

## UNIT 9 Electrolysis

**Recommended Prior Knowledge** This unit should be taught towards the end of the course. It is recommended that Units 1,2,4,5 and 6 are taught before this unit.

**Context** This unit builds on students' understanding of atomic structure, ionic bonding, ionic equations, energy changes, redox reactions and metal extraction. The unit can be used to consolidate and reinforce ideas from these syllabus areas.

**Outline** The unit examines the electrolysis of molten and aqueous compounds. Students should have the opportunity to observe or carry out these reactions as small scale experiments in the laboratory. More able students should be practise writing ionic equations for the reactions and predicting the products of electrolysis. They should discuss the reactions using ideas of redox in terms of electron transfer. Less able students should be able to learn the products of the reactions they study. The manufacture of aluminium is included in the unit. This gives an opportunity for studying the social and environmental importance of recycling of metals.

	Summary of learning Outcomes (see syllabus for full detail)	Suggested Teaching Activities	Further teacher guidance	Online resources
4	<b>Electrolysis</b>			
a	describe electrolysis as the conduction of electricity by ionic compounds when molten or dissolved in water, leading to decomposition	Students can compare the conduction of electricity by metals and ionic compounds. They should be able to describe the term 'electrolyte' by referring to its decomposition by an electric current.		<a href="http://www.chemsoc.org/networks/learnnet/classic_exp.htm">www.chemsoc.org/networks/learnnet/classic_exp.htm</a> Look at experiment 34
b	describe the evidence for the existence of ions.		Practical experiment with a $\text{KMnO}_4$ crystal on moist filter paper a useful demonstration	<a href="http://www.btinternet.com/~chemistry.diagrams/electrolysis.htm">http://www.btinternet.com/~chemistry.diagrams/electrolysis.htm</a> <a href="http://www.wpbschoolhouse.btinternet.co.uk/page10/page10.htm">www.wpbschoolhouse.btinternet.co.uk/page10/page10.htm</a> Click on 'Extra Electrochemistry'
c	describe the electrolysis of molten lead bromide (mobility of ions and electrode products)	This can be carried out as a demonstration by melting a small sample in a crucible and electrolysing it, while heating, using graphite electrodes.	If possible, this should be carried out in a fume cupboard as the toxic bromine vaporises.	
d	predict the products of electrolysis of a molten binary compound	Students should be able to predict the products of electrolysing other simple compounds e.g. other metal halides.		

e,f	<p>apply the idea of selective discharge to predict the likely products of an electrolysis of an aqueous electrolyte (inert electrodes)</p> <p>Examples: concentrated aqueous sodium chloride, aqueous copper(II) sulphate, dilute sulphuric acid</p>	<p>Students can carry out the electrolysis of the named solutions using graphite electrodes in small cells. Adding Universal Indicator to aqueous sodium chloride allows identification of the alkali (sodium hydroxide) and chlorine (the indicator is bleached). Students should carry out at least one experiment where the gases are collected and tested.</p> <p>Students should be given rules of selective discharge and should practise predicting the products of electrolysis of a range of other aqueous ionic salts.</p>	<p>This is also an opportunity to teach the gas tests for hydrogen and oxygen (Syllabus learning outcome 1.3(c))</p>	<p><a href="http://www.chemsoc.org/networks/earnnet/classic_exp.htm">www.chemsoc.org/networks/earnnet/classic_exp.htm</a> Look at experiments 82, 92, 100</p> <p><a href="http://teachers.cie.org.uk/teacher_support/pdf/0620_nosss_8.html">http://teachers.cie.org.uk/teacher_support/pdf/0620_nosss_8.html</a> (you will need your school's user name and password to access this simulation on the teacher's support site)</p>
g	construct ionic equations for the reactions	Students need to be able to write ionic equations, with state symbols, for common reactions at both the anode and cathode, including the discharge of oxygen gas from hydroxide ions from water.	It is also important that reactions are discussed in terms of redox (electron transfer, oxidation number change)	
i	describe the electrolysis of aqueous copper(II) sulphate with copper electrodes (to purify copper)	This can be taught alongside the electrolysis of aqueous copper(II) sulphate with inert electrodes. Students need to be able to compare the two processes e.g. the different observations and anode reactions.	Interesting issues to discuss include the need for very pure copper for use in electrical cable. This can be linked to the recycling of used copper first discussed in Unit 6.	<a href="http://www.s-cool.co.uk/contents.asp">www.s-cool.co.uk/contents.asp</a> click on 'GCSE revision' then 'Chemistry' then choose topic: 'Electrolysis'. Use the 'Quick learn' section.
j	describe electroplating of metals	<p>Students can make 'initial badges' by painting initials or symbols using nail varnish on zinc strips and then electroplating them with copper. The varnish can then be removed.</p> <p>Students can research the uses of electroplating.</p>	The zinc can be cleaned by dipping in conc. sodium hydroxide and dilute hydrochloric acid.	

