mat
- filter funnel and paper
- a small conical flask
- an evaporating basin
- a crystallising dish.

Technical information

To prepare 1.0 mol/dm^3 dilute sulfuric acid, consult CLEAPSS.

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

Additional information

The waste crystals can be recycled to make up new copper (II) sulfate stock solutions.

Neutralisation

Determination of the reacting volumes of solutions of a strong acid and a strong alkali by titration.

	Chemistry
RPA	2
Specification reference	4.4.2.5

There are two parts to this investigation, dependent of the tier of entry:

- Foundation Tier students carry out an investigation to find the volume of dilute sulfuric acid needed to neutralise a known volume of sodium hydroxide solution.
- Higher Tier students carry out an investigation to find the concentration of a dilute sulfuric acid solution, using a sodium hydroxide solution of known concentration.

By using this method your students will have the opportunity to develop the following aspects of the chemistry AT skills	
AT 1	use of appropriate apparatus to make and record a range of measurements accurately including volume of liquids
AT 8	use of appropriate qualitiative reagents and techniques to analyse and identify unknown samples or products including the determination of concentrations of strong acids and strong alkalis

Materials

Each student should have:

For the basic method

- 25 cm^3 volumetric pipette
- pipette filler
- 50 cm^3 burette
- 250 cm^3 conical flask
- small funnel
- clamp stand and clamp
- white tile
- 0.1 mol/dm^3 sodium hydroxide solution (concentration shown in mol/dm^3 on label for HT)
- 0.08 mol/dm^3 sulfuric acid (concentration NOT shown on label for HT)
- phenolpthalein indicator.

Technical information

Consult CLEAPSS to prepare:

- 0.08 mol/dm^3 dilute sulfuric acid
- 0.1 mol/dm^3 sodium hydroxide solution
- phenolpthalein indicator.

25 cm^3 0.1 mol/dm^3 NaOH is neutralised by 15.6 cm^3 0.08 mol/dm^3 H_2SO_4. Therefore, it should be possible to complete all three titrations using one fill of a standard 50 cm^3 burette. However, the student sheet assumes for simplicity that the burette is refilled each time to 0.00 cm^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.

A suggested alternative approach from teachers and technicians

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:

- put 25 cm^3 dilute acid into one measuring cylinder
- use second measuring cylinder to measure 20 cm^3 alkali and pour into a conical flask
- add a drop or two of a suitable indicator to the alkali
- 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
- return any unused acid from the dropper to the measuring cylinder
- read the final volume of acid in the measuring cylinder.

AQA technician results

Volume of dilute sulfuric acid needed to neutralise 25 cm^3 sodium hydroxide solution (cm^3)			
Trial 1 (rough)	**Trial 2**	**Trial 3**	**Mean**
17.05	15.55	15.35	15.45

Note that the rough titration has not been included in the mean calculation as it is an outlier.

Electrolysis

Investigate what happens when aqueous solutions are electrolysed using inert electrodes.

	Trilogy	Synergy	Chemistry
RPA	9	21	3
Specification reference	5.4.3.4	4.7.5.3	4.4.3.4

By using this method your students will have the opportunity to develop the following aspects of the chemistry AT skills	
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 in different situations
AT 7	use of appropriate apparatus and techniques to draw, set up and use electrochemical cells for separation and production of elements and compounds

Materials

For the basic method

- 0.5 mol/dm^3 copper (II) chloride solution
- 0.5 mol/dm^3 sodium chloride solution
- a Petri dish lid with bored holes
- two carbon rod electrodes with support bungs
- two crocodile/4 mm plug leads
- low voltage power supply
- blue litmus paper
- forceps.

Technical information

To prepare 0.5 mol/dm^3 copper (II) chloride solution and 0.5 mol/dm^3 sodium chloride solution, consult CLEAPSS.

Small petri dish lids fit 100 cm^3 beakers well and can be drilled out at 180° 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.

Solution	**Positive electrode (anode)**			**Negative electrode (cathode)**		
	Observations	**Element formed**	**State**	**Observations**	**Element formed**	**State**
Copper (II) chloride	Bubbles of gas Bleaches blue litmus white	Chlorine	gas	Brown/red solid coating on rod	Copper	solid
Sodium chloride	Bubbles of gas Bleaches blue litmus white	Chlorine	gas	Bubbles of gas (more rapid production)	Hydrogen	gas

Additional information

This practical activity could involve developing a hypothesis to reinforce working scientifically, so students could work individually or in groups to devise a hypothesis about the products that will be formed at the electrodes.

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 potential difference to 4 V and the electrolysis times to 5 minutes will minimize the risk of chlorine exposure.

Suggested alternative approaches from teachers and technicians

- A simpler version can be carried out in a Petri dish:
  - place approximately 5 cm^3 of copper(II) chloride solution in the Petri dish
  - connect two carbon fibre electrodes to a 4 V power source
  - chlorine is produced at the anode and copper at the cathode
  - if a drop of potassium iodide is also placed in the covered Petri dish it will darken as the electrolysis progresses. This is because the chlorine is displacing the iodine.
- You can watch the CLEAPSS version of this on YouTube at youtube.com/watch?v=KvW-g1FQV9E

Temperature changes

Investigate the variables that affect temperature change in chemical reactions eg acid plus alkali.

