

GCSE Chemistry: Required practical activities

DRAFT

Introduction

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. By carrying out carefully considered practical work, students will enhance their investigative thinking, improve their mastery of techniques and consolidate their understanding of key scientific concepts.

The assessment of practical skills is changing, so we are creating documents to help you and your students prepare for the changes including the *Required practical summary*. It provides further details on how the sample lessons in this document meet the specified practical skills, mathematical skills and Working scientifically skills.

This document contains the required practical activities for the GCSE Chemistry qualification. By undertaking the required practical activities, students will have the opportunity to experience all of the required apparatus and techniques needed for the qualifications. However, these activities are only suggestions and teachers are encouraged to develop activities, resources and contexts that provide the appropriate level of engagement and challenge for their own students.

These sample activities have been written by practising teachers and use apparatus and materials that are commonly found in most schools.

When planning your lessons, remember that the required practical activities listed as ‘chemistry **only**’ (practicals 2 and 7) are only required by GCSE Chemistry and not for either of the combined science specifications.

Getting started

Risk assessment

These required practical activities have been suggested by teachers who have successfully carried them out in the lab. However it is the responsibility of the centre to ensure that full risk assessments have been carried out in each case.

Trialling

The practical activities should be trialled before use with students to ensure that they match the resources available within the school or college.

GCSE science practical handbook

Further guidance on carrying out effective practical work will be made available in the new AQA *Science Practical Handbook* which will be published in the spring 2016. It will provide resources for teachers and students including:

1. cross-board apparatus and techniques and Ofqual regulations
2. practical skills assessment in question papers
3. sample practical lessons
4. guidelines for supporting students in practical work
5. improving the quality of practical work
 - a. working scientifically
 - b. collecting data
 - c. graphing
 - d. glossary of terms
6. practical progression ladders
7. student resources.

GCSE Chemistry required practical activity 1: 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 candidate needs:

- 40cm³ 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.

40cm³ 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.

Alternative practical

Outline method	Suggested apparatus	Suggested reagents
Add zinc carbonate to cold dilute sulfuric acid in small amounts with stirring until in excess. Filter and evaporate filtrate to concentrate. Leave to crystallise.	Beaker, conical flask, filter funnel & paper, glass rod, spatula, Bunsen burner, tripod, gauze, clamp stand, heatproof mat, evaporating basin, crystallising dish.	Dilute sulfuric acid, zinc carbonate.

GCSE Chemistry required practical activity 1: 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

In this investigation you will use the reaction between an acid and an insoluble base to prepare an aqueous solution of a salt. After filtering to remove excess unreacted base, you will evaporate the filtrate to leave a concentrated solution of the salt, which will crystallise as it cools and evaporates further. These crystals, when dry, will be of high purity.

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

Method

You are provided with the following:

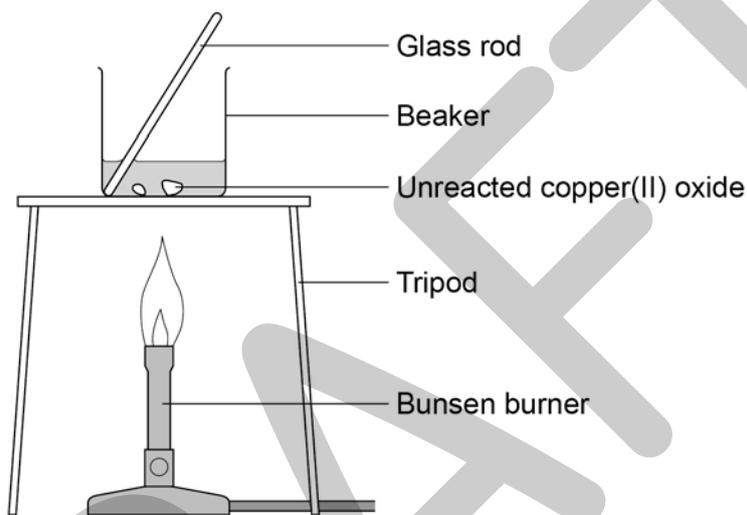
- 40cm³ 1.0M dilute sulfuric acid
- Copper (II) oxide powder
- Spatula, glass rod
- 100cm³ beaker, Bunsen burner, tripod, gauze, heatproof mat.
- Filter funnel and paper, clamp stand, conical flask.
- 250cm³ beaker, evaporating basin, crystallising dish.

Risk Assessment

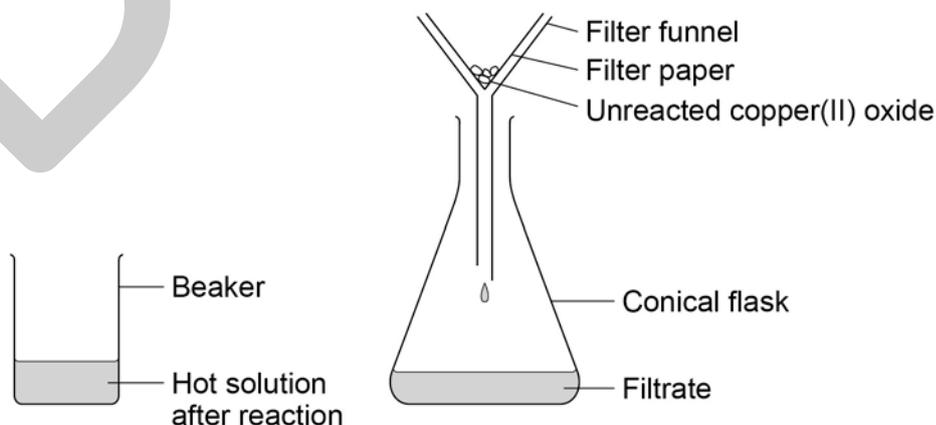
Safety goggles must be worn throughout

You should read these instructions carefully before you start work.

