# Chemistry PAG 7: Production of salts

# Combined Science PAG C4: Production of salts

# Suggested Activity 2: Microscale copper sulfate synthesis

## Instructions and answers for teachers and technicians

These instructions cover the learner activity section which can be found on [page 10](#_PAG_7:_Production). This Practical activity supports OCR GCSE Chemistry and Combined Science.

**When distributing the activity section to the learners, either as a printed copy or as a Word file, you will need to remove the teacher instructions section.**

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| This is a **suggested** practical activity that can be used as part of teaching the GCSE (9-1) Gateway Science (A) and Twenty First Century Science (B) specifications.  These are **not controlled assessment tasks**, and there is **no requirement to use these particular activities**.  You may modify these activities to suit your learners and centre. Alternative activities are available from, for example, [Royal Society of Biology](https://www.rsb.org.uk/education/teaching-resources/secondary-schools), [Royal Society of Chemistry](http://www.rsc.org/learn-chemistry), [Institute of Physics](http://www.iop.org/education/teacher/resources/index.html), [CLEAPSS](http://science.cleapss.org.uk/) and [publishing companies](https://global.oup.com/education/content/secondary/key-issues/gcse_science_2016/?region=uk), or of your own devising.  Further details are available in the [specifications](http://www.ocr.org.uk/science) (Practical Skills Topics), and in these [videos](https://www.youtube.com/playlist?list=PLBD9B84FF4BD54AA4). |

**OCR recommendations:**

**Before carrying out any experiment or demonstration based on this guidance, it is the responsibility of teachers to ensure that they have undertaken a risk assessment in accordance with their employer’s requirements, making use of up-to-date information and taking account of their own particular circumstances. Any local rules or restrictions issued by the employer must always be followed.**

**CLEAPSS resources are useful for carrying out risk-assessments: (**<http://science.cleapss.org.uk>**).**

**Centres should trial experiments in advance of giving them to learners. Centres may choose to make adaptations to this practical activity, but should be aware that this may affect the Apparatus and Techniques covered by the learner.**

### Introduction

In this activity, learners will synthesis copper(II) sulfate(VI) by a microscale method, minimising the amounts of substance used and the potentially hazardous heating of large volumes sulfuric acid. The activity can also be completed within a lesson from reaction to crystal formation, allowing better continuity of learning.

This method is based on the CLEAPSS activity <http://science.cleapss.org.uk/Resource-Info/Hydrated-copper-sulfate-preparation-Microscale-method.aspx>. A standard scale synthesis is available at <http://science.cleapss.org.uk/Resource-Info/PP027-Making-copper-sulfate-crystals.aspx> with associated video.

Another standard-scale synthesis is also available from the Royal Society of Chemistry/Nuffield Foundation Practical Chemistry project <http://www.rsc.org/learn-chemistry/resource/res00001917/reacting-copper-ii-oxide-with-sulfuric-acid>.

### DfE Apparatus and Techniques covered

The codes used below match the OCR Practical Activity Learner Record Sheet ([**Chemistry**](https://www.ocr.org.uk/Images/295630-gcse-chemistry-student-record-sheet.doc) / [*Combined Science*](http://www.ocr.org.uk/Images/304431-gcse-combined-science-learner-record-sheet.doc)) and Trackers ([**Chemistry**](http://www.ocr.org.uk/Images/323481-gcse-chemistry-practical-tracker.zip) / [*Combined Science*](http://www.ocr.org.uk/Images/323483-gcse-combined-science-practical-tracker.zip)) available online. **There is no requirement to use these resources.**

By doing this experiment, learners have an opportunity to develop the following skills:

**1** [*1*]: Use of appropriate apparatus to make and record a range of measurements accurately, including: **i** [*iii*]) mass; **ii** [*iv*]) time; **iv** [*vi*]) volume of liquids; *[ix]* pH

**2** [*2*]: Safe use of appropriate heating devices and techniques including use of: ii) a water bath OR an electric heater

**3** [*8*]: Use of appropriate apparatus and techniques for: i) conducting and monitoring chemical reactions; ii) conducting and monitoring chemical reactions, including appropriate reagents and/or techniques for the measurement of pH in different situations

**4** [*9*]: Safe use of a range of equipment to purify and/or separate chemical mixtures including: i) evaporation; ii) filtration; iii) crystallisation

**6** [*11*]: Safe use and careful handling of gases, liquids and solids, including: i) careful mixing of reagents under controlled conditions; ii) using appropriate apparatus to explore chemical changes and/or products

### Aims

To synthesis and crystallise hydrated copper(II) sulfate(VI).