	Trilogy	Synergy	Chemistry
RPA	10	18	4
Specification reference	5.5.1.1	4.7.3.3	4.5.1.1

By using this method your students will have the opportunity to develop the following aspects of the chemistry AT skills	
AT1	use of appropriate apparatus to make and record a range of measurements accurately, including mass, temperature and volume of liquids
AT 5	making and recording appropriate observations during chemical reactions including changes in temperature
AT 6	safe 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

Materials

For the basic method

- 2 mol/dm^3 hydrochloric acid
- 2 mol/dm^3 sodium hydroxide solution
- expanded polystyrene cups and lids with thermometer holes
- thermometers.

Technical information

To prepare 2 mol/dm^3 hydrochloric acid, consult CLEAPSS.

To prepare 2 mol/dm^3 sodium hydroxide solution, consult CLEAPSS.

Additional information

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 fairly concentrated in order to produce reasonable temperature changes.

2 mol/dm^3 sodium hydroxide is particularly hazardous to the eyes.

Results from our technician adviser trials

Total volume of sodium hydroxide added in cm^3	**Maximum temperature in ^oC**		
	First trial	**Second trial**	**Mean**
0	20.0	21.0	
5	24.0	24.6	
10	26.8	27.6	
15	28.6	29.6	
20	30.8	31.3	
25	31.8	32.8	
30	32.0	32.6	
35	31.6	31.8	
40	30.6	31.0	

Rates of reaction

Investigate how changes in concentration affect the rates of reactions by both measuring the volume of a gas produced and monitoring a change in colour or turbidity.

	Trilogy	**Synergy**	**Chemistry**
RPA	11	19	5
Specification reference	5.6.1.2	4.7.4.3	4.6.1.2

By using this method your students will have the opportunity to develop the following aspects of the chemistry AT skills	
AT1	use of appropriate apparatus to make and record a range of measurements accurately, including mass, time, temperature and volumes of liquids and gases
AT 3	use of appropriate apparatus and techniques for conducting and monitoring chemical reactions
AT 5	making and recording appropriate observations during chemical reactions including the measurement of rates of reaction by a variety of methods such as production of gas and colour change
AT 6	safe and careful handling of liquids and solids, including careful mixing of reagents under controlled conditions, using appropriate apparatus to explore chemical changes

Activity 1: Investigating measurement of rate of reaction using volume of gas produced Materials

For the basic method

- magnesium ribbon cut into 3 cm lengths
- dilute hydrochloric acid, 1.0 mol/dm^3 and 1.5 mol/dm^3
- safety goggles
- conical flask (100 cm^3)
- single-holed rubber bung and delivery tube to fit conical flask
- water trough
- two measuring cylinders (100 cm^3)
- clamp stand, boss and clamp
- stopclock.

Technical information

The magnesium ribbon needs to be cleaned by rubbing lengths of the ribbon with fine sandpaper to remove the layer of oxidation. Gas syringes can be used instead of troughs of water and measuring cylinders.

To prepare hydrochloric acid, see CLEAPSS.

The AQA technician adviser results are below:

Time in seconds	**Volume of gas produced (cm^3)**	
	1.0 mol/dm^3	**1.5 mol/dm^3**
10	4.0	12.0
20	9.0	25.0
30	16.0	36.0
40	23.0	49.0
50	31.0	56.0
60	39.0	56.0
70	44.0	56.0
80	50.0	56.0
90	50.0	56.0
100	50.0	56.0

Activity 2: investigating measurement of rate of reaction using colour change or turbidity

Materials

For the basic method

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

Technical information

To prepare 40 g/dm^3 sodium thiosulfate solution, consult CLEAPSS. The concentration is specified in g/dm^3 rather than mol/dm^3 to simplify graph plotting for students.

To prepare 1.0 mol/dm^3 dilute hydrochloric acid, consult CLEAPSS.

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

Additional information

Sulfur dioxide gas is released during the reaction, which can exacerbate breathing difficulties in people with conditions such as asthma. The laboratory should be well ventilated and it might be appropriate to cover the neck of the conical flask with cling film for example.

Consult CLEAPPS guide for additional safety information and for safe disposal instructions.

Concentration of sodium thiosulfate in g/dm^3	**Time taken for cross to disappear in seconds**			
	First trial	**Second trial**	**Third trial**	**Mean**
8	137	138	156	
16	76	75	77	
24	46	47	46	
32	37	40	37	
40	27	25	27	

Chromatography

Investigate how paper chromatography can be used to separate and tell the difference between coloured substances. Students should calculate R_f values.

	Trilogy	**Synergy**	**Chemistry**
RPA	12	9	6
Specification reference	5.8.1.3	4.2.2.4	4.8.1.3

In this practical students use paper chromatography to separate and identify a mixture of food colourings.

By using this method students will have the opportunity to develop the following aspects of the chemistry AT skills	
AT 4	safe use of a range of equipment to purify and/or separate chemical mixtures including chromatography

Materials

For the basic method

- a 250 cm^3 beaker
- a wooden spill or pencil to support the chromatography paper
- paper clip
- a ruler
- a pencil
- distilled water
- four known food colourings labelled A–D
- unknown food colouring labelled U
- rectangle of chromatography paper
- five glass capillary melting point tubes.

Technical information

There are several brands of food colouring available. It will be necessary to experiment to obtain a type that gives good results. The unknown mixture **U** should contain two of the known food colourings 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

Chromatography paper should be 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 action and are a convenient way of making small, concentrated, reproducible spots.

Wet chromatography paper is difficult to take measurements from. Because of the drying time involved it may be necessary to take measurements and do calculations during the following lesson. Hairdryers might be used to speed up drying time.

