# Chemistry PAG 3: Separation techniques

# Combined Science PAG C3: Separation techniques

# Suggested Activity 1: Separation in synthesis

## Instructions and answers for teachers and technicians

These instructions cover the learner activity section which can be found on [page 11](#_Learner_Activity). 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.**

|  |
| --- |
| 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 use a variety of separation techniques to produce a sample of crystallised hydrated copper(II) sulfate. The focus on the experiment is on the different separation techniques involved.

The method is based on one from CLEAPSS, ‘Preparation of copper(II) sulfate-5-water’, Laboratory Handbook Section 13, pp1332-33: [www.cleapss.org.uk/attachments/article/0/Sec13.pdf](http://www.cleapss.org.uk/attachments/article/0/Sec13.pdf).

### DfE Apparatus and Techniques covered

The codes used below match the OCR Practical Activity Learner Record Sheet ([**Chemistry**](http://www.ocr.org.uk/Images/295630-gcse-chemistry-learner-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; **iv** [*vi*]) volume of liquids

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

**6** [*11*]: Safe use and careful handling of gases, liquids and solids, including: i) careful mixing of reagents under controlled conditions

### Aims

To use a variety of separation techniques to produce hydrated copper(II) sulfate crystals.

### Intended class time

30 minutes + overnight crystallisation

### Links to Specifications:

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

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

C2.1j suggest suitable purification techniques given information about the substances involved

C3.1a use chemical symbols to write the formulae of elements and simple covalent and ionic compounds

C3.1b use the names and symbols of common elements and compounds and the principle of conservation of mass to write formulae and balanced chemical equations and half equations

C3.1c use the names and symbols of common elements from a supplied periodic table to write formulae and balanced chemical equations where appropriate

C3.1e construct balanced ionic equations

C3.1f describe the physical states of products and reactants using state symbols (s, l, g and aq)

C3.1k deduce the stoichiometry of an equation from the masses of reactants and products and explain the effect of a limiting quantity of a reactant

C3.3d describe neutralisation as acid reacting with alkali or a base to form a salt plus water

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)

C5.1h calculate the percentage yield of a reaction product from the actual yield of a reaction

WS1.2e evaluate methods and suggest possible improvements and further investigations

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

WS1.3c carrying out and representing mathematical and statistical analysis

WS1.3e interpreting observations and other data

WS1.3g evaluating data in terms of accuracy, precision, repeatability and reproducibility

WS1.3h identifying potential sources of random and systematic error

WS1.4a use scientific vocabulary, terminology and definitions

WS1.4b recognise the importance of scientific quantities and understand how they are determined

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

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

WS1.4e interconvert units

WS1.4f use an appropriate number of significant figures in calculation

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

WS2d communicating the scientific rationale for investigations, methods used, findings and reasoned conclusions

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

C1.1.9 use chemical symbols to write the formulae of elements and simple covalent compounds

C1.1.10 use the names and symbols of common elements and compounds and the principle of conservation of mass to write formulae and balanced chemical equations

C1.1.11 use arithmetic computations and ratios when balancing equations

C2.4.3 use the names and symbols of the first 20 elements, Groups 1, 7 and 0 and other common elements from a supplied Periodic Table to write formulae and balanced chemical equations where appropriate

C2.4.4 describe the physical states of products and reactants using state symbols (s, l, g and aq)

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

C3.2.3 use the names and symbols of common elements and compounds and the principle of conservation of mass to write formulae and balanced chemical equations and ionic equations

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

C5.1.8 suggest suitable purification techniques given information about the substances involved

C5.3.6 deduce the stoichiometry of an equation from the masses of reactants and products and explain the effect of a limiting quantity of a reactant

C5.3.12 calculate the percentage yield of a reaction product from the actual yield of a reaction (separate science only)

C5.4.4 describe neutralisation as acid reacting with alkali to form a salt plus water including the common laboratory acids hydrochloric acid, nitric acid and sulfuric acid and the common alkalis, the hydroxides of sodium, potassium and calcium

IaS1.2. suggest appropriate apparatus, materials and techniques, justifying the choice with reference to the precision, accuracy and validity of the data that will be collected

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

IaS2.2. when processing data use SI units where appropriate (e.g. kg, g, mg; km, m, mm; kJ, J) and IUPAC chemical nomenclature unless inappropriate

IaS2.3. when processing data use prefixes (e.g. tera, giga, mega, kilo, centi, milli, micro and nano) and powers of ten for orders of magnitude

IaS2.6. when processing data use an appropriate number of significant figures

IaS2.10. evaluate an experimental strategy, suggest improvements and explain why they would increase the quality (accuracy, precision, repeatability and reproducibility) of the data collected, and suggest further investigations

IaS2.11. in a given context interpret observations and other data (presented in diagrammatic, graphical, symbolic or numerical form) to make inferences and to draw reasoned conclusions, using appropriate scientific vocabulary and terminology to communicate the scientific rationale for findings and conclusions