k	describe the production of electrical energy from simple cells.	<p>Students should use a voltmeter to measure voltages when different pairs of electrodes are dipped in an aqueous electrolyte e.g. dilute hydrochloric acid. They can also try making a fruit battery by using a citrus fruit or potato as the electrolyte.</p> <p>More able students should discuss the size of the voltage to the difference in reactivity of the metals.</p>	<p>This should be linked to the reactivity series (Syllabus learning outcome 9.2)</p> <p>Students could research the Daniell Cell as an extension activity.</p>	<p><a href="http://www.chemsoc.org/networks/earnnet/classic_exp.htm">www.chemsoc.org/networks/earnnet/classic_exp.htm</a> Look at experiments 7, 15.</p> <p><a href="http://science.howstuffworks.com/battery.htm">http://science.howstuffworks.com/battery.htm</a></p> <p><a href="http://www.wpbschoolhouse.btinternet.co.uk/page10/page10.htm">www.wpbschoolhouse.btinternet.co.uk/page10/page10.htm</a> Click on 'Reactivity of Metals'</p>
4 h & 9.5 a	<b>Manufacture of Aluminium</b> outline the manufacture of aluminium from pure aluminium oxide dissolved in cryolite.	<p>Students should be familiar with a schematic diagram of an industrial cell for the electrolysis of molten aluminium oxide in molten cryolite. Teaching points include...</p> <ul style="list-style-type: none"> <li>• the role of the cryolite.</li> <li>• electrode reaction, names of substances involved and ionic equations.</li> <li>• reactions discussed in terms of redox (oxygen and electron transfer, oxidation number change)</li> <li>• the processes that erode the anodes.</li> </ul>	<p>Further discussion can focus on the large energy demand for the process and the implications for depletion of non-renewable fuels. This should be linked to the importance of recycling of aluminium, first discussed in Unit 6.</p>	<p><a href="http://www.wpbschoolhouse.btinternet.co.uk/page10/page10.htm">www.wpbschoolhouse.btinternet.co.uk/page10/page10.htm</a> Click on 'Extraction of Metals' and 'Extra Industrial Chemistry'</p> <p><a href="http://www.alfed.org.uk/aluminium.htm">www.alfed.org.uk/aluminium.htm</a></p> <p><a href="http://www.btinternet.com/~chemistry.diagrams/aluminium_extraction.htm">http://www.btinternet.com/~chemistry.diagrams/aluminium_extraction.htm</a></p>
b c	<p>explain the apparent lack of reactivity of aluminium</p> <p>state the uses of aluminium related to its properties</p>	<p>Suggested experiment is to compare the reaction with dilute acid of an 'old' aluminium strip to one that has had its surface oxide layer removed by rubbing with sandpaper (or been cleaned with vinegar).</p>	<p>Contrast the role of the impervious oxide layer to the oxidation of iron causing iron to rust (Syllabus learning objective 10 (d))</p>	<p><a href="http://www.chemsoc.org/networks/earnnet/classic_exp.htm">www.chemsoc.org/networks/earnnet/classic_exp.htm</a> Look at experiment 55</p>