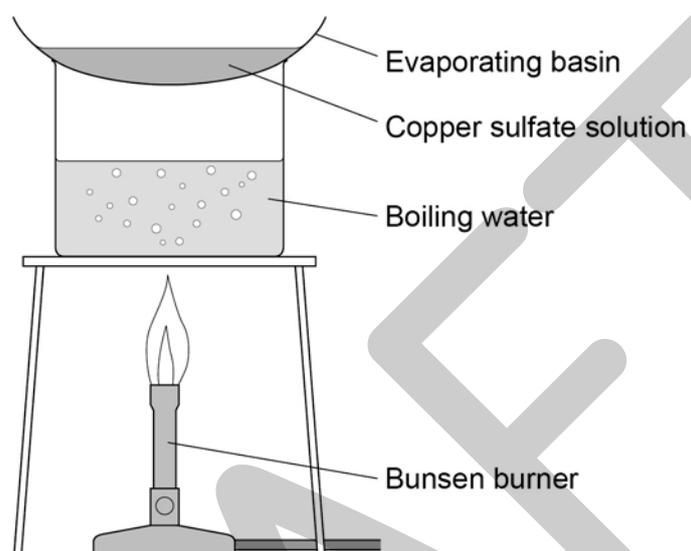
1. Measure 40cm^3 sulfuric acid into the beaker. The volume does not need to be very accurate, so you can use the graduations on the beaker.
2. Set up the tripod, gauze and heatproof mat. Heat the acid **gently** using the Bunsen burner until it is almost boiling. Turn off the burner.



3. Using the spatula, add **small** amounts of copper (II) oxide powder at a time, stirring with the glass rod. Continue to do this if, after stirring, the black powder disappears and the solution is clear blue.
4. Stop adding it when some black powder remains after stirring.
5. Set up the filter funnel and paper over the conical flask, using 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 on the tripod and gauze (see diagram) until around half of the solution remains. You will have to estimate this volume.



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 and **gently** pat them dry between two pieces of filter paper. These are pure dry crystals of copper (II) sulfate.

GCSE Chemistry Required practical activity 2: Neutralisation (chemistry only)

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/dm ³ and g/dm ³ 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 student needs:

- 25cm³ volumetric pipette
- Pipette filler
- 50cm³ 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.

25cm³ 0.1M NaOH is neutralised by 15.6cm³ 0.08M H₂SO₄. Therefore it should be possible to complete all three titrations using one fill of a standard 50cm³ burette. However, the student sheet assumes for simplicity that the burette is refilled each time to 0cm³. 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 (rather than blowing) 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.

Phenolphthalein indicator can be substituted if methyl orange is used. The colour change on the sheet will need to be altered to pink to colourless.

Additional information

If volumetric pipettes and fillers are not available, 50 cm³ measuring cylinders could be substituted, although accuracy will be reduced. Clean heatproof mats could be used instead of white tiles. It is very difficult to manage without burettes, however.

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.

Alternative practicals

The experiment can also be done with hydrochloric acid and an alternative indicator. Furthermore, the alkali could be the reagent of unknown concentration instead of the acid.

Outline method	Suggested apparatus	Suggested reagents
Place NaOH (aq) of known (HT: unknown) concentration in conical flask using graduated pipette and filler. Titrate with dilute HCl of known concentration from burette. Repeat and calculate mean titre and (HT only) concentration of alkali.	Graduated pipette, pipette filler, conical flask, white tile, burette, clamp stand, small funnel.	Dilute sodium hydroxide solution, dilute hydrochloric acid, phenolphthalein.

GCSE Chemistry required practical activity 2: Neutralisation (chemistry only)

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.

In this investigation you will use the colour change in an acid-base indicator to find the volume of dilute sulfuric acid needed to exactly neutralise 25cm³ of sodium hydroxide solution.