### Mathematical Skills covered

M1a Recognise and use expressions in decimal form

M1c Use ratios, fractions and percentages

M1d Make estimates of the results of simple calculations

M2a Use an appropriate number of significant figures

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

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. 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. | | 1.2 mol/dm3 sulfuric(VI) acid, H2SO4(aq) | c. 15 cm3 | HSE warning symbol | WARNING: Causes skin and serious eye irritation. |  | | copper(II) sulfate(VI)-5-water **PRODUCED** | c. 6 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) |  Equipment  * eye protection * beaker (250 cm3) * boiling tube * conical flask (100 cm3) * crystallising dish / petri dish * filter funnel * filter paper (Whatman No. 1) * Bunsen burner * tripod, gauze and heat proof mat * paper towel * access to a mass balance * access to a kettle |

### Health and Safety

Eye protection should be worn at all times.

Avoid raising dust when weighing the copper(II) oxide – use of a balance in a fume cupboard that is not switched on, with the sash partially pulled down is recommended. Otherwise, ensure there is good ventilation in the laboratory.

Take particular care to ensure conical flasks are stable on gauzes during heating, and learners know how to handle hot glassware safely – e.g with a folded paper towel.

### Method

This is a good opportunity for learners to practice their skills in handling a variety of chemicals and apparatus, including dealing with hot glassware and solutions. Clear instructions are provided – talking through the safety implications before starting the practical work is recommended.

### Images from trials

|  |  |  |
| --- | --- | --- |
| Warm sulfuric acid and copper oxide | Synthesised copper sulfate | Filtering the mixture |
| Warm sulfuric acid and copper oxide | Synthesised copper sulfate | Filtering the mixture |
| Evaporating some of the solvent | Saturated copper sulfate solution in a crystallising dish | Crystallisation of copper sulfate hydrate crystals |
| Evaporating some of the solvent | Saturated copper sulfate solution in a crystallising dish | Crystallisation of copper sulfate hydrate crystals |

### Analysis of results – Trial results

You can draw your own table, or use the one below:

|  |  |
| --- | --- |
| Item | mass / g |
| crystallising/petri dish+ crystals (measured) | 54.48 |
| dish (measured) | 50.15 |
| crystals (calculated) | 4.33 |

|  |  |  |
| --- | --- | --- |
| **1.** | The theoretical yield for this reaction is 4.5 g. Showing you workings, calculate your percentage yield. [**3 mark**] |  |
|  | percentage yield =  =  ✓ = 96% ✓ (2 sig. fig ✓) | |

|  |  |  |
| --- | --- | --- |
| **2.** | Evaluate the practical procedure, suggesting improvements that could be made to increase your percentage yield. [**4 marks**] |  |
|  | Any suitable limitations (✓✓) and suggested improvements (✓✓). For example   * copper sulfate solution not fully transferred between equipment; rinse equipment with deionised water after transfer and add to solution * some anhydrous copper sulfate produced during evaporation of solvent; reduce the evaporation by Bunsen burner time | |

### Extension opportunities

|  |  |  |
| --- | --- | --- |
| **1.** | An alternative method for synthesising copper(II) sulfate is the reaction between basic copper(II) carbonate, which contains copper(II) carbonate and copper(II) hydroxide.  Write the word equation, symbol equation and ionic equation for the reactions between copper(II) carbonate and copper(II) hydroxide, and sulfuric acid. Name the type of reaction occurring. [**7 mark**] |  |
|  | copper(II) carbonate + sulfuric acid → copper sulfate + carbon dioxide + water ✓  CuCO3(s) + H2SO4(aq) → CuSO4(aq) + H2O(l) ✓  CuCO3(s) + 2H+(aq) → Cu2+(aq) + CO2(g) + H2O(l) ✓  copper(II) hydroxide + sulfuric acid → copper sulfate + water ✓  Cu(OH)2(s) + H2SO4(aq) → CuSO4(aq) + 2H2O(l) ✓  Cu(OH)2(s) + 2H+(aq) → Cu2+(aq) + 2H2O(l) ✓  neutralisation reaction ✓ | |

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| **2.** | Describe how the method you use would be modified if an insoluble salt was being synthesised from two soluble salt solutions. [**3 marks**] |  |
|  | The two solutions would be mixed at room temperature – no heating would be required. ✓  The product would be separated as the residue rather than the filtrate. ✓  The product would be left to dry out, rather than to crystallise and then dry out. ✓ | |

**Document updates**

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# Chemistry PAG 3: Separation techniques

# Combined Science PAG C3: Separation techniques

# Suggested Activity 1: Separation in synthesis

## Learner Activity

### Introduction

There are several common separation techniques that form part of the toolkit of a chemist, including filtration, evaporation of solvents and crystallisation. In this activity, you will prepare crystals of hydrated copper(II) sulfate by reaction of copper(II) oxide with hot sulfuric acid. Through filtration, evaporation of some of the water and crystallisation you will produce the beautiful blue crystals, which can then be used in other practical activities.

