# Electrochemical cells 3 (microscale)

## Aim

To set up microscale electrochemical cells and to measure voltages. You will use strips of filter paper to create several different microscale electrochemical cells in a petri dish and measure the voltages generated by these cells.

Time required for activity: 40 mins

## Introduction

A basic half-cell can be constructed when a piece of solid metal is in contact with a solution of a salt of the ions of that metal. When two half-cells are connected together a potential difference is set up. This is called the cell potential (or electromotive force). The cell potential can be measured using a high resistance voltmeter. As very little current is drawn by the voltmeter, and therefore each half-cell is effectively in equilibrium, the voltage measured will be close to the standard cell potential (if standard conditions are used).

Traditionally, electrochemical cells are made up using small beakers of solution with strips of metal forming the electrodes. In this microscale experiment the whole cell is made up on one piece of filter paper. Multiple cells can be constructed in one petri dish, making investigation and data collection efficient.

## Specification Theory Content Links

Chemistry A H432: 5.2.3g

Chemistry B H433: DMd

## Health and Safety

The zinc sulfate used in this practical can cause serious eye damage so you must wear eye protection throughout the activity.

## Equipment

* eye protection
* 10cmpetri dish or other flat-bottomed container
* copper piece (c. 1cm2)
* iron piece (c. 1cm2)
* zinc granule (c. 1cm2)
* strips of filter paper (c. 2 × 10 cm)
* dropping pipettes
* voltmeter (0–5V) or multimeter (e.g. Draper 52320)
* moldm–3 copper sulfate(VI) solution
* 0.1 moldm–3 iron(II) sulfate(VI)
* 0.1 moldm–3 magnesium sulfate(VI)
* 0.1 mol dm-3 zinc sulfate(VI)
* magnesium ribbon
* saturated potassium nitrate(V) solution

Petri dish

Zinc granule on filter paper

dampened with Zn2+(aq)

Copper piece on filter paper

dampened with Cu2+(aq)

Filter paper strip

**Fig. 1** Diagram of a microscale electrochemical cell.

### Part 1: Making a standard solution of sodium hydrogencarbonate

| Procedure | Understanding |
| --- | --- |
| 1. Place the petri dish on a flat surface and lay the filter paper in the dish.
 | Read through the whole procedure carefully before starting work. What is a suitable format for recording your observations and results? |
| 1. Add 3–4 drops of 0.1moldm–3 copper sulfate(VI) solution to one end of the filter paper and place the piece of copper on top .This is your copper half-cell.
 | Consider the concentration of the solutions being used to make the half-cells. What impact might this have on the overall cell potential?  |
| 1. Add 3–4 drops of zinc sulfate(VI) solution to the other end of the filter paper and place the granule of zinc on top. This is your zinc half-cell.
 | What chemistry will happen at the interface of the metal and the solution during the experiment? Can you write a half-equation for the process occurring?  |
| 1. Carefully add drops of saturated potassium nitrate(V) solution to the centre of the filter paper, allowing it to spread out until it just touches the other two solution areas. NOTE: carry out this step slowly.
 | Why does the potassium nitrate(V) solution have to spread out to touch the other solutions at each end of the filter paper? |
| 1. Place the wires/probes of the voltmeter on the surface of the top (dry) surface of each metal and record the measured voltage.

If using a multimeter to measure voltage, make sure a convenient scale is used, e.g. 2000mV.  | Make sure that you are recording your results according to the units setting on the multimeter/voltmeter.  |
| 1. Lay a second piece of filter paper at right angles to the first.
 | It is essential that the edges of the pieces of filter paper touch or overlap. Why is this? |
| 1. Repeat steps 2–5 using magnesium and magnesium sulfate (VI) solution, and iron and iron (II) sulfate (VI) solution.
 | How many different cell combinations can you make using the four half-cells available? |
| 1. By placing the wires/probes of the voltmeter on alternately on the different electrodes you can take measurements of the cell potentials for all six possible cells.
 | How will you make sure that all the possible combinations of half-cells have been measured?  |

