Electrochemical cells

A video featuring these experiments is available at https://rsc.li/3l0g6sR, along with teacher notes and worksheets for learners.

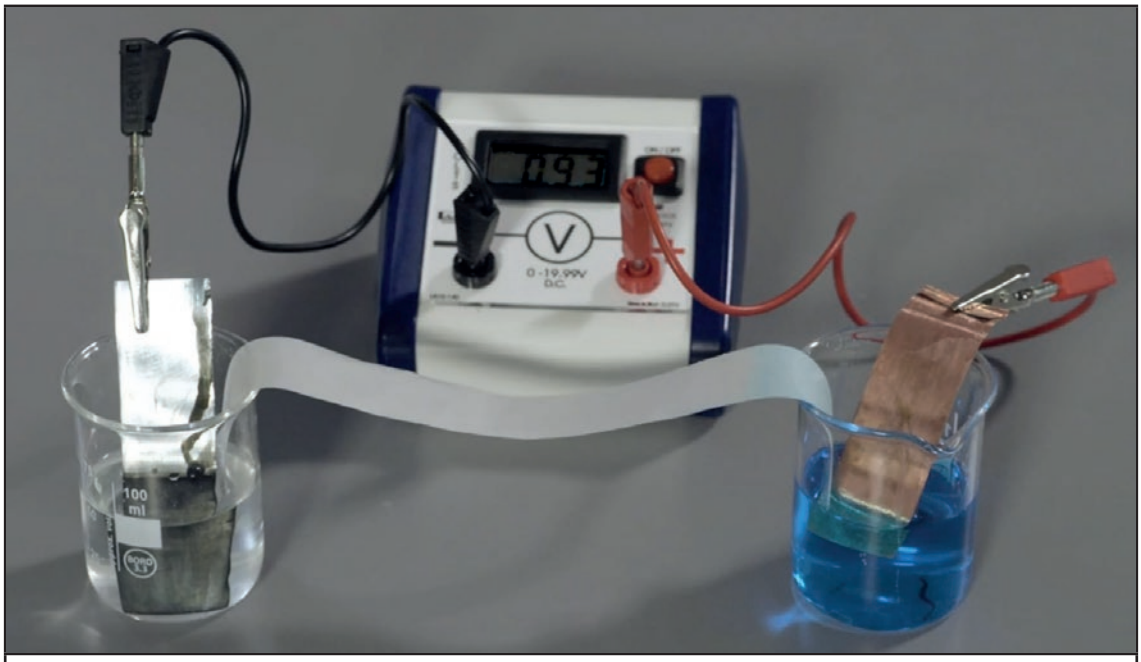
1. Simple copper and zinc cell

Equipment

- 2 x beakers, 100 cm^3
- 1 x piece of zinc metal
- 1 x piece of copper metal
- 2 x pieces of emery paper to clean metal
- copper(II) sulfate(VI) solution, 1.0 mol dm^{-3}, 50 cm^3
- zinc sulfate(VI) solution, 1.0 mol dm^{-3}, 50 cm^3
- 1 x strip of filter paper damped with saturated potassium nitrate(V) solution (salt bridge)
- 2 x crocodile clips
- 2 x tweezers
- 1 x voltmeter (to 2 decimal places) or multimeter set to 2 volts

Safety equipment: safety spectacles

Equipment set-up and tips



The zinc metal is placed in the zinc sulfate solution which is linked via a salt bridge to the copper sulfate solution containing the copper metal. Both metals are connected to a voltmeter.

You can use plastic tweezers to avoid handling the wet filter paper bridge.

2. Electrochemical cells microscale

Equipment (per group)

- 2 x Petri dishes big enough to hold filter paper lying flat
- 2 x filter paper to fit Petri dish
- 1 x pair of scissors
- 1 x voltmeter (to 2 decimal places) or multimeter (set to measure voltage up to 2 V)
- 2 x electrical leads (red and black preferably)
- 4 x pieces of emery paper to clean the metal foil/ribbon
- 1 x tweezers

Safety equipment: safety spectacles

Preparation

Solutions to be either made up in small dropper bottles, enough for one set per group. Alternatively make up in larger bottles for students to share between groups.

Each group will need the following:

- potassium nitrate(V) solution, saturated, 10 cm^3
- copper(II) sulfate(VI) solution, 1.00 mol dm^{-3}, 10 drops
- copper(II) sulfate(VI) solution, 0.10 mol dm^{-3}, 5 drops
- copper(II) sulfate(VI) solution, 0.01 mol dm^{-3}, 5 drops
- zinc sulfate(VI) solution, 1.00 mol dm^{-3}, 5 drops
- iron(II) sulfate(VI)) solution (freshly made), 1.00 mol dm^{-3}, 5 drops
- magnesium sulfate(VI) solution, 1.00 mol dm^{-3}, 5 drops

Samples of metal:

- copper, 1 cm^2, 5 pieces
- zinc, 1 cm^2, 1 piece
- magnesium ribbon, 1 cm, 1 piece
- iron, 1 cm^2 piece or 1 nail

Equipment set-up and tips

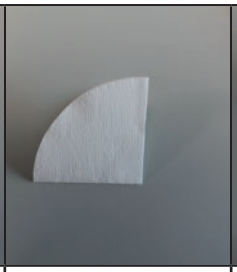
Solutions can be provided in beakers with plastic pipettes to dispense, if dropper bottles are not available.