Students should be reminded not 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. If desired, a Petri dish makes a suitable lid.

Identifying ions

Use of chemical tests to identify the ions in unknown single ionic compounds covering the ions from Flame tests and sulphates.

	Chemistry
RPA	7
Specification reference	4.8.3

By using this method your students will have the opportunity to develop the following aspects of the chemistry AT skills	
AT 2	safe use of appropriate heating devices and techniques including 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 test and precipitation reactions

Materials

For the basic method to fulfil the ATs:

- nichrome wire mounted in handle
- limewater
- 0.4 mol/dm^3 dilute hydrochloric acid
- 0.1 mol/dm^3 barium chloride solution
- 0.4 mol/dm^3 dilute nitric acid
- 0.05 mol/dm^3 silver nitrate solution
- 0.4 mol/dm^3 known labelled cation salt solutions: LiCl, NaCl, KCl, $CaCl_2$, $CuCl_2$
- 0.4 mol/dm^3 known labelled anion salt solutions: Na_2CO_3, Na_2SO_4, NaCl, NaBr, NaI
- 0.4 mol/dm^3 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 or corks fitted with a loop of wire. If nichrome wires are not available, soaked splints can be briefly heated to give acceptable results.

Consult CLEAPSS to prepare:

- 0.4 mol/dm^3 dilute hydrochloric acid
- 0.1 mol/dm^3 barium chloride solution
- 0.4 mol/dm^3 dilute nitric acid
- 0.05 mol/dm^3 silver nitrate solution.

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.

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.

Suggested alternative approaches from teachers and technicians

- It may simplify organisation if each test (flame test, carbonate test, sulfate test, halide test) is set up at a separate station.
- The flame tests described in the handbook can be carried out using solutions (0.4 mol/dm^3: LiCl, NaCl, KCl, $CaCl_2$, $CuCl_2$) and splints rather than nichrome wire.
- Carbonate test: Fill 5 test tubes with the sodium solutions (0.4 mol/dm^3: Na_2CO_3, Na_2SO_4, NaCl, NaBr, NaI) add approx. 1 cm depth of HCl to the tubes in turn. If any bubbles are produced test for CO_2 using a lit splint. If this extinguishes then the test is positive.

AQA technician results

Activity 1

Metal ion	**Lithium**	**Sodium**	**Potassium**	**Calcium**	**Copper**
Flame colour	crimson	yellow	lilac	orange/red	green

Activity 2, 3 and 4

Non-metal ion	**Carbonate**	**Sulfate**	**Chloride**	**Bromide**	**Iodide**
Carbonate test	Effervescent goes cloudy	No change	No change	No change	No change
Sulfate test	No change	White precipitate	No change	No change	No change
Halide test	No change	No change	White precipitate	Cream precipitate	Yellow precipitate

Water purification

Analysis and purification of water samples from different sources.

To include pH measurement, removal of dissolved solids and distillation.

	Trilogy	**Synergy**	**Chemistry**
RPA	13	11	8
Specification reference	5.10.1.2	4.4.1.8	4.10.1.2

This practical involves several activities.

- Students demonstrate that a sample of water is impure by:
  - measuring the pH and comparing it with the pH of pure water
  - demonstrating that the sample contains dissolved solids by evaporating it and revealing dissolved solids. They can extend the analysis by calculating the mass of dissolved solids present.
- Students then distil the water. They then re-test the distillate to show that the water has been purified.

This can be delivered in a range of different contexts to suite the ability of your students eg accessing drinking water on a cruise ship or on a desert island.

By using this method students will have the opportunity to develop the following aspects of the chemistry AT skills	
AT1	use of appropriate apparatus to make and record a range of measurements accurately including mass
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

Materials

For the basic method

pH tests

- safety goggles
- pure distilled water
- samples of water at different pH values
- universal indicator solution or paper.

Dissolved solids

- sample of a prepared salt solution or mineral bottled water (concentration unimportant but should give good crystal formation when evaporated)
- Bunsen burner
- tripod
- gauze
- heatproof mat
- evaporating basin
- weighing balance.

Distillation

- conical flask with delivery tube with bung
- 1 boiling tube
- ice bath.

Additional information

In the **distillation experiment** students will need to be cautioned to remove the heat source if it seems likely the salt water will boil over through the delivery tube. They should also be told to keep the delivery tube at least 2 cm 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.

Student worksheets

Making salts

Making soluble salts: preparation of pure dry copper sulfate crystals.

In this practical you will:

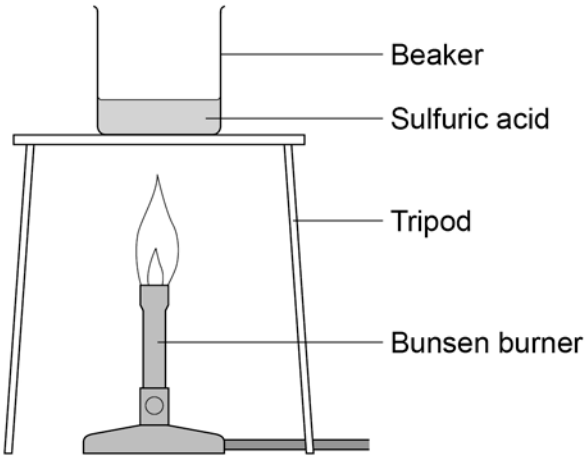
- react sulfuric acid with insoluble copper (II) oxide to prepare an aqueous solution of the salt copper sulfate
- separate out unreacted copper (II) oxide by filtration
- prepare pure dry crystals of copper sulfate from the solution.