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

Method

You are provided with the following:

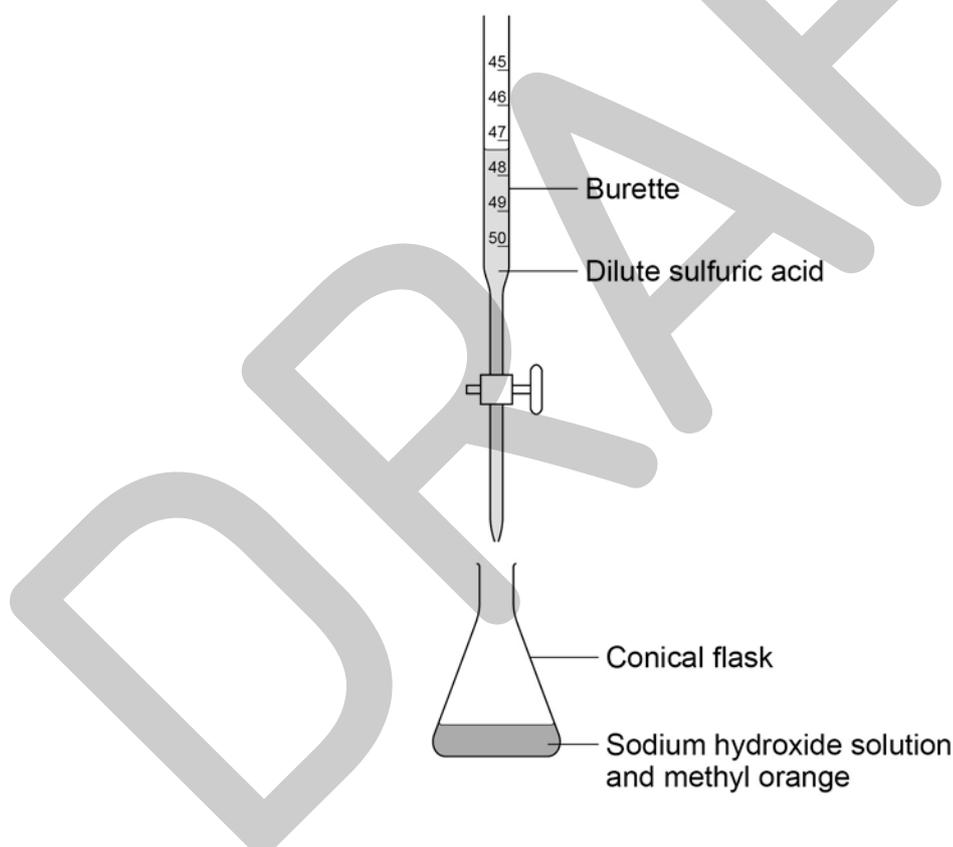
- 25cm³ volumetric pipette and pipette filler
- Burette, small funnel and clamp stand
- 250cm³ conical flask
- White tile
- Dilute sulfuric acid
- Sodium hydroxide solution
- Methyl orange indicator

Risk assessment

Safety goggles must be worn throughout

You should read these instructions carefully before you start work.

1. Use the pipette and pipette filler to put exactly 25cm^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, so that there is just enough room underneath for the conical flask and tile.
3. Making sure the burette tap is closed; use the small funnel to carefully fill the burette with dilute sulfuric acid to the 0cm^3 line. You should do this at a low level so that you are not pouring acid from above head height – for example, with 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 dropwise rate. Whilst adding acid, constantly swirl the flask and look for a colour change from yellow to red in the indicator.
6. When there are signs that the colour change is close to being permanent, 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 in the first blank space in the table below.

-
8. Repeat the whole investigation twice more and record the results of your repeats in the second and third blank spaces.
 9. Calculate the mean value for the volume of acid needed to neutralise 25cm^3 of the sodium hydroxide solution. Record this value in the final space in the table.

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

GCSE Chemistry required practical activity 2: Neutralisation (chemistry only)

Student sheet – Higher Tier

Required practical activity	Apparatus and techniques
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.	AT 1, AT 8

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

In this investigation you will use the colour change in an acid-base indicator to find the volume of dilute sulfuric acid of unknown concentration needed to exactly neutralise 25cm³ of 0.5 mol/dm³ sodium hydroxide solution. You will then calculate the concentration of the acid used in mol/dm³ and g/dm³.

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

Method

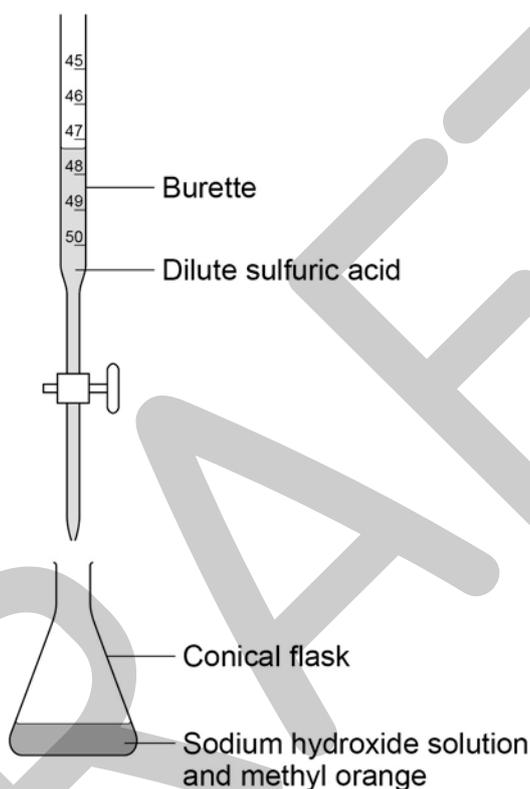
You are provided with the following:

- 25cm³ volumetric pipette and pipette filler
- Burette, small funnel and clamp stand
- 250cm³ conical flask
- White tile
- Dilute sulfuric acid of unknown concentration
- 0.1 mol/dm³ sodium hydroxide solution
- Methyl orange indicator

Risk assessment

Safety goggles must be worn throughout.

