Cambridge Assessment
International Education

Cambridge International AS & A Level

Constructing electrochemical cells and measuring electrode cell potentials

Transcript

An electrochemical cell is a device that is able to produce electricity from chemical reactions.

Examples include standard batteries found in almost every home.

Here is a working electrochemical cell producing a voltage reading on the voltmeter attached.

This experiment describes how to set up an electrochemical cell and how to calculate the cell potential.

Copper sulfate and zinc sulfate are added to the beakers. The copper metal is connected to the connecting wire and placed in the copper solution. Next, the zinc metal is connected to the connecting wire and added to the zinc solution.

The voltmeter is switched on and shows a reading of zero.

For a voltage to register on the voltmeter, a salt-bridge is placed in the two solutions. A salt bridge can be made by taking a sheet of filter paper and soaking it in a saturated salt solution.

When the salt-bridge is placed into each half-cell, a voltage is produced.

The overall function of the salt bridge is to maintain electrical neutrality and in so doing completes the electrical circuit in the electrochemical cell.

If a negative voltage is produced, the terminals attached to each metal are switched around, so that a positive potential difference is registered and the voltage is recorded.

The cell is left working for 20 minutes.

An electrochemical cell involves a spontaneous chemical change, brought about by redox reactions at each half-cell.

In the zinc/copper example, zinc is the more reactive of the two metals and is the anode. Zinc loses electrons therefore oxidation occurs at the anode.

At the copper cathode, reduction occurs.

Copper ions accept electrons, which travel from the external circuit from the zinc half-cell, combining to produce copper.

As two electrons are lost from the anode and accepted at the cathode, the two half-equations can be combined to give the overall equation for the change that occurs in the electrochemical cell.

The cell has been operating for 20 minutes and is still working.

However, the voltage being produced by it is lower than at the start and there are also observable changes to the electrodes.

The zinc anode has become tarnished and has started to degrade around the edges.

The copper cathode has freshly deposited copper on it and appears slightly thicker than the zinc anode.

Here is a visual summary of the whole process for the zinc–copper cell.

The zinc atoms give up two electrons and pass into solution as zinc ions.

To compensate for each zinc ion entering the electrolyte, two chloride ions also enter the electrolyte from the salt bridge. This maintains the charge balance.
The electrons from the zinc anode, travel around the external circuit.

At the copper cathode, copper ions from the electrolyte combine with two electrons from the external circuit to yield more copper atoms. This increases the mass of the cathode.

The deficiency in charge caused by the loss of each copper ion is met by the addition of two sodium ions entering the electrolyte from the salt bridge.

The salt-bridge maintains the charge balance in both half-cells.

As the cell continues to work, the concentration of copper ions decreases and the concentration of zinc ions increases.

Eventually the cell will stop working.

The overall standard cell potential is the difference between the values of the two half-cells (+0.34 volts for copper and −0.76 volts for zinc).

In order to calculate the cell voltage, the less positive standard cell potential is always subtracted from the more positive standard cell potential.

The positive cell voltage value indicates that the reaction is a spontaneous process.

Electrochemical cells produce electricity by spontaneous chemical reactions.

Different half-cell combinations with different metals can be tested and the standard cell potential values calculated. The concentrations and the temperature of the solutions affect the standard cell potential values.