Apparatus

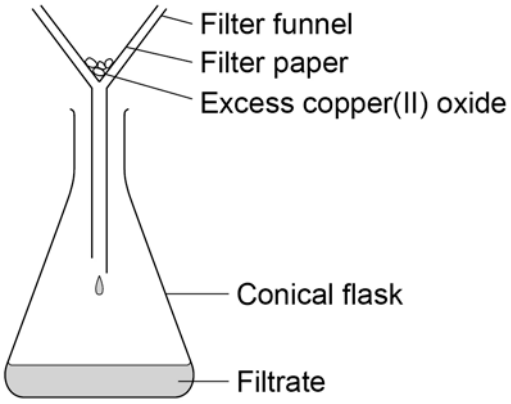
- dilute sulfuric acid
- a measuring cylinder
- copper(II) oxide powder
- a spatula
- a glass rod
- a 100 cm^3 beaker
- a 250 cm^3 beaker
- a Bunsen burner
- a tripod
- gauze
- a heatproof mat
- a filter funnel and paper
- a small conical flask
- an evaporating basin
- a crystallising dish.

Method

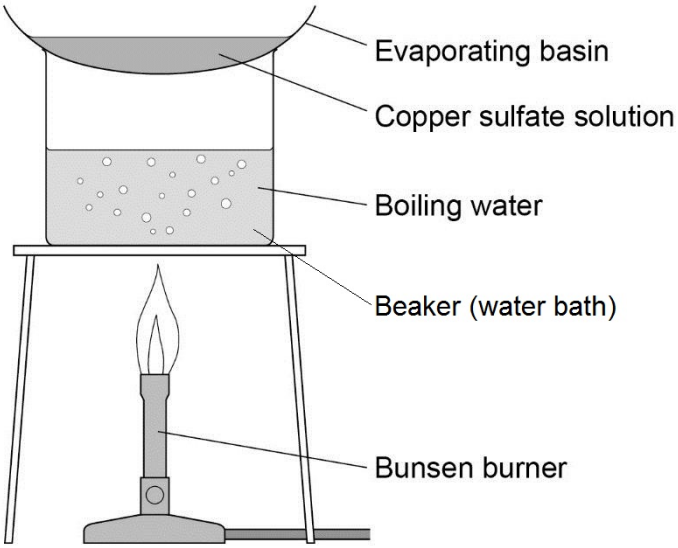
1. Measure 40 cm^3 sulfuric acid and put it into the 100 cm^3 beaker.
2. Set up the Bunsen burner, tripod, gauze and heatproof mat. Put the beaker on the gauze and heat the acid **gently** until it is almost boiling. **Turn off the Bunsen burner**.



3. Remove the glass beaker from the tripod. Use the spatula to add a **small** amount of copper (II) oxide powder to the hot acid. Stir with the glass rod. The copper (II) oxide will disappear and the solution will turn clear blue.
4. Add some more copper (II) oxide and stir again.
5. Keep adding the copper (II) oxide until some of it remains after stirring.
6. Allow the apparatus to cool completely.
7. Set up the filter funnel and paper over the conical flask. Filter the contents of the beaker.



8. Pour the filtrate from the conical flask into the evaporating basin.
9. Set up a water bath using the 250 cm^3 beaker on the tripod and gauze.
10. Evaporate the filtrate gently using the water bath.



11. When crystals start to form, stop heating the water bath.
12. Pour the remaining solution into the crystallising dish.
13. Leave the crystallising dish in a cool place for at least 24 hours.
14. Remove the crystals from the concentrated solution with a spatula.

    Gently pat the crystals dry between two pieces of filter paper.

Task

Write a word and a symbol equation for the chemical reaction you have carried out in the space below.

Neutralisation

Foundation Tier only.

Determination of the reacting volumes of solutions of a strong acid and a strong alkali by titration.

In this practical you will use a burette and colour change indicator to find out the volume of sulfuric acid that neutralises 25 cm^3 of sodium hydroxide solution.

Apparatus

You should have:

- a 25 cm^3 volumetric pipette and pipette filler
- burette
- a small funnel
- a clamp and clamp stand
- a 250 cm^3 conical flask
- a White tile
- dilute sulfuric acid
- sodium hydroxide solution
- phenolpthalein indicator.

Method

1. Use the pipette and pipette filler to put exactly 25 cm^3 sodium hydroxide solution into the conical flask.
2. Put the flask on a white tile.
3. Clamp the burette vertically in the clamp stand. There should be just enough room underneath for the conical flask and tile.
4. Close the burette tap.
5. Use the small funnel to carefully fill the burette with dilute sulfuric acid. Before it completely fills put a small beaker underneath the tap, gently open it to allow acid to fill the tap, before closing again and filling the burette to the 0.00 cm^3 line. Remove the funnel.
6. Put 5–10 drops of phenolpthalein indicator into the conical flask. Swirl the flask to mix and put under the burette on top of the tile. The contents of the flask will go pink.
7. Carefully open the burette tap so that 10 cm^3 sulfuric acid slowly flows into the flask. Constantly swirl the flask when adding the acid. Then add the acid drop by drop until you see a permanent colour change from **pink to colourless** in the flask.

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

8. Read the burette scale carefully and record the volume of acid you added to 2dp. Use a table like this one:

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

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

Task

a. Calculate the mean value for the volume of acid needed to neutralise 25 cm^3 of the sodium hydroxide solution.

b. Why do you think we call the first trial 'rough'? How did this volume help you as you repeated the practical work?