### Intended class time

30–40 minutes

### Links to Specifications:

### Gateway Science (Suite A) – including Working Scientifically (WS)

CM2.1ii provide answers to an appropriate number of significant figures

C2.1f describe, explain and exemplify the processes of filtration, crystallisation, simple distillation and fractional distillation [to include: knowledge of the techniques]

C3.3k describe techniques and apparatus used to measure pH

C4.1c recall the general properties of transition metals and their compounds and exemplify these by reference to a small number of transition metals [to include melting point, density, reactivity, formation of coloured ions with different charges and uses as catalysts]

WS1.3a presenting observations and other data using appropriate methods

WS1.4a use scientific vocabulary, terminology and definitions

WS1.4c use SI units and IUPAC chemical nomenclature unless inappropriate

WS1.4d use prefixes and powers of ten for orders of magnitude

WS2a carry out experiments

WS2b make and record observations and measurements using a range of apparatus and methods

WS2c presenting observations using appropriate methods to include descriptive, tabular diagrammatic and graphically

### Twenty First Century Science (Suite B) – including Ideas about Science (IaS)

C2.5.1 recall the general properties of transition metals (melting point, density, reactivity, formation of coloured ions with different charges and uses as catalysts) and exemplify these by reference to copper, iron, chromium, silver and gold

C5.1.7 describe, explain and exemplify the processes of filtration, crystallisation, simple distillation and fractional distillation.

C6.1.4 recall that relative acidity and alkalinity are measured by pH including the use of universal indicator and pH meters

IaS1.6 plan experiments or devise procedures by constructing clear and logically sequenced strategies to: i) make observations, ii) produce or characterise a substance, iii) test hypotheses, iv) collect and check data, v) explore phenomena

IaS1.8 use appropriate scientific vocabulary, terminology and definitions to communicate the rationale for an investigation and the methods used using diagrammatic, graphical, numerical and symbolic forms

IaS2.1 present observations and other data using appropriate formats

### Mathematical Skills covered

M1a Recognise and use expressions in decimal form

M1b Recognise and use expressions in standard form

M1c Use ratios, fractions and percentages

M2a Use an appropriate number of significant figures

M3a Understand and use the symbols: =, <, <<, >>, >, ∝, ~

M3b Change the subject of an equation

M3c Substitute numerical values into algebraic equations using appropriate units for physical quantities

M3d Solve simple algebraic equations

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| Technical Requirements – PER GROUPChemicals  | **Identity** | **Approximate quantity required or produced PER GROUP** | **Hazard information** | | **Risk information** | | --- | --- | --- | --- | --- | | copper(II) oxide, CuO(s) | c. 0.2 g | HSE warning symbol  Hazard warning image | WARNING  Harmful if swallowed. Very toxic to aquatic life with long-lasting effects | Avoid raising dust – see CLEAPSS Hazcard 26 and below. | | 1.4 mol/dm3 sulfuric(VI) acid, H2SO4(aq) | c. 1.5 cm3 | HSE warning symbol | WARNING: Causes skin and serious eye irritation. |  | | copper(II) sulfate(VI)-5-water **PRODUCED** | c. 0.5 g | HSE warning symbol  Hazard warning image | Harmful if swallowed. Causes skin and serious eye irritation. Very toxic to aquatic life with long lasting effects. | Crystals can be saved for making CuSO4(aq) |   *Note: CuO: if a fume cupboard is available, copper oxide should be weigh out on a mass balance in fume cupboard with the flow turned off, and the sash partly pulled down.* Equipment  * universal indicator paper * cotton wool * dropping pipette * forceps * glass marker pen * glass vial (c. 14 cm3) * plastic syringe (2 or 5 cm3) * timer * watch glass (c. 5 cm) * weighing boat * white tile * access to a camera / smartphone camera (optional) * access to a mass balance (2 decimal places) * access to a sand bath (baking tray of sand on a hot plate)   *Note: glass vials are available from e****.****g****.*** *TIMSTAR (VI6982) and SCICHEM (TVL060030)* |

### Health and Safety

Eye protection should be worn at all times.

Learners will need to take care not to touch the sand when transferring glassware to and from the sand bath.

### Method

This micro-scale method reduces the amount of substance used, reducing costs and hazards. An additional advantage is that learners can go from the dull black powder of copper oxide to the shiny blue crystals of hydrated copper sulfate within a lesson, allowing for a better flow of learning.

