# Chemistry PAG 2: Electrolysis

# Combined Science PAG C1: Electrolysis

# Suggested Activity 2: Microscale electrolysis of copper(II) chloride

## Instructions and answers for teachers & 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.**

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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 carry out a micro-scale electrolysis of copper(II) chloride solution in a petri-dish, producing copper solid and chlorine gas. Within the petri dish, the chlorine gas reacts with the potassium bromide and potassium chloride solutions via displacement reactions, and with damp blue litmus paper demonstrating the acid and bleaching nature of the chlorine gas in water.

This activity can be modified to reduce the number of observations the learners are making, allowing them to focus on less chemistry. For example, the set-up could be used without the potassium salt solutions, and just focus on the reaction of chlorine gas with the blue litmus paper. Such changes will affect the Apparatus and Techniques covered, so modification of the learner sheet may be appropriate.

This resource is adapted from the CLEAPSS experiment ‘The microelectrolysis of copper(II) chloride – <https://www.youtube.com/watch?v=KvW-g1FQV9E>

Further information and instructions for making the electrolysis cell can be found at:

* <http://science.cleapss.org.uk/Resource-Info/GL163-Make-it-guide-microscale-electrolysis-apparatus.aspx>
* <http://science.cleapss.org.uk/Resource-Info/GL196-Make-it-guide-microscale-Hoffmann-voltameter.aspx>

Another micro-scale electrolysis experiment is available from the Royal Society of Chemistry Microscale Chemistry publication <http://www.rsc.org/learn-chemistry/resource/res00000541/electrolysis-using-a-microscale-hoffman-apparatus>.

### 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:

**3** [*8*]: Use of appropriate apparatus and techniques for: i) conducting and monitoring chemical reactions

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

**7** [*12*]: Use of appropriate apparatus and techniques to: i) draw electrochemical cells for separation and production of elements and compounds; ii) set up and use electrochemical cells for separation and production of elements and compounds

**8**: Use of appropriate qualitative reagents and techniques to analyse and identify unknown samples or products including: i) gas tests

### Aims

To set-up a micro-scale electrolysis reaction of copper(II) chloride, and to analyse the products formed.

### Intended class time

20-25 minutes

### Links to Specifications:

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

C3.4a recall that metals (or hydrogen) are formed at the cathode and non-metals are formed at the anode in electrolysis using inert electrodes

C3.4d describe electrolysis in terms of the ions present and reactions at the electrodes

C3.4e describe the technique of electrolysis using inter and non-inert electrodes

C4.1a recall the simple properties of Groups 1, 7 and 0

C4.1b explain how observed simple properties of Group 1, 7 and 0 depend on the outer shell of electrons of the atoms and predict properties from given trends down the groups

C4.2a describe tests to identify selected gases

C6.1b explain why and how electrolysis is used to extract some metals from ores

W1.3a presenting observations and other data using appropriate methods

W1.3e interpreting observations and other data

W1.3f presenting reasoned explanations

W1.4a use scientific vocabulary, terminology and definitions

WS2a carry out experiments

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

WS2c presenting observations using appropriate methods

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

C1.4.2 describe a test to identify chlorine (using blue litmus paper)

C2.2.6 recall the simple properties of Group 7 elements including their states and colours at room temperature and pressure, their colours as gases, their reactions with Group 1 elements and their displacement reactions with other metal halides

C2.2.7 describe experiments to identify the reactivity pattern of Group 7 elements including displacement reactions

C3.2.5 explain why electrolysis is used to extract some metals from their ores

C3.3.1 describe electrolysis in terms of the ions present and reactions at the electrodes

C3.3.3 recall that metals (or hydrogen) are formed at the cathode and non-metals are formed at the anode in electrolysis using inert electrodes

C3.3.4 use the names and symbols of common elements and compounds and the principle of conversation of mass to write half equations

C3.3.5 explain reduction and oxidation in terms of gain or loss of electrons, identifying which species is oxidised and which are reduced

C3.3.8 describe the technique of electrolysis of an aqueous solution of a salt

IaS2.1 present observations and other data using appropriate formats

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

No defined mathematical skill is covered in this experiment.