Higher Tier only

Determination of the

- **reacting volumes of solutions of a strong acid and a strong alkali by titration**
- **concentration of one of the solutions in mol/dm^3 and g/dm^3 from the reacting volumes and the known concentrations of other solutions**

In this practical you will:

- use a burette and colour change indicator to find out the volume of sulfuric acid that neutralises 25 cm^3 of 0.1 mol/dm^3 sodium hydroxide solution
- use your results to calculate the concentration of the sulfuric acid in mol/dm^3 and in g/dm^3.

Apparatus

- a 25 cm^3 volumetric pipette and pipette filler
- burette
- a small funnel
- a clamp and clamp stand
- a 250 cm^3 conical flask
- a White tile
- dilute sulfuric acid, concentration not known
- 0.1 mol/dm^3 sodium hydroxide solution
- phenolpthalein indicator.

Method

1. Use the pipette and pipette filler to put exactly 25 cm^3 sodium hydroxide solution into the conical flask.
2. Put the flask on a white tile.
3. Clamp the burette vertically in the clamp stand. There should be just enough room underneath for the conical flask and tile.
4. Close the burette tap.
5. Use the small funnel to carefully fill the burette with dilute sulfuric acid. Before it completely fills put a small beaker underneath the tap, gently open it to allow acid to fill the tap, before closing again and filling the burette to the 0.00 cm^3 line. Remove the funnel.
6. Put 5–10 drops of phenolpthalein indicator into the conical flask. Swirl the flask to mix and put under the burette on top of the tile. The contents of the flask will go pink.

7. Carefully open the burette tap so that 10 cm^3 of sulfuric acid slowly flows into the flask. Constantly swirl the flask when adding the acid. Then add the acid drop by drop until you see a permanent colour change from pink to colourless in the flask.
8. You need to be able to shut the tap immediately after a single drop of acid causes the colour to become permanently colourless.
9. Read the burette scale carefully and record the volume of acid you added to 2dp. Use a table like this one:

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

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

Task

a. Calculate the mean value for the volume of acid needed to neutralise 25 cm^3 of the sodium hydroxide solution.

b. 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

moles NaOH = Molarity x volume / 1000

= _____ moles NaOH

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.

NaOH : H_2SO_4
2 : 1 so moles NaOH = ½ moles H_2SO_4

= _____ moles H_2SO_4

Step 3

Concentration of H_2SO_4 = answer from step 2 x 1000/mean volume used

= _____ mol/dm^3

Step 4

$$\text{Number of moles} = \frac{\text{mass of substance (g)}}{M_r \text{ of substance}}$$

A_r (H) = 1; A_r (O) = 16; A_r (S) = 32

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

Electrolysis

Investigate what happens when two different aqueous solutions are electrolysed using inert electrodes.

In this practical you will:

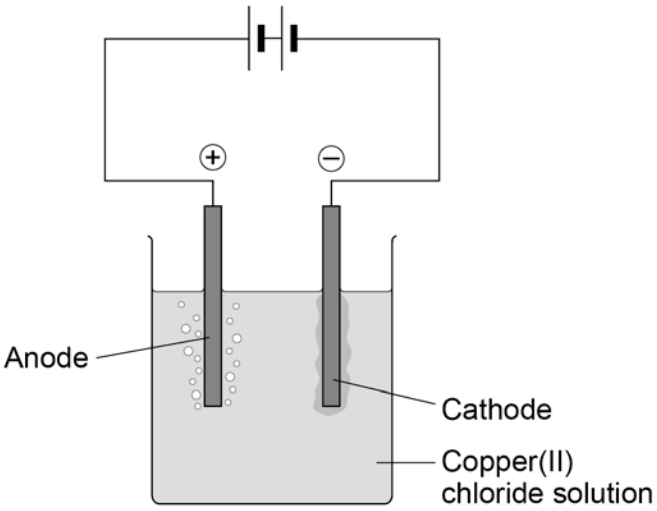
- use a low voltage power supply and carbon rod electrodes to pass a current through two different salt solutions
- identify the element formed at the positive and negative electrodes for each solution
- add extra detail to the basic electrochemical diagram provided.

Apparatus

- copper(II) chloride solution
- sodium chloride 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
- forceps.

Method

1. Pour approximately 50 cm^3 copper (II) chloride solution into the beaker.
2. Add the petri dish lid and insert the carbon rods through the holes. **The rods must not touch each other**.
3. Attach crocodile leads to the rods. Connect the rods to the dc (red and black) terminals of a low voltage power supply.



4. Select 4 V on the power supply and switch on.
5. Look at both electrodes and record your initial observations in the table below.
6. Use forceps to hold a piece of blue litmus paper in the solution next to the anode (positive electrode) and identify the element?

   Write all your observations in a table like this one.

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

Care - switch off the power supply after 5 minutes.

7. Rinse the electrochemical cell apparatus and collect a new set of electrodes.

   Repeat steps 1–8 using the other solution sodium chloride and complete the following tasks to show your understanding of the chemistry of electrolysis.

   a. Draw a fully labelled diagram of your electrochemical cell.

   b. What is the third main product of this electrolysis reaction that could be detected with the use of red litmus?

Electrolysis is also used to extract metals from their ore. Aluminium is manufactured by the electrolysis of a molten mixture of aluminium oxide and cryolite using carbon as the positive electrode.