The method also allows the learners to experience techniques different to those likely used in their Key Stage 3 lessons, and those that will help develop their fine motor skills.

Measuring pH using universal indicator paper shows an increase in pH due to the neutralisation of the acid by the copper oxide. Note that the resultant copper sulfate solution doesn’t have a pH of 7, as the solution is weakly acidic. This may be a worth discussing with the learners.

### Images from trials

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| Images from the trials  Figure 1 – Images from the trial |

### Results – Trial results

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| --- | --- | --- |
| **1.** | Print and stick in a photo of your crystals and/or accurately sketch one of the crystals. [**1 mark**] |  |
|  | crystals | |

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| **2.** | pH measurements | |  |
|  | before reaction: pH 1-2 | after reaction: 4-5 |  |

### Extension opportunities

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| --- | --- | --- |
| **1.** | Write the word equation, symbol equation and ionic equation for the reaction between copper oxide and sulfuric acid. Name the type of reaction occurring.  [**5 marks**] |  |
|  | copper oxide + sulfuric acid → copper sulfate + water ✓  CuO(s) + H2SO4(aq) → CuSO4(aq) + H2O(l) ✓  CuO(s) + 2H+(aq) → Cu2+(aq) + H2O(l) ✓  neutralisation reaction ✓  the pH of the solution increased as the acid was neutralised by reaction with the copper oxide ✓ | |

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| **2.** | Using amount of substance calculations, show that copper oxide was in excess. Explain why this is preferable to having sulfuric acid in excess [**6 marks**] |  |
|  | amount of CuO: *n* = *m* / *M*r = 0.20 / 79.5 ✓ = 2.5 × 10–3 mol ✓  amount of H2SO4 : *n* = *c* × *V* = 1.4 × (1.5 / 1000) ✓ = 2.1 x 10–3 mol ✓  reaction stoichiometry is 1 : 1 ✓  therefore CuO is in (molar) excess ✓ | |

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| **3.** | A student made 1.5 g of hydrated copper sulfate crystals (CuSO4⋅5H2O). Calculate the percentage by mass of copper in this substance, and hence the mass of copper present in the sample **[4 marks]** |  |
|  | Mr(CuSO4⋅5H2O) = 249.6 ✓  %(Cu in CuSO4⋅5H2O) = (63.5 / 249.6) × 100 ✓ = 25.4% ✓  mass of copper in 1.5 g = 1.5 × 25.4% = 0.38 g ✓ | |
|  |  |  |
| **4.** | Describe the equipment and methods you would use for making pure dry hydrated copper sulfate crystals on a larger scale [**4 marks**] |  |
|  | *Any four suitable and safe steps – for example:*  Calculate the mass of copper oxide and volume of sulfuric acid required ✓  Heat the acid in a conical flask in a boiling water bath / with a Bunsen burner / electric heater ✓  Add the copper oxide and stir until no further reaction occurs. ✓  Filter the mixture through a filter paper in a funnel ✓  Boil the mixture on a Bunsen burner / electric heater for 2-3 minutes ✓  Pour the concentrated solution into a crystallising dish and allow to cool ✓  After 24–48 hours, decant off any remaining liquid and allow the crystals to air dry. ✓ | |

**Document updates**

v1 November 2016 Published on qualification page

v1.1 January 2017 Consolidation of labelling and formatting of activities

v1.2 February 2017 Addition of pH measurement to practical and associated questions

v1.3 June 2021 Updated to meet digital accessibility standards



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# Chemistry PAG 7: Production of salts

# Combined Science PAG C4: Production of salts

# Suggested Activity 2: Microscale copper sulfate synthesis

## Learner Activity

### Introduction

Many useful products in everyday life are salts, and can be synthesised and purified with simple chemistry. For example, hydrated copper sulfate can be used as a fungicide (controlling fungus on grapes), and an algicide (controlling algea in fish ponds). It is synthesised industrially by reacting copper with hot sulfuric acid. In the lab, it is safer to synthesise via the neutralisation of sulfuric(VI) acid with copper oxide.

In this activity, you will carry out a micro-scale synthesis and purification of hydrated copper sulfate. The reaction is relatively quick, and should allow you to go from black powder to blue crystals within one lesson.

### Aims

To synthesise and purify hydrated copper sulfate.