You should read these instructions carefully before you start work.



1. Use the pipette and pipette filler to put exactly 25cm^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, so that there is just enough room underneath for the conical flask and tile.
3. Making sure the burette tap is closed; use the small funnel to carefully fill the burette with dilute sulfuric acid to the 0cm^3 line. You should do this at a low level so that you are not pouring acid from above head height – for example, with 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 dropwise rate. Whilst adding acid, constantly swirl the flask and look for a colour change from yellow to red in the indicator.

- When there are signs that the colour change is close to being permanent, 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.
- Read the burette scale carefully and record the volume of acid you added in the first blank space in the table below.
- Repeat the whole investigation twice more and record the results of your repeats in the second and third blank spaces.
- Calculate the mean value for the volume of acid needed to neutralise 25cm^3 of the sodium hydroxide solution.

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

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

Calculations

$$\text{Concentration (mol/dm}^3\text{)} = \text{number of moles} \div \text{volume of solution (dm}^3\text{)}$$

Step 1:

$$\begin{aligned} \text{Moles of sodium hydroxide in 25cm}^3 &= \text{concentration} \times \text{volume} = 0.1 \text{ mol/dm}^3 \times (25 \div 1000) \text{ dm}^3 \\ &= \underline{\hspace{2cm}} \text{ moles} \end{aligned}$$

Step 2:



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

$$\text{So moles of sulfuric acid used} = (\text{answer from step 1}) \div 2 = \underline{\hspace{2cm}} \text{ moles}$$

Step 3:

$$\begin{aligned} \text{Concentration of sulfuric acid (mol/dm}^3\text{)} &= \text{moles} \div \text{mean volume of acid} \\ &= (\text{answer from step 2}) \div (\text{mean volume from table} \div 1000) \\ &= \underline{\hspace{2cm}} \text{ mol/dm}^3 \end{aligned}$$

Step 4:

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

$$A_r(\text{H}) = 1; A_r(\text{O}) = 16; A_r(\text{S}) = 32$$

$$M_r(\text{H}_2\text{SO}_4) = \underline{\hspace{2cm}}$$

$$\begin{aligned} \text{Concentration of sulfuric acid (g/dm}^3\text{)} &= (\text{answer from step 3}) \times M_r(\text{H}_2\text{SO}_4) \\ &= \underline{\hspace{2cm}} \text{ g/dm}^3 \end{aligned}$$

GCSE Chemistry required practical activity 3: 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 (Chemistry only)

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

Materials

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

- 0.5M copper(II) chloride solution
- 0.5M copper(II) sulfate solution
- 0.5M sodium chloride 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 100cm³ 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.

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.

Alternative practicals

Outline method	Suggested apparatus	Suggested reagents
Place solution of NaBr in beaker. Electrolyse using dc power supply and carbon rods. Identify products at electrodes. Repeat for some of: NaI, AgNO ₃ , H ₂ SO ₄ , HCl	Small beaker, lid, carbon rods, crocodile / 4mm plug leads, dc power supply.	Dilute solutions of sodium bromide, sodium iodide, silver nitrate, sulfuric acid, hydrochloric acid.

GCSE Chemistry required practical activity 3: 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 (Chemistry only)

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

In this investigation 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
Teachers to add these with particular reference to working scientifically

Method

You are provided with the following:

- Copper(II) chloride solution
- Copper(II) sulfate solution
- Sodium chloride solution
- Sodium sulfate solution
- 100cm³ beaker with petri dish lid
- Two carbon rod electrodes
- Two crocodile / 4mm plug leads
- Low voltage power supply
- Blue litmus paper
- Tweezers

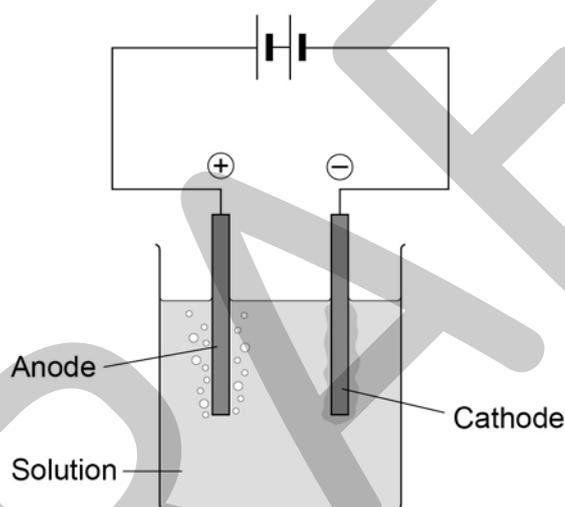
Risk assessment

Safety goggles must be worn throughout.

You should read these instructions carefully before you start work.