To support with your revision:

a. Explain why a mixture is used as the electrolyte.

b. Explain why the positive electrode must be continuously replaced.

c. Write half equations for the chemical reactions happening at both electrodes (HT only).

Temperature changes

Investigate the variables that affect temperature change in chemical reactions eg acid plus alkali.

In this practical you will:

- react sodium hydroxide solution with hydrochloric acid
- measure the temperature changes during the reaction
- plot a graph of your results and record the temperature change.

Apparatus

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

Method

1. Measure 30 cm^3 dilute hydrochloric acid and put it 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 your result in a table like this.

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			

4. Measure 5 cm^3 sodium hydroxide solution.
5. Pour the sodium hydroxide into the polystyrene cup. Fit the lid and gently stir the solution with the thermometer through the hole.
6. Look carefully at the temperature rise on the thermometer.
7. When the reading on the thermometer **stops changing**, record the highest temperature reached in the table.
8. Repeat steps 4–7 to add further 5 cm^3 amounts of sodium hydroxide to the cup each time, recording your temperature reading in the results table.
9. Repeat until a maximum of 40cm^3 of sodium hydroxide has been added.
10. Wash out all the equipment and repeat the experiment for your second trial.

Analysis and conclusion

a. Calculate the **mean** maximum temperature reached for each volume of sodium hydroxide. Record these means in your table.

b. Plot a graph from your results and draw two straight lines of best fit.

c. From the graph read off the maximum temperature change.

d. This is an example of an **exothermic** reaction, when heat is given out. Can you explain why the results you recorded show that the temperature started to fall after a certain volume of sodium hydroxide had been added?

e. Can you explain what is happening to the chemical bonds in the reactants and the products when an exothermic reaction is taking place?

Rates of reaction

How does the concentration of an acid affect the rate of reaction?

Activity 1 – by measuring the volume of gas produced

In this practical you will:

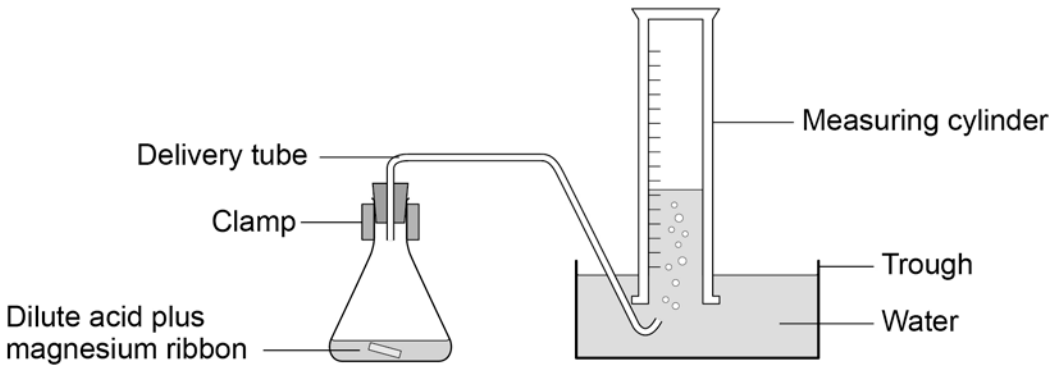
- react magnesium ribbon with different concentrations of hydrochloric acid
- measure the volume of gas produced for each concentration.
- use your results to work out how the rate of reaction is affected by the concentration of the acid.

Apparatus

- safety goggles
- a 100 cm^3 conical flask
- a single-holed rubber bung and delivery tube to fit conical flask
- a water trough
- two 100 cm^3 measuring cylinders
- a clamp stand, boss and clamp
- a stop clock
- magnesium ribbon cut into 3 cm lengths
- two different concentrations of dilute hydrochloric acid, 1.0 mol/dm^3 and 1.5 mol/dm^3

Method

1. Measure 50 cm^3 of 1.0 mol/dm^3 hydrochloric acid using one of the measuring cylinders. Pour the acid into the 100 cm^3 conical flask.
2. Fit the bung and delivery tube to the top of the flask.
3. Half fill the trough or bowl with water.
4. Fill the other measuring cylinder with water. Make sure it stays filled with water when you invert it into the water trough and that the delivery tube is positioned correctly.



5. Add a single 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.
6. Record the volume of hydrogen gas given off at suitable intervals (eg 10 seconds) in a table like this:

Time in seconds	**Volume of gas produced cm^3**	
	1.0 mol/dm^3	**1.5 mol/dm3**
10		
20		
30		
40		
50		
60		
70		
80		
90		
100		

Continue timing until the volume of gas does not change.

7. Repeat steps **1–6** using 1.5 mol/dm^3 hydrochloric acid.

Analysis, conclusion and evaluation

a. Plot a graph of your results.

b. Draw a line of best fit. The results should generate a curve not a straight line.

c. Plot the curve for both 1.0 mol/dm^3 and 1.5 mol/dm^3 hydrochloric acid on the same graph.

d. Use your graph to compare the rates of reaction with different concentrations of hydrochloric acid with magnesium.

e. Use kinetic theory to explain your findings.

How does the concentration of sodium thiosulphate affect the rate of reaction?

Activity 2 – investigating measurement of rate of reaction using colour change or turbidity

In this practical you will:

- react different concentrations of sodium thiosulfate with hydrochloric acid
- use a stop clock to time how long it takes for the mixture to become cloudy for each concentration
- use your results to work out how the rate of reaction changes as the concentration of the sodium thiosulfate changes.