### Intended class time

30–40 minutes

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| --- |
| Experiment set-up  Figure 1: Producing copper sulfate with a sand bath  Experiment set-up  Figure 2: Purifying the copper sulfate by filtering  Experiment set-up  Figure 3: Purifiying the copper sulfate by evaporation and crystallisation. |

### Chemicals and equipment (per group)

* 1.4 mol/dm3 sulfuric(VI) acid (WARNING: causes skin and serious eye irritation)
* copper(II) oxide (WARNING: harmful if swallowed)
* universal indicator paper
* cotton wool
* dropping pipette
* forceps
* glass marker pen
* glass vial (c. 14 cm3)
* plastic syringe (2 or 5 cm3)
* timer
* watch glass (c. 5 cm)
* weighing boat
* white tile
* access to a camera / smartphone camera (optional)
* access to a mass balance (2 decimal places)
* access to a sand bath (baking tray of sand on a hot plate)

### Health and Safety

* Eye protection should be worn at all times.
* Take care when transferring glassware to and from the sand bath – do not touch the sand.
* The product, copper sulfate, is harmful (WARNING: harmful if swallowed, causes skin and serious eye irritation) – dispose of as instructed by your teacher.

### Method

1. Using a dropping pipette, add 1.5 cm3 of sulfuric acid to a glass vial.
2. Measure the pH of the acid with universal indicator paper.
3. Weigh out 0.18–0.20 g of copper oxide in a weighing boat, and add to the acid.
4. Place the vial in the sand-bath for 1–2 minutes (figure 1).

* ***The solution will turn blue with the formation of copper sulfate.***

1. Measure the pH of the solution with universal indicator paper.
2. Remove the vial from the sand bath and allow to cool.
3. Using forceps, place a small piece of cotton wool in the nozzle of a syringe.

***‼ Make sure you don’t press the cotton wool all the way into the nozzle.***

1. Using a tile to help hold the vial at an angle, draw all of the reaction mixture up into the syringe through the cotton wool (figure 2)
2. Remove the cotton wool, and carefully dispense the filtered solution into a watch glass.
3. Using forceps, carefully place the watch glass on the sand bath (figure 3).
4. Watch the solution carefully – when white solid appears at the edge of the solution remove the watch glass to a white tile.

***‼ It is important not to evaporate too much solution on the sand-bath, otherwise you won’t get good quality crystals.***

1. Observe the solution over 5-10 minutes – if available, take a photo of your solution with a camera/smart phone for your records.

### Results

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| --- | --- | --- |
| **1.** | Print and stick in a photo of your crystals and/or accurately sketch one of the crystals. |  |
|  |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
| **2.** | pH measurements | |  |
|  | before reaction: | after reaction: |  |

### Extension opportunities

|  |  |  |
| --- | --- | --- |
| **1.** | Write the word equation, symbol equation and ionic equation for the reaction between copper(II) oxide and sulfuric(VI) acid. Name the type of reaction occurring and explain your evidence for this. [**5 marks**] |  |
|  |  | |

|  |  |  |
| --- | --- | --- |
| **2.** | Using amount of substance calculations, show that copper oxide was in excess. Use standard form and the appropriate number of significant figures in your answers. Explain why this is preferable to having sulfuric acid in excess [**6 marks**] |  |
|  |  | |

|  |  |  |
| --- | --- | --- |
| **3.** | A student made 1.5 g of hydrated copper sulfate crystals (CuSO4⋅5H2O). Calculate the percentage by mass of copper in this substance, and hence the mass of copper present in the sample. **[4 marks]** |  |
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| --- | --- | --- |
| **4.** | Describe a method for making hydrated copper sulfate crystals on a larger scale  [**4 marks**] |  |
|  |  | |

### DfE Apparatus and Techniques covered

If you are using the OCR Practical Activity Learner Record Sheet ([**Chemistry**](https://www.ocr.org.uk/Images/295630-gcse-chemistry-student-record-sheet.doc) / [*Combined Science*](http://www.ocr.org.uk/Images/304431-gcse-combined-science-learner-record-sheet.doc)) you may be able to tick off the following skills:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Chemistry** | | | |  | ***Combined Science*** | | | |
| 1–i | 1–ii | 1–iv | 2-ii |  | *1–iii* | *1–iv* | *1–vii* | *1–ix* |
| 3–i | 3–ii | 4–i | 4–ii |  | *2-ii* | *8–i* | *8–ii* | *9–i* |
| 4–iii | 6–i | 6–ii |  |  | *9–ii* | *9–iii* | *11–i* | *11–ii* |