1. Pour copper (II) chloride solution into the beaker to about 50cm³.
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 4v on the power supply and switch on.
4. Look at both electrodes. Is there bubbling at neither, one or both electrodes?
5. Using tweezers 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?
6. After no more than five minutes, switch off and 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 out the equipment carefully and repeat the investigation with solutions of copper (II) sulfate, sodium chloride and sodium sulfate.

Additional information:

If a gas is produced at the positive electrode which does **not** bleach blue litmus paper, it 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.

solution	Positive electrode (anode)		Negative electrode (cathode)	
	Observations	Element formed	Observations	Element formed
copper (II) chloride				
copper (II) sulfate				
sodium chloride				
sodium sulfate				

GCSE Chemistry required practical activity 4: 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 student needs:

- 2M dilute hydrochloric acid
- 2M sodium hydroxide solution
- Expanded polystyrene cups and lids with thermometer holes
- 0-110°C thermometers

Technical information

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

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

30cm thermometers are preferable to 15cm 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, 10cm³ portions of 1M sodium hydroxide could be substituted.

Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- Safety goggles must be worn throughout.
- 2M dilute hydrochloric acid (IRRITANT) is covered by Hazcard 47A
- 1M sodium hydroxide solution (CORROSIVE) is covered by Hazcard 91

Trialling

The practical should be trialled before use with students.

Alternative practicals

Outline method	Suggested apparatus	Suggested reagents
Add a fixed mass of finely divided magnesium, zinc, iron and copper to dilute hydrochloric acid in an expanded polystyrene cup. Stir. Measure maximum temperature change for each metal.	Expanded polystyrene cup and lid, thermometer, stirring rod, spatula, measuring cylinder, balance.	Zinc powder, magnesium powder, iron filings, copper turnings, dilute hydrochloric acid.

GCSE Chemistry required practical activity 4: 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.

In this investigation you will monitor the temperature rise as small volumes of sodium hydroxide solution are added to dilute hydrochloric acid in an insulated cup. You will then plot a graph of your results and work out how much sodium hydroxide was needed to fully react with the acid.

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

Method

You are provided with the following:

- 2M dilute hydrochloric acid
- 2M sodium hydroxide solution
- Expanded polystyrene cup and lid
- 250cm³ beaker
- 10cm³ and 50cm³ measuring cylinders.
- thermometer

Risk Assessment

Safety goggles must be worn throughout.

You should read these instructions carefully before you start work.

1. Use the large measuring cylinder to put 30cm^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 on the back of this sheet.
4. Put 5cm^3 sodium hydroxide solution into the small measuring cylinder.
5. Pour the sodium hydroxide into the cup, quickly 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 5cm^3 portions of sodium hydroxide to the cup until a total of 40cm^3 has been added. The last few additions should produce a temperature fall rather than a rise.
7. Repeat the **whole investigation** (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 and record it in the third blank column.
9. Plot a line graph of total volume of sodium hydroxide added in cm^3 (x axis) against mean maximum temperature in $^{\circ}\text{C}$ (y axis). Draw two straight lines of best fit - one through the points which are increasing, and another through those 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 25cm^3 dilute hydrochloric acid.

Total volume of sodium hydroxide added (cm^3)	Maximum temperature ($^{\circ}\text{C}$)		
	First trial	Second trial	Mean
0			
5			
10			
15			
20			
25			
30			
35			
40			

GCSE Chemistry required practical activity 5: 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.

Materials

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

- 40g/dm³ sodium thiosulfate solution.
- 2.0M dilute hydrochloric acid
- printed black paper cross
- stopclock

Technical information

To prepare 40g/dm³ sodium thiosulfate solution, consult CLEAPSS Recipe Book 87 and Guide L195. The concentration is specified in g/dm³ rather than mole/dm³ to simplify graph plotting for students. However, if it is desired that a Higher Tier group work in mole/dm³ then the base thiosulfate solution should be 0.2M. The diluted solutions prepared by students will then be 0.16, 0.12, 0.08 and 0.04mole/dm³

To prepare 2.0M 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
- 2.0M 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.

Alternative practicals

Outline method	Suggested apparatus	Suggested reagents
Add different concentrations of dilute hydrochloric acid to a fixed mass of marble chips. Either measure the volume of CO ₂ produced every 30 seconds using a gas syringe or inverted measuring cylinder, or perform on a tared balance and measure the loss in mass every 30 seconds.	Conical flask, delivery tube with bung, trough, measuring cylinder, gas syringe, stopclock, balance.	Marble chips, dilute hydrochloric acid.

GCSE Chemistry required practical activity 5: 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.

In this investigation you will use the reaction between sodium thiosulfate and hydrochloric acid to find out how the rate of reaction changes as the thiosulfate solution becomes more dilute.

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

Method

You are provided with the following:

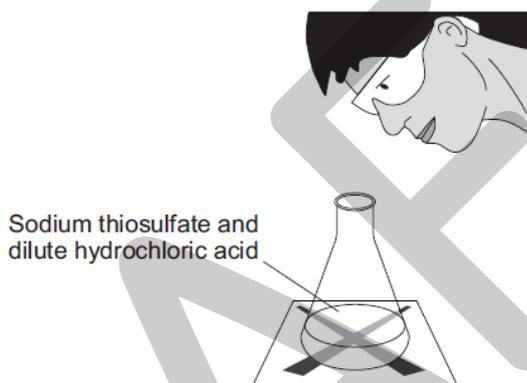
- 40g/dm³ sodium thiosulfate solution.
- 2.0M dilute hydrochloric acid
- 10cm³ and 100cm³ measuring cylinders
- 100cm³ conical flask
- printed black paper cross
- stopclock

Risk assessment

Safety goggles must be worn throughout.