Apparatus

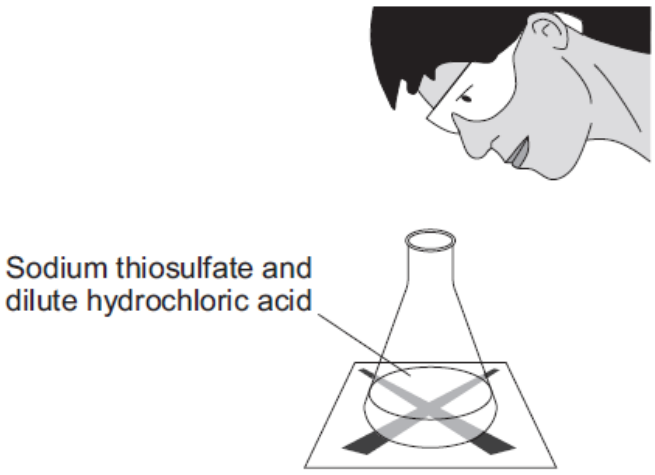
- 40 g/dm^3 sodium thiosulfate solution
- dilute hydrochloric acid
- 10 cm^3 measuring cylinder
- 100 cm^3 measuring cylinder
- 100 cm^3 conical flask
- printed black paper cross
- stopclock.

Method

1. Measure 10 cm^3 sodium thiosulfate solution and put it into the conical flask.
2. Measure 40 cm^3 of water. Add the water to the conical flask.
3. This dilutes the sodium thiosulfate solution to a concentration of 8 g/dm^3.
4. Put the conical flask on the black cross.
5. Measure 10 cm^3 of dilute hydrochloric acid.
6. Put this acid into the flask. At the same time swirl the flask gently and start the stopclock.

7. 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.



8. Record the time it takes for the cross to disappear in the table below. Record the time **in 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				

9. Repeat steps **1–7** changing the concentration of sodium thiosulphate each time as below

   - 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).

Analysis, conclusion and evaluation

a. Share results with two other groups. Record these results in the second and third blank columns of your table.

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

c. Plot a graph and draw a smooth curved line of best fit.

d. Describe the relationship between the independent variable and the dependent variable? What were your control variables?

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

f. Evaluate the two methods that you have used to investigate the effect of concentration on rate of reaction.

Chromatography

Investigate how paper chromatography can be used to separate and identify a mixture of food colourings.

In this practical you will:

- use paper chromatography to separate a mixture of food colourings
- calculate the R_f value for each pure food colouring in the solvent water
- use your R_f values to identify which colourings are in the unknown mixture, U.

Apparatus

- a 250 cm^3 beaker
- a wooden spill
- a rectangle of chromatography paper
- four known food colourings labelled A–D
- an unknown mixture of food colourings labelled U
- five glass capillary tubes
- a paper clip
- a ruler
- a pencil.

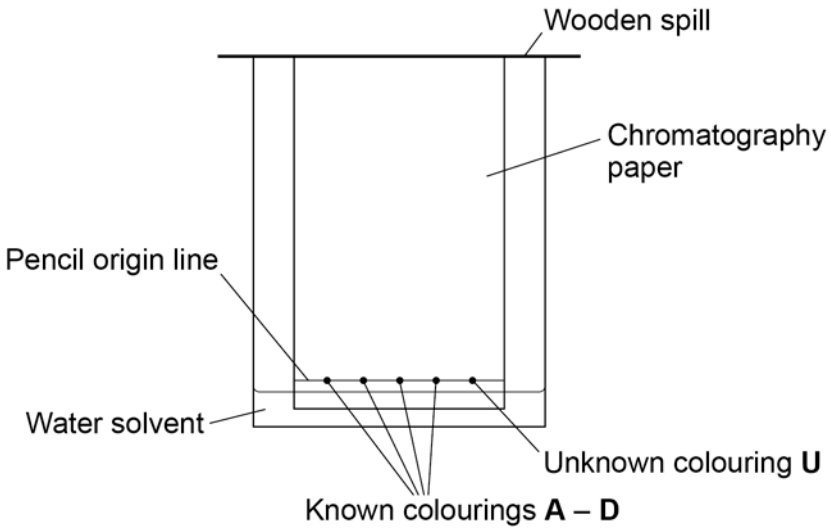
Method

1. Use a ruler to draw a horizontal pencil line 2 cm from the bottom short edge of the chromatography paper. This is your **origin line**.
2. Mark five pencil spots at equal intervals across the origin line. Make sure you keep at least
3. 0.5 cm away from each edge of the paper.
4. Use a glass capillary tube to put a small spot of each colouring **A**, **B**, **C** and **D** on four of the pencil spots. Use a different tube for each colouring. Use the fifth tube to put a small spot of the unknown mixture **U** on the fifth pencil spot.
   Try to make sure each spot is no more than 2-3 mm in diameter.
   Label each spot **in pencil**.
5. Pour water into the beaker to a depth of **no more than 1 cm**.
6. Clip the top short edge of the chromatography paper to the wooden spill. The top end is the end furthest from the spots.
7. Carefully rest the wooden spill on the top edge of the beaker. The bottom edge of the paper should dip into the water solvent.

Make sure that:

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

Your apparatus should look like this:



7. 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.**
8. Carefully remove the paper from the beaker. Draw another pencil line on the dry part of the paper as close to the wet edge as possible. This is called the **solvent front line.**
9. Hang the paper up to dry thoroughly.
10. Measure the distance in mm between the two pencil lines. This is the distance travelled by the water solvent.
11. For each of food colour A, B, C and D measure the distance in mm from the start line to the middle of the spot.