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| Technical Requirements – PER GROUPChemicals  | **Identity** | **Approximate quantity required or produced PER GROUP** | **Hazard information** | | **Risk information** | | --- | --- | --- | --- | --- | | 0.5 mol dm–3 aqueous copper(II) chloride solution, CuC*l*2(aq) | 0.5 cm3 | Currently not classified as hazardous at this concentration | |  | | 0.5 mol dm–3 aqueous potassium bromide solution, KBr(aq) | 0.2 cm3 | Currently not classified as hazardous at this concentration | |  | | 0.2 mol dm–3 aqueous potassium iodide solution, KI(aq) | 0.2 cm3 | Currently not classified as hazardous at this concentration | |  | | chlorine | 1 cm3 produced (per group) | HSE toxic warning symbol  Hazard warning - environment  Hazard warning | DANGER  May cause or intensity fire; oxidiser. Causes skin irritation. Causes serious eye irritation. Toxic if inhaled. May cause respiratory irritation. Very toxic to aquatic organisms. | Ensure learners keep the lid on the petri dish during and after the electrolysis. Keep the room well ventilated. |  Equipment  * pre-prepared petri-dish with two small holes on opposite sides, and lid (see note below) * two graphite or carbon-fibre (e.g. kite rods) electrodes * 2 crocodile clips and wires * power-pack/9 V battery * blue litmus paper * dropping pipettes * blu-tack |

### Notes

55 mm OR 90 mm polystyrene petri dishes both work, and are widely available (e.g Timstar PE12035) for about 10p each. Drill two holes 1mm wider than the electrodes being used on opposite sides of the petri-dish base. Alternatively, carefully remove sections of the petri-dish side with a small pair of wire cutters. Alternatively, heat a large nail in a Bunsen flame and use this to melt holes through the petri dish. See <http://science.cleapss.org.uk/Resource-Info/GL163-Make-it-guide-microscale-electrolysis-apparatus.aspx> for further details.

4-6 stock bottles of the solutions with pipettes or dropper bottles will speed up the setting up of the electrochemical cells.

### Health and Safety

Eye protection should be worn at all times.

Ensure the petri-dish is covered when the circuit is connected to the power source- this will help contain the chlorine gas while the learners are looking closely at set-up to make their observations.

Ensure the laboratory is well ventilated. Take particular care if you have any asthmatic members of the group.

### Method

Learners will set up and run the electrochemical cell, producing copper at the cathode and chlorine at the anode. They will make a variety of observations including of the production of these substances and their chemical reactions.

### Images from trials

|  |  |
| --- | --- |
| After the electrolysis is completed  After the electrolysis is completed | Showing the formation of copper at the cathode  Showing the formation of copper at the cathode |

### Analysis of results – Trial results

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

|  |  |
| --- | --- |
| **Where?** | **Observation** |
| potassium bromide drop | turned from colourless to light orange/brown |
| potassium iodide drop | turned from colourless to orange/brown |
| positive electrode (anode) | bubbles formed |
| negative electrode (cathode) | brown/black substance formed |
| damp blue litmus paper | turned pink then white |
| copper(II) chloride drop | slowly turned from pale blue to colourless |

The questions you set your learners will depend on what the focus of the experiment is.

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| --- | --- | --- |
| **1.** | Chlorine is an acidic and bleaching gas in solution. Describe and explain the evidence you have for the production of chlorine gas. **[4 marks]** |  |
|  | Blue litmus paper turns red in the presence of acids ✓, and turns white in the presence of a bleach ✓. The chlorine gas dissolved in the water forming hydrochloric acid ✓ which turned the litmus paper pink/red, and a bleach ✓ which turned the paper white. |  |

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| **2.** | Chlorine is a reactive gas and will displace less reactive Group 7 elements from solution. Describe and explain the evidence that you have for the production of chlorine gas. **[6 marks]** |  |
|  | A gas is formed at the anode ✓, where chloride ions can discharge ✓. The reactivity of the halogens decreases down Group 7 ✓, therefore chlorine is more reactive than bromine and iodine ✓. When chlorine dissolves in the colourless potassium bromide solution, the solution turns pale orange/brown as bromine forms ✓. When chlorine dissolves in the colourless potassium iodide solution, the solution turn dark brown as iodine forms ✓. |  |