### Aims

To use a variety of separation techniques to produce a hydrated copper(II) sulfate crystals.

### Intended class time

30 minutes + overnight crystallisation

### Chemicals and equipment (per group)

* eye protection
* beaker (250 cm3)
* boiling tube
* conical flask (100 cm3)
* crystallising dish / petri dish
* filter funnel
* filter paper (Whatman No. 1)
* Bunsen burner
* tripod, gauze and heat proof mat
* paper towel
* access to a mass balance
* access to a kettle
* copper(II) oxide (WARNING: Harmful)
* sulfuric acid (WARNING: Irritant)

### Health and Safety

* Eye protection should be worn at all times.
* Take particular care with handling hot glassware – your teacher will demonstrate how to use folded paper towels to safely move hot apparatus (or by another method).

|  |  |
| --- | --- |
| Stage 1 | Stage 2 |
| Stage 1 | Stage 2 |
| Stage 3 | Stage 4 |
| Stage 3 | Stage 4 |

Figure 1: The steps involved in producing hydrated copper(II) sulfate crystals

### Method

**Synthesis of copper sulfate**

1. Half fill a 250 cm3 beaker with boiling water from a kettle.
2. Add 15 cm3 1.2 mol dm–3 sulfuric acid into a boiling tube and place in the hot water.
3. Weigh out between 1.8 and 2.0 g copper(II) oxide onto a weighing boat.
4. Add about one quarter of the copper(II) oxide to the boiling tube.
5. Lift the tube from the beaker and agitate, then return the tube to the water.
6. Add another quarter of the copper(II) oxide and agitate the tube as before.
7. Replace the water in the beaker with boiling water from a kettle.
8. Add another quarter of the copper(II) oxide and agitate the tube as before.
9. Add the remaining copper(II) oxide, and agitate every minute of so over five minutes –   
   the resultant mixture should be cloudy.

**Purification of copper(II) sulfate solution**

1. Set up a filter funnel in a 100 cm3 conical flask, with a folded Whatman No. 1 filter paper – ask your teacher is you can’t remember how to fold this.
2. Filter the mixture from the boiling tube into the conical flask.

**Production of hydrated copper(II) sulfate crystals**

1. Label and measure the mass of a crystallising dish / petri dish. Record the mass.
2. Place the conical flask on a tripod and gauze.
3. Boil the solution for **3 MINUTES ONLY** **– DO NOT ALLOW TO BOIL DRY**.
4. Turn off the Bunsen burner, and allow the solution to stop boiling.
5. Using a folded paper towel, carefully pick up the conical flask, and pour the hot solution into your dish.
6. Allow the solution to cool for five minutes – you may observe crystals forming at this point.
7. Your teacher will arrange for your dish to be stored somewhere warm where it won’t be disturbed until your next lesson.

**Measuring the mass of product**

1. Measure the mass of your dish and the copper sulfate crystals.
2. Transfer the crystals to a stock jar – they can be used in other practical activities later on.
3. Rinse and return your equipment.

### Analysis of results

You can draw your own table, or use the one below:

|  |  |
| --- | --- |
| Item | mass / g |
| crystallising/petri dish+ crystals (measured) |  |
| dish (measured) |  |
| crystals (calculated) |  |

Your ability to analyse your observations may depend on how much of the GCSE Chemistry/Combined Science course you have studied. Your teacher will let you know which questions you should focus on:

|  |  |  |
| --- | --- | --- |
| **1.** | The theoretical yield for this reaction is 4.5 g. Showing you workings, calculate your percentage yield. [**3 mark**] |  |
|  |  | |

|  |  |  |
| --- | --- | --- |
| **2.** | Evaluate the practical procedure, suggesting improvements that could be made to increase your percentage yield. [**4 marks**] |  |
|  |  | |

### Extension opportunities

|  |  |  |
| --- | --- | --- |
| **1.** | Write the word equation, symbol equation and ionic equation for the reactions between copper(II) carbonate and copper(II) hydroxide, and sulfuric acid. Name the type of reaction occurring. [**7 marks**] |  |
|  |  | |

|  |  |  |
| --- | --- | --- |
| **2.** | Describe how the method you use would be modified if an insoluble salt was being synthesised. [**3 marks**] |  |
|  |  | |

### DfE Apparatus and Techniques covered

If you are using the OCR Practical Activity Learner Record Sheet ([**Chemistry**](http://www.ocr.org.uk/Images/295630-gcse-chemistry-learner-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-iv | 4-i | 4-ii |  | *1-iii* | *1-vi* | *9-i* | *9-ii* |
| 4-iii | 6-i |  |  |  | *9-iii* | *11-i* |  |  |