12. Record your measurements in the table below:

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

Analysis, conclusion and evaluation

a. Calculate the R_f value for each of the known colours. Use the equation:

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

b. Observe the spots made by food colouring mixture **U**.

c. What conclusions can you draw from your results?

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

e. How do you know that a chemical is pure from chromatography results? Are there any other ways that chemists use to ensure that a substance is a pure substance?

Identifying ions

Use of chemical tests to identify the ions in unknown single ionic compounds

In this practical you will:

- use flame tests and add a range of solutions to analyse a range of known ionic compounds
- use your results to identify the ions present in an unknown solution.

Apparatus

- Bunsen burner
- test tubes and test tube rack
- teat pipette
- nichrome wire mounted in handle or cork
- limewater
- 0.4 mol/dm^3 dilute hydrochloric acid
- 0.1 mol/dm^3 barium chloride solution
- 0.4 mol/dm^3 dilute nitric acid
- 0.05 mol/dm^3 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’.

Method

Activity 1 Flame Tests

1. Pour about 1 cm depth of each of the labelled chloride solutions 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 a table like this:

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

4. Clean the wire carefully.
5. Repeat steps 2–4 for each of the other four solutions.
6. Empty and clean the test tubes.

Activity 2 Carbonate test

1. Pour about 1 cm depth of each of the labelled sodium solutions into five test tubes in the rack.
2. Place 1 cm depth of limewater in a sixth test tube.
3. Add 1 cm depth of dilute hydrochloric acid to each sodium salt solution in turn.
4. Only if you see bubbles, quickly use the teat pipette to transfer the gas produced to the limewater. You should pipette the gas into the limewater solution. Your teacher may show you how to do this.
5. You will need to take several pipettes of the gas coming off at the surface to get a change in the limewater.
6. Record your results in the first blank row of a table like this:

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

7. Empty and clean the test tubes.

Activity 3 Sulfate test

1. Pour about 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 ‘Sulfate test’ row of your table.
4. Empty and clean the test tubes.

Activity 4 Halide test

1. Pour about 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 ‘Halide test’ row of your table.

Testing the unknown salt solution

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

Flame test	**Carbonate test**	**Sulphate test**	**Halide test**

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

Water purification

Analysing and purifying a sample of water and making it safe to drink.

In this practical you will:

- analyse a water sample
- purify a water sample by distillation.

Activity 1: Analysing a sample of water

Apparatus

- 10 cm^3 of each of the water samples to be tested
- universal indicator paper or solution.

Method

1. Use the universal indicator paper to measure the pH of the water sample.
2. Accurately weigh an empty evaporating basin and record to two decimal places.
3. Pour 10 cm^3 of water sample 1 into the evaporating basin.
4. Heat the evaporating basin on a tripod and gauze using a Bunsen burner until the solids start to form and the majority of water has evaporated.
5. Weigh the cooled evaporating basin again and calculate the mass of the solids that were dissolved in the water.
6. Record your results in a table:

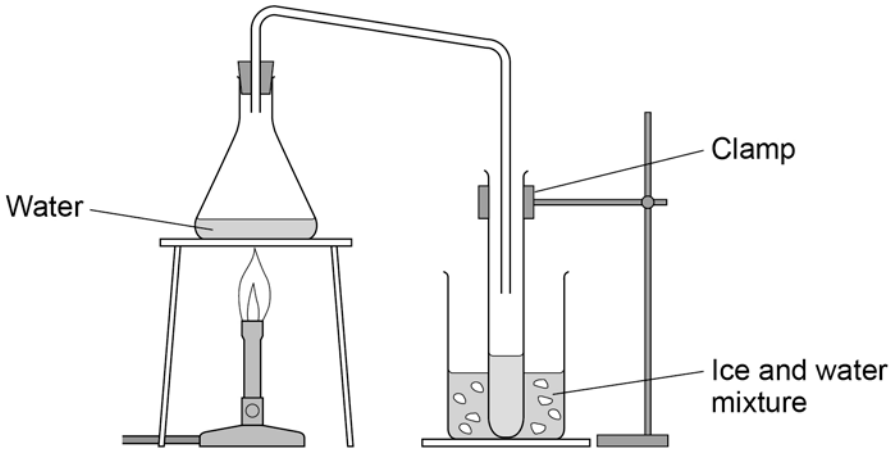
	pH	**Mass of solids dissolved in 10 cm^3**
Water sample 1		
Water sample 2		
Water sample 3		

Activity 2: Purifying a sample of water by distillation

Apparatus

- 10 cm^3 of water sample 1
- a Bunsen burner
- a tripod
- gauze
- a heatproof mat
- clamp and clamp stand
- conical flask with delivery tube and bung
- a boiling tube
- ice bath.

1. Place the water sample in the conical flask. Set up the apparatus for distillation as shown in the diagram.



2. Heat the water using the Bunsen burner until it boils. Then reduce the heat so that the water boils gently.
3. The distilled water will collect in the cooled test tube. Collect about 1 cm depth of water in this way, then stop heating.
4. Analyse the water you have distilled by determining its boiling point.

Task

Use the following key words to write a paragraph to explain how you have collected a sample of pure water:

- evaporation
- condensation
- steam
- gas
- liquid
- boiling
- temperature
- cool surface.

What is the difference between **pure** water and **potable** water?

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Visit our website for information, guidance, support and resources at aqa.org.uk/8462

You can talk directly to the science subject team

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