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| **3.** | In solution, copper is present as Cu2+ ions and forms a blue substance (called a complex) with water. Describe and explain the evidence you have for the production of copper metal. **[4 marks]** |  |
|  | A brown/black substance forms at the negative electrode (cathode) ✓ where the positive copper ions discharge during electrolysis ✓. The copper chloride solution slowly decolourised during the electrolysis ✓ as the copper ions come out of solution ✓. |  |

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| **4.** | Draw a diagram to show how you would carry out the electrolysis of a larger volume (e.g. 20 cm3) of copper(II) chloride. **[4 marks]** |  |
|  | +  –  power supply ✓  graphite electrode (cathode) ✓  graphite electrode (anode) ✓  copper(II) chloride solution ✓  beaker |  |

### Extension opportunities

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| **1.** | Write word and symbol equations for the different reactions that have occurred: | |  |
|  | **(a)** | Copper(II) chloride drop: Two half equations and full redox equation [**6 marks]** |  |
|  |  | copper ions + electrons → copper ✓  Cu2+(aq) + 2e– → Cu(s) ✓  chloride ions → chlorine + electrons ✓  2C*l*–(aq) → C*l*2(g) + 2e– ✓  copper ions + chloride ions → copper + chlorine ions ✓  Cu2+(aq) + 2C*l*–(aq)→ Cu(s) + C*l*2(g) ✓ |  |

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|  | **(b)** | Displacement reaction in the potassium bromide drop **[2 marks]** |  |
|  |  | chlorine + bromide → chloride + bromine ✓  C*l*2(g) + 2Br–(aq) → 2C*l*–(aq) + Br2(aq) ✓ |  |

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|  | **(c)** | Displacement reaction in the potassium iodide drop **[2 marks]** |  |
|  |  | chlorine + iodide→ chloride +iodine ✓  C*l*2(g) + 2I–(aq) → 2C*l*–(aq) + I2(aq) ✓ |  |

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| **2.** | Predict, with explanation, what will happen to the rate of electrolysis over time.  **[2 marks]** |  |
|  | As the concentration of the copper(II) ions decreases, the solution becomes less conductive ✓ so the rate of electrolysis decreases ✓. (In some observations, the discharged copper ‘grows’ from the cathode towards the anode, and an increase in the rate of bubble formation is seen, presumably as the effective size of the electrode is increased). |  |

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| **3.** | Explain why the colour of the copper(II) chloride solution changes over time. **[2 marks]** |  |
|  | The copper(II) ion forms a complex in solution (with six water molecules) which is blue ✓. As the copper ions discharge at the cathode, the concentration of this complex decreases ✓, hence the solution becomes less blue. |  |

### Document updates

v1 Published on the qualification pages

v1.1 January 2017 Consolidated labelling and formatting of activities

v1.2 February 2017 Correction of Combined Science labelling

v1.3 June 2021 Update to meet digital accessibility standards



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# Chemistry PAG 2: Electrolysis

# Combined Science PAG C1: Electrolysis

# Suggested Activity 2: Microscale electrolysis of copper(II) chloride

## Learner Activity

### Introduction

In this activity, you will pass an electrical current through copper(II) chloride solution to form two electrolysis products, copper and chlorine. The reaction will be carried out as a microscale experiment, which allows multiple experiments to be conducted at the same time, while minimising the amount of reagents used and the risks associated with chlorine gas.