### Analysis

| Procedure | Understanding |
| --- | --- |
| 1. Look up the standard electrode potentials for each of the four half-cells you have made.
 | You can use a textbook, data book or a reliable scientific website to find the values. How can you assess how reliable the source you have chosen is?  |
| 1. Calculate the standard cell potentials for the six possible cells and compare these values with those that you measured.
 | How similar are the values you measured to the standard cell potentials calculated from the standard data values? State and explain the reasons for any differences between the calculated and measured values.  |

### Practical skills, apparatus and techniques assessed

| a | Reference | Description of skill/technique |
| --- | --- | --- |
|  | 1.2.1(a) | Applied an investigative approach to the activity. |
|  | 1.2.1(b) | Safely and correctly used the apparatus at all times. |
|  | 1.2.1(c) | Followed written instructions.  |
|  | 1.2.1(d) | Recorded contemporaneous results during the practical activity. |
|  | 1.2.1(e) | Recorded the results in a clear and appropriate format.Recorded subsequent calculations using raw data. |
|  | 1.2.1(f) | Presented information and data in a scientific way.Accurately recorded the cell potential values to an appropriate number of significant figures. Recorded results with appropriate units.  |
|  | 1.2.1(j) | Demonstrated competency in using the equipment and recording the cell potential voltages.  |
|  | 1.2.2(j) | Set up and an electrochemical cell and measured the voltage.  |

## Extension Questions and Further Investigations

1. Write overall reactions for each cell prepared.
2. Outline a plan to use this method to determine how the cell potential depends on the ion concentration in one of the half-cells. How would you analyse the results from such an investigation?

## Scientific and Practical Understanding

By connecting two half-cells together you are allowing a redox reaction to take place. Oxidation will take place in one of the half-cells. This releases electrons. These electrons make their way across the connection between the two half-cells (the salt bridge) and the ions in the other half-cell are reduced by gaining these electrons. The movement of these electrons is measured by the voltmeter placed across the two half-cells.

The overall cell potential, *E*ocell , is found by combining the electrode potentials of both half-cells as follows:

*E*ocell = *E*o(positive electrode) – *E*o(negative electrode)

The negative electrode or half-cell is the one with the more negative value of electrode potential meaning it has a higher tendency to lose electrons. Therefore, the more negative half-cell loses the electrons and is oxidized and the more positive half-cell gains those electrons and is reduced.

The half-equations for each half-cell are combined to give the overall reaction for the cell. For example;

Cu2+ + 2e– ⇌ Cu(s) *E*~~o~~ = +0.34 V (positive electrode)

Zn2+ + 2e– ⇌ Zn(s) *E*~~o~~ = –0.76 V (negative electrode)

The zinc half-cell has the more negative electrode potential and is therefore oxidised so moves in the left-hand direction. The copper half-cell will be reduced and moves to the right. The overall equation is:

Zn(s) + Cu2+(aq)→ Zn2+(aq) + Cu(s)

The cell potential is: *E*~~o~~cell = (+0.34V) – (–0.76V) = 1.10V

There are several reasons why the cell potentials measured here don’t match the standard electrode potentials expected. Make sure you can describe and explain why.

## Notes and References

It is advisable to check the [CLEAPSS website](http://www.cleapss.org.uk/) in advance of undertaking the practical tasks.

Health and safety should always be considered before undertaking any practical work. A full risk assessment of any activity should always be undertaken.

We recommend that this practical is trialled in advance of giving it to students. Keep the trial results as part of centre records for assessing the Practical Endorsement.

CLEAPSS. 2014. Electrochemical cells and electrode potentials available at: [Microscale and reduced scale chemistry; Experimental notes](http://docplayer.net/26948463-Microscale-and-reduced-scale-chemistry-experimental-notes.html)

Additional information and trial data for the analysis section can be found here:

[Teacher Guide: PAG 8.3](https://teachcambridge.org/resource_finder?results=20&page=1)