You should read these instructions carefully before you start work.

1. Use a measuring cylinder to place 10cm^3 sodium thiosulfate solution into the conical flask. Again using a measuring cylinder, dilute this by adding 40cm^3 water. This will make a solution of thiosulfate with a concentration of 8g/dm^3 . Put the conical flask on the black cross.
2. Put 10cm^3 of dilute hydrochloric acid into the small measuring cylinder.
3. As you tip this acid into the flask, swirl it gently and at the same time start the stopclock.
4. Looking down through the top of the flask, stop the clock when you can no longer see the cross.



5. Write the time taken **in seconds** in the first blank column of the table on the back of this sheet. You will need to multiply any minutes by 60 and then add the extra seconds.
6. Repeat **steps 1 - 4** four times, but **in step 1** use:
 - 20cm^3 sodium thiosulfate + 30cm^3 water (concentration 16g/dm^3)
 - 30cm^3 sodium thiosulfate + 20cm^3 water (concentration 24g/dm^3)
 - 40cm^3 sodium thiosulfate + 10cm^3 water (concentration 32g/dm^3)
 - 50cm^3 sodium thiosulfate + no water (concentration 40g/dm^3)
7. Repeat the **whole investigation** (steps 1 – 5) twice more and record the results in the second and third blank columns of the table.
8. Calculate the **mean** time for each of the thiosulfate concentrations and record it in the fourth blank column, leaving out of your calculations any anomalous values.
9. Plot a line graph of thiosulfate concentration in g/dm^3 (x axis) against mean time taken to obscure the cross in seconds (y 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?
10. Compare your results with those of others in the class. Is there evidence that this investigation is reproducible?

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

GCSE Chemistry required practical activity 6: 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 R _f values.	AT 1, AT 4

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

Materials

In addition to access to general laboratory equipment, each candidate 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° 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.

Alternative practicals

Outline method	Suggested apparatus	Suggested reagents
Use rectangular chromatography paper suspended in a large beaker to separate mixed dyes alongside the pure components of the mixtures, using water, ethanol and/or water-ethanol mixtures as solvent. Dry, take measurements and compare the effect of different solvents on R_f values.	Large beaker, glass rod, chromatography paper, melting point tubes for spotting,	Ethanol, inks, food colourings.

GCSE Chemistry required practical activity 6: 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 R_f values.	AT 1, AT 4

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

In this investigation 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
Teachers to add these with particular reference to working scientifically

Method

You are provided with the following:

- 250cm³ beaker
- Glass rod
- A rectangle of chromatography paper
- Four known food colourings labelled A to D
- An unknown mixture of food colourings labelled U
- Glass capillary tubes

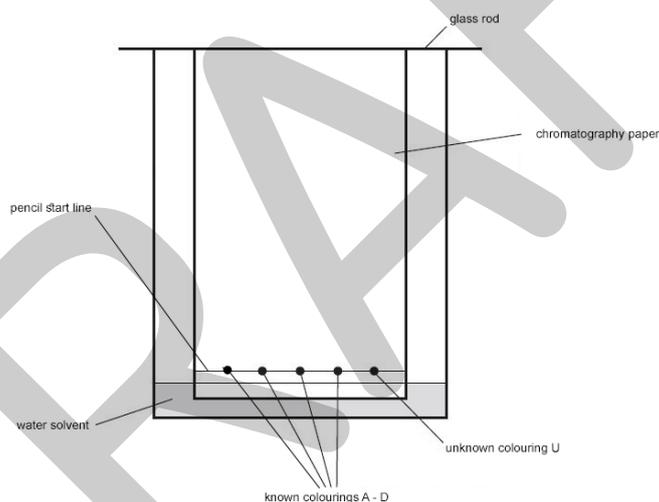
Risk assessment

Safety goggles must be worn throughout.

You should read these instructions carefully before you start work.

1. Using a ruler, draw a horizontal pencil line 2cm from a short edge of the chromatography paper. Mark five pencil spots at equal intervals across the line, keeping at least 1cm away from each end.
2. Use a glass capillary tube to put a small spot of each known colouring and the unknown one on the five pencil spots. Try to make sure each spot is no more than 5mm in diameter. Label each spot **in pencil**.
3. Pour water into the beaker to a depth of **no more than 1cm**.
4. Attach the edge of the paper furthest from the spots to the glass rod so that when the rod is rested on the top edge of the beaker, the bottom edge of the paper dips into the water.

Ensure that the pencil line is above the water surface, and that the sides of the paper do not touch the beaker wall.



5. Without disturbing the beaker, wait for the water solvent to travel at least three quarters of the way up the paper. Carefully remove it and 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. Write the same distance in the table below for each colouring.
8. 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.
9. Use the equation:

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

to calculate the R_f value for each of the known colours. Write them in the table.