Using a multimeter.

Folding the filter paper

Starting with circular filter paper.

Fold in half.

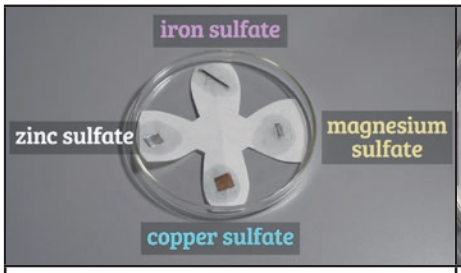
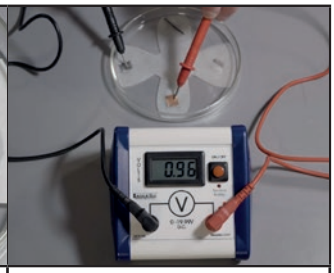


Fold in half again.

Cut the filter paper.

Unfold.

Adding the metals and solution

		
Use pencil to label each petal. Add metal and a few drops of the metal ions solution to each petal.	Add enough potassium nitrate solution to meet the dampened areas in the petals.	Record the potential difference between each half cell.

Safety

Read our standard health & safety guidance and carry out a risk assessment before running any live practical.

Refer to SSERC/CLEAPSS Hazcards and recipe sheets.

Hazard classification may vary depending on supplier.

Chemical supplied for the practical	Preparation
Potassium nitrate(v) solution, saturated KNO_3 (aq)  **WARNING** Harmful (ingestion) Irritant (skin, eyes) Irritant (respiratory)	Potassium nitrate(v) solid KNO_3 (s) MW = 101.10 g mol^{-1}  **WARNING** May intensify fire; oxidiser Some suppliers may also indicate one or more of the following: - causes skin irritation - causes serious eye irritation - may cause respiratory irritation
Copper(II) sulfate(VI) solution, 1.00 mol dm^{-3} $CuSO_4$ (aq)  **WARNING** Harmful (ingestion) Corrosive (eyes) Irritant (skin)	Copper(II) sulfate(VI) pentahydrate solid, $CuSO_4.5H_2O$ (s) MW = 249.68 g mol^{-1}  **DANGER** Harmful if swallowed Causes skin irritation Causes serious eye damage Very toxic to aquatic life with long lasting effects
Copper(II) sulfate(VI) solution, 0.10 mol dm^{-3} $CuSO_4$ (aq)  **WARNING** Irritant (skin, eyes)	Can be prepared by diluting copper(II) sulfate(VI) solution, 1.00 mol dm^{-3} (see above for details)

Chemical supplied for the practical	Preparation
Copper(II) sulfate(VI) solution, 0.01 mol dm^{-3} $CuSO_4$ (aq) Currently not classified as hazardous	Can be prepared by diluting copper(II) sulfate(VI) solution, 0.10 mol dm^{-3} (see above for details)
Zinc sulfate(VI), 1.00 mol dm^{-3} $ZnSO_4$ (aq)  **DANGER** Corrosive (eyes)	Zinc sulfate(VI) heptahydrate, solid $ZnSO_4.7H_2O$ (s) MW = 287.54 g mol^{-1}  **DANGER** Harmful if swallowed Causes serious eye damage Very toxic to aquatic life with long lasting effects
Iron(II) sulfate(VI) 1.00 mol dm^{-3} $FeSO_4$ (aq)  **WARNING** Irritant (eyes)	Iron(II) sulfate(VI) heptahydrate, solid $FeSO_4.7H_2O$ (aq) MW = 278.01 g mol^{-1}  **WARNING** Causes skin irritation Causes serious eye irritation Harmful if swallowed
Magnesium sulfate(VI) 1.00 mol dm^{-3} $MgSO_4$ (aq) Currently not classified as hazardous	Magnesium sulfate(VI) heptahydrate, solid $MgSO_4.7H_2O$ (s) MW = 246.47 g mol^{-1} Currently not classified as hazardous
Copper metal Cu (s) Currently not classified as hazardous	
Magnesium ribbon Mg (s)  **DANGER** Classification labelling vary depending on supplier. Some will indicate no hazard and some will give the following hazards: - flammable solid - self-heating in large quantities - may catch fire In contact with water releases flammable gases	
Zinc foil Zn (s) Currently not classified as hazardous	
Iron nail or foil Fe (s) Currently not classified as hazardous	

Take care as the pieces of metal may have sharp edges, take extra care when handling. After use, they can be cleaned using emery paper.

Disposal

Solutions from the demonstrations can be filtered and reused for the same activity apart from the iron(II) sulfate(VI) solution that needs to be diluted to 0.2 mol dm^{-3} and poured down the foul-water drain.

Place the filter paper used for the salt bridge and the flower in a bucket of water to rinse followed by disposal with general waste.

Dilute the water used to rinse the filter paper and pour down a foul water drain.