Objectives

C3.22 Recall that electrolytes are ionic compounds in the molten state or dissolved in water.

C3.23 Describe electrolysis as a process in which electrical energy, from a direct current supply, decomposes electrolytes.

C3.24 Explain the movement of ions during electrolysis, in which:

a positively charged cations migrate to the negatively charged cathode

b negatively charged anions migrate to the positively charged anode.

C3.27 **H** Write half equations for reactions occurring at the anode and cathode in electrolysis.

C3.28 **H** Explain oxidation and reduction in terms of loss or gain of electrons.

C3.29 **H** Recall that reduction occurs at the cathode and that oxidation occurs at the anode in electrolysis reactions.

C3.31 *Investigate the electrolysis of copper sulfate solution with inert electrodes and copper electrodes.*

Maths requirements

1a Recognise and use expressions in decimal form.

1c Use ratios, fractions and percentages.

4a Translate information between graphical and numeric form.

4b Understand that y = mx + c represents a linear relationship.

4c Plot two variables from experimental or other data.

4d Determine the slope and intercept of a linear graph.

Learning outcomes

6th **SC3.22** State the meaning of the term ‘electrolyte’.

7th **SC3.23** Outline what happens during electrolysis.

7th **SC3.24** Explain the movement of the ions during electrolysis.

8th **SC3.27** **H** Write half equations for the reactions at the electrodes.

9th **SC3.28** **H** Explain the meaning of oxidation and reduction in terms of the movement of electrons.

8th **SC3.29** **H** State the electrodes at which oxidation and reduction occur.

Exploring

1. Core practical – Electrolysis of copper sulfate solution

This practical forms part of the core practical requirement of the specification. It is supported by the information on *Students' sheet CP4(Electrolysis-copper sulfate solution)* and in the Student Book.

A set of instructions for this practical is given on Students' sheet CP4 (Electrolysis).

There are two parts to the core practical – electrolysis of copper sulfate solution, first using copper electrodes and second using inert (graphite) electrodes. You may wish to split this over two or more lessons, depending on the length of your lessons.

Method 1 involves the electrolysis using copper electrodes and is quantitative as students measure the mass change of the electrodes using different currents. Students should use fresh copper sulfate solution for this experiment. This does take quite a long time and you could reduce the time for the practical by giving groups different currents to use and asking them to pool their results at the end. The copper electrodes can be dried by dipping the ends in propanone, removing them and shaking until the propanone evaporates. This should be carried out in a fume cupboard. Alternatively, students can leave their labelled electrodes to dry until the next lesson, then measure the electrode masses and carry out the analysis. Students can reuse the same electrodes provided they rub them with emery paper to remove any loose pieces of copper from the surface. The copper sulfate solution can be reused from this experiment.

Method 2 involves the electrolysis using inert electrodes and is qualitative as students observe and explain the formation of copper and oxygen at the electrodes. It is possible that some of the oxygen will react with the graphite to produce carbon dioxide but, at the low temperature of the experiment, this is likely to be minimal and can be ignored.

Support: Select the most appropriate support for students from:

- Students stick the methods on pages 1 and 2 of the worksheet into their books/files and then answer the directed questions on page 2. Students may need to be given additional information to complete question 2 in method 1. You may need to tell them what type of graph to draw and how to label the axes.
- Students stick the method into their books/files and then fill in their results on page 3 of the worksheet and answer the scaffolded questions on their results and conclusions. Students may need to be given additional information to complete question 3 on page 3. You may need to tell them what type of graph to draw and how to label the axes.

Stretch: Students follow the instructions on pages 1 and 2 of the worksheet, and then write up the experiment in their own words, by designing their own results tables, and writing a conclusion and an evaluation (with help from Skills Sheets PD2, PD5, SC1, TR1, TR4 and UE11 as needed). The directed questions on page 3 of the worksheet should not be printed/copied, and consider removing some or all of the directed questions on page 2.

Expected results

Students should obtain a similar pattern in their results to those shown in the table below.

Current (A)	Mass of anode at start (g)	Mass of anode at end (g)	Mass of cathode at start (g)	Mass of cathode at end (g)
0.2	2.77	2.69	2.51	2.58
0.3	2.68	2.55	2.55	2.66
0.4	2.53	2.36	2.62	2.76
0.5	2.36	2.15	2.70	2.87

⚠ Safety

Wear eye protection. Propanone is an irritant and highly flammable – there should be no sources of ignition in the laboratory.

Equipment (per group)

eye protection, emery paper, low voltage d.c. supply (0–12 V), ammeter (0–1 A), variable resistor, connecting leads, crocodile clips, 100 cm^3 beaker, stop clock, two graphite rods, two strips of copper foil about 2 cm wide and long enough to reach the bottom of the beaker, copper sulfate solution (about 50 cm^3, 0.5 mol dm^{-3}), access to a beaker of propanone, access to a fume cupboard, access to a balance (at least 2 d.p.), graph paper

Course resources

Chem Students' sheet CP4