10. Match the spots in the unknown sample U with those from A – D using the colour and distance travelled to help you. Which of colourings A – D are in mixture U? Are there any other colourings in U which do **not** match A – D?

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

11. Match the spots in the unknown sample U with those from A – D using the colour and distance travelled to help you. Which of colourings A – D are in mixture U? Are there any other colourings in U which do **not** match A – D?

GCSE Chemistry Required practical activity 7: Identifying Ions (chemistry only)

Teachers' notes

Required practical activity	Apparatus and techniques
Use of chemical tests to identify the ions in unknown single ionic compounds covering the ions in sections. (chemistry only)	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 student needs:

- nichrome wire mounted in handle
- limewater
- 0.4M dilute hydrochloric acid
- 0.1M barium chloride solution
- 0.4M dilute nitric acid
- 0.05M silver nitrate solution
- 0.4M known labelled cation salt solutions: LiCl, NaCl, KCl, CaCl₂, CuCl₂
- 0.4M known labelled anion salt solutions: Na₂CO₃, Na₂SO₄, NaCl, NaBr, NaI
- 0.4M 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 0.4M dilute hydrochloric acid, consult CLEAPSS Recipe Book 43 and Guide L195.

To prepare 0.1M barium chloride solution, consult CLEAPSS Recipe Book 10 and Guide L195.

To prepare 0.4M dilute nitric acid, consult CLEAPSS Recipe Book 61 and Guide L195.

To prepare 0.05M 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.
- 0.4M dilute hydrochloric acid (LOW RISK at this concentration) is covered by Hazcard 47A
- 0.1M barium chloride solution (HARMFUL) is covered by Hazcard 10A
- 0.4M dilute nitric acid (IRRITANT) is covered by Hazcard 67
- 0.05M 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.

Alternative practical

Outline method	Suggested apparatus	Suggested reagents
Addition of dilute NaOH solution dropwise and then in excess to solutions of compounds containing Cu^{2+} , Fe^{2+} , Fe^{3+} , Al^{3+} , Ca^{2+} and Mg^{2+} .	Pipettes, test tubes, rack, glass rods.	Dilute sodium hydroxide, soluble chlorides or sulfates of each cation.

GCSE Chemistry Required Practical activity 7: Identifying Ions (chemistry only)

Student sheet

Required practical activity	Apparatus and techniques
Use of chemical tests to identify the ions in unknown single ionic compounds covering the ions in sections. (Chemistry only)	AT 1, AT 8

Identify the ions in a single ionic compound using chemical tests

In this investigation you will analyse a range of known ionic compounds by flame testing and the addition of acids, barium chloride and silver nitrate. You will then apply the knowledge you gain to identify the ions in an unknown compound.

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

Method

You are provided with the following:

- Bunsen burner
- test tubes and test tube rack
- teat pipette
- nichrome wire mounted in handle
- limewater
- 0.4M dilute hydrochloric acid
- 0.1M barium chloride solution
- 0.4M dilute nitric acid
- 0.05M 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'.

Risk assessment

Safety goggles must be worn throughout.

You should read these instructions carefully before you start work.

- Flame Tests:** Pour around 1cm depth of each of the **labelled chloride solutions** into five test tubes in the rack. Dip the nichrome wire into the first solution, and then hold the tip of the wire in a blue Bunsen burner flame. Clean the wire carefully between tests and test the other four solutions in the same way. Record your observation in **table 1** on the back of this sheet. Empty and clean the test tubes.
- Carbonate test:** Pour around 1cm depth of each of the **labelled sodium solutions** into five test tubes in the rack. Place 2cm depth of limewater in a sixth tube. Add 1cm depth of **dilute hydrochloric acid** to each sodium salt in turn. **If** (and 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. Record your results in the first blank row of **table 2**. Empty and clean the test tubes.
- Sulfate test:** Pour around 1cm depth of each of the **labelled sodium solutions** into five test tubes in the rack. Add a few drops of **dilute hydrochloric acid** to each solution, followed by 1cm depth of **barium chloride** solution. Record your observations in the second blank row of **table 2**. Empty and clean the test tubes.
- Halide test:** Pour around 1cm depth of each of the **labelled sodium solutions** into five test tubes in the rack. Add a few drops of **dilute nitric acid** to each solution, followed by 1cm depth of **silver nitrate** solution. Again, record your observations in **table 2**.
- Unknown:** Repeat tests 1 to 4 on the unknown salt solution. Use your results from **test 1** and **table 1** to identify the positive metal ion in the unknown compound, and your results from **tests 2, 3 and 4** and **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 8: 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

Distillation of salt water to produce potable water

Materials

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

- 50cm³ salt water (concentration unimportant but should give good positive test results for sodium and chloride ions)
- nichrome wire mounted in handle
- 0.4M dilute nitric acid
- 0.05M silver nitrate solution
- A few ice cubes

Technical information

Nichrome wires can be mounted in lengths of glass capillary tube to form a handle. Two right-angled delivery tubes can be linked with rubber tubing to create the double right-angle required. The tubes should be pre-inserted into suitable rubber bungs.