### Aims

To set-up a microscale electrolysis reaction of copper(II) chloride, and to analyse the products formed.

|  |
| --- |
| +  –  crocodile clip  negative electrode (cathode)  power supply  potassium iodide solution  potassium bromide solution  copper(II) chloride solution  damp blue litmus paper  petri dish  positive electrode (anode)  wire |

**Figure 1: The electrochemical cell setup**

### Intended class time

20-25 minutes

### Equipment (per group)

* pre-prepared petri-dish with two small holes on opposite sides, and a lid
* two graphite/carbon-fibre electrodes
* 2 crocodile clips and wires
* power-pack/9V battery
* 0.5 mol dm–3 aqueous copper chloride solution (low hazard)
* 0.5 mol dm–3 aqueous potassium bromide solution (low hazard)
* 0.2 mol dm–3 aqueous potassium iodide solution (low hazard)
* dropping pipettes
* blue litmus paper
* blu-tack

### Health and Safety

* Eye protection should be worn at all times.
* Ensure the laboratory is well ventilated – chlorine gas (DANGER: Toxic and irritant) is produced. Your teacher will discuss this with you before the practical is carried out.
* Ensure the petri-dish is covered when the circuit is connected to the power source.

### Method

1. Set up the apparatus as shown in Figure 1. Slide the electrodes through the pre-drilled holes in the side of the petri-dish – the gap between the ends should be about 1 cm – and connect the crocodile clips to electrodes.. **Do not turn on the power supply yet**.

*You may need to use blu-tack to prevent the ends of the electrodes from ‘tipping-up’ – see Figure 2 below.*

1. Pipette about10 drops of the copper(II) chloride solution between the ends of the electrodes

*Both electrodes need to be within the drop so that the circuit is complete and the current can flow.*

1. Pipette about five drops each of potassium bromide and potassium iodide separately onto the petri-dish.

*These solutions will both react with one of the products of electrolysis of copper(II) chloride* *– you will be looking for a colour change.*

1. Dampen a 2-3 cm piece of blue litmus paper and place in the petri dish.

*The indicator paper is usually used to test for acidic substances, but can also be used to test for substances that bleach – again you will be looking for a colour change.*

1. Turn on the power supply to about 3 V for up to two minutes and record your observations in a table. If you are using a battery, the reactions should be complete within about one minute.

*Your observations will be in all three solution drops and the litmus paper. Do not run the electrolysis for more than two minutes.*

1. Dismantle your experimental set up. Place the indicator paper in the bin, and rinse the petri-dish and electrodes in a sink.

### Analysis of results

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

|  |  |
| --- | --- |
| **Where?** | **Observation** |
| potassium bromide drop |  |
| potassium iodide drop |  |
| positive electrode (anode) |  |
| negative electrode (cathode) |  |
| damp blue litmus paper |  |
| copper(II) chloride drop |  |

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.** | Chlorine is an acidic and bleaching gas in solution. Describe and explain the evidence you have for the production of chlorine gas. **[4 marks]** |  |
|  |  |  |

|  |  |  |
| --- | --- | --- |
| **2.** | Chlorine is a reactive gas and will displace less reactive Group 7 elements from solution. Describe and explain the evidence that you have for the production of chlorine gas.**[6 marks]** |  |
|  |  |  |

|  |  |  |
| --- | --- | --- |
| **3.** | In solution, copper is present as Cu2+ ions and forms a blue substance (called a complex) with water. Describe and explain the evidence you have for the production of copper metal. **[4 marks]** |  |
|  |  |  |

|  |  |  |
| --- | --- | --- |
| **4.** | Draw a diagram to show how you would carry out the electrolysis of a larger volume (e.g. 20 cm3) of copper(II) chloride. **[4 marks]** |  |
|  |  |  |

### Extension opportunities

|  |  |  |  |
| --- | --- | --- | --- |
| **1.** | Write word and symbol equations for the different reactions that have occurred: | |  |
|  | **(a)** | Copper(II) chloride drop: Two half equations and full redox equation **[6 marks]** |  |
|  |  |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
|  | **(b)** | Displacement reaction in the potassium bromide drop **[2 marks]** |  |
|  |  |  |  |

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|  | **(c)** | Displacement reaction in the potassium iodide drop **[2 marks]** |  |
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| --- | --- | --- |
| **2.** | Predict, with explanation, what will happen to the rate of electrolysis over time.  **[2 marks]** |  |
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| --- | --- | --- |
| **3.** | Explain why the colour of the copper(II) chloride solution changes over time. **[2 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*** | | | |
| 3-i | 6-ii | 7-i | 7-ii |  | *8-i* | *11-ii* | *12-i* | *12-ii* |
| 8-i |  |  |  |  |  |  |  |  |