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.

To prepare 0.4M dilute nitric acid, consult CLEAPSS Recipe Book 61 and Guide L195.

To prepare 0.05M silver nitrate solution, consult CLEAPSS Recipe Book 77 and Guide L195.

Additional information

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 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.

Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- Safety goggles should be worn throughout.
- 0.4M dilute nitric acid (IRRITANT) is covered by Hazcard 67
- 0.05M silver nitrate (LOW RISK at this concentration) is covered by Hazcard 87

Trialling

The practical should be trialled before use with students.

Supplementary demonstration

Outline method	Suggested apparatus	Suggested reagents
Distillation of solutions 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.	Tripod, gauze, clamp stand, heatproof mat, Bunsen burner OR electric heating mantle, side arm distillation flask, thermometer in bung, Liebig condenser, conical flask.	Salt water, copper sulfate solution, diluted ink, diluted food colouring.

GCSE Chemistry Required practical activity 8: 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

Distillation of salt water to produce potable water

In this investigation you will test salt water for the presence of sodium and chloride ions. After distillation, you will test the water again to check that these ions 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:

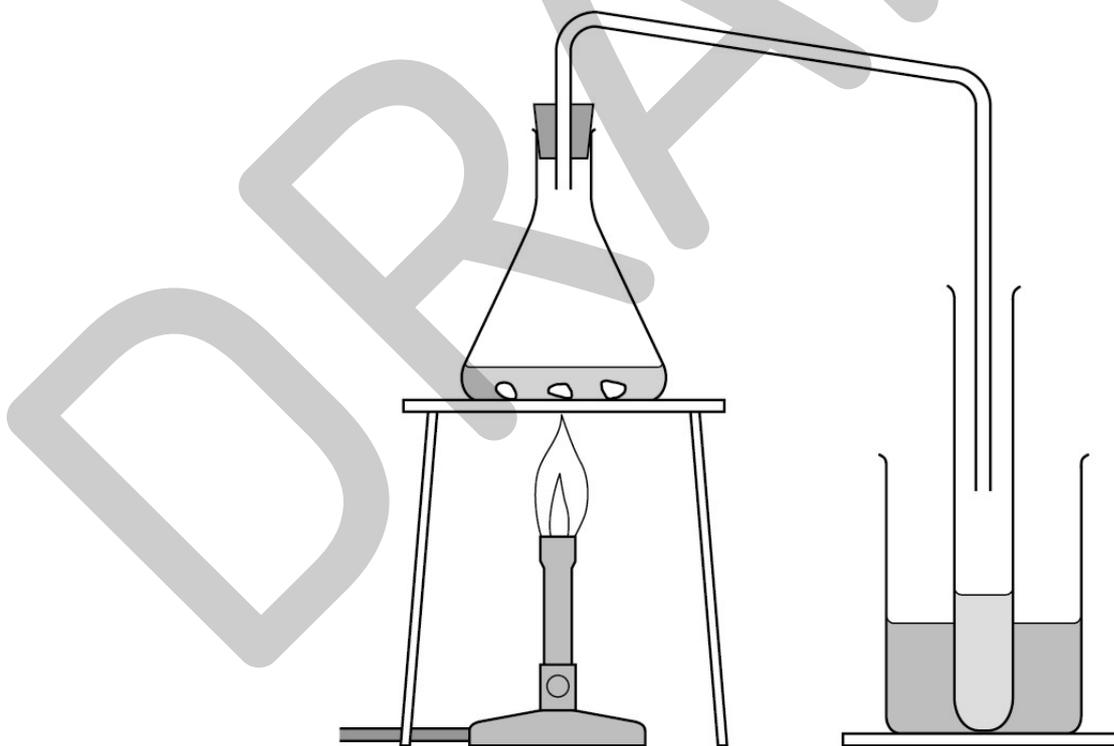
- 50cm³ salt water.
- Bunsen burner, tripod, gauze, heatproof mat.
- 250cm³ beaker, clamp stand, 250cm³ conical flask, delivery tube with bung, test tube, ice.
- An additional test tube, test tube rack, nichrome wire, dilute nitric acid, silver nitrate solution.

Risk assessment

Safety goggles must be worn throughout.

You should read these instructions carefully before you start work.

1. Pour around 1cm depth of the salt water into the test tube in the rack. Dip the nichrome wire into this solution, and then hold the tip of the wire in a blue Bunsen burner flame. Record your observation in the table on the back of this sheet.
2. Now add a few drops of dilute nitric acid to this solution, followed by 1cm depth of silver nitrate solution. Again, record your observations in the table.
3. Place the remaining salt water in the conical flask and set up the apparatus for distillation as shown in the diagram. 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.
4. Heat the 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 1cm depth of water in this way, then stop heating.
5. Repeat the tests in steps 1 and 2 again using the distilled water, making sure that the nichrome wire and test tube have been cleaned. Again, record your results in the table.



	Flame test	Nitric acid and silver nitrate
Salt water		
Distilled water		

A yellow flame test confirms the presence of sodium ions. A white precipitate with nitric acid and silver nitrate solution confirms the presence of chloride ions.