Exercise walk-through

4.3
Electrolysis (4.4.3.1–4.4.3.3)

AQA · GCSE · Chemistry

The reactivity of metals

- When metals react, their atoms lose electrons and form a **positive ion** .
- The more easily a metal does this, the more reactive it is.
- The **reactivity series** puts the metals in order: potassium, sodium, lithium, calcium, magnesium, zinc, iron, copper, from most to least reactive.
- Carbon and hydrogen are not metals, but they are included as reference points.

$$\mathrm{Zn(s)} + \mathrm{CuSO_4(aq)} \rightarrow \mathrm{ZnSO_4(aq)} + \mathrm{Cu(s)}$$

Electrolysis

- At the **cathode**, the metal forms if it is less reactive than hydrogen (such as copper). Otherwise hydrogen forms.
- At the **anode**, if the solution contains a **halide** ion (**chloride**, bromide or iodide), the **halogen** forms. Otherwise oxygen forms.
- hydrogen burns with a squeaky pop when a **lighted splint** is held near it;

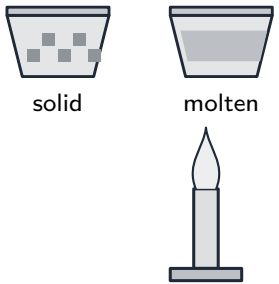
$$\mathrm{Al}^{3+} + 3\mathrm{e}^- \rightarrow \mathrm{Al} \qquad 2\mathrm{O}^{2-} \rightarrow \mathrm{O}_2 + 4\mathrm{e}^-$$

Sources for this lesson

- AQA, *GCSE Chemistry (8462) specification*, section 4.4, and the required practicals handbook.
- Smithsonian Institution, "The Aluminum Apex of the Washington Monument" (1884 capstone, 100 troy ounces).
- C. M. Hall, US Patent 400,766, "Process of Reducing Aluminium from its Fluoride Salts by Electrolysis" (filed July 1886), and P. Héroult, French patent 175,711 (April 1886).
- Royal Society of Chemistry, *Practical Chemistry*: "Preparing a salt" and "Electrolysis of solutions".

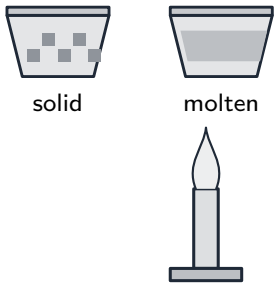
Exercise 2.1

2.1 Explain why solid lead bromide does not conduct electricity, but molten lead bromide does. [2]



Exercise 2.1

2.1 Explain why solid lead bromide does not conduct electricity, but molten lead bromide does. [2]

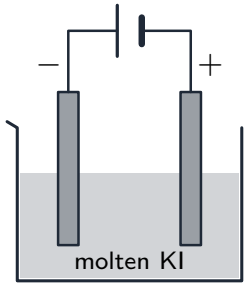


2.1

- in the solid, the ions are fixed in place; when molten, the ions are free to move to the electrodes

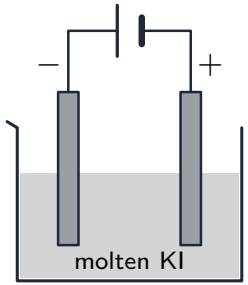
Exercise 2.2

2.2 Molten potassium iodide is electrolysed. Name the product at the cathode and the product at the anode. [2]



Exercise 2.2

2.2 Molten potassium iodide is electrolysed. Name the product at the cathode and the product at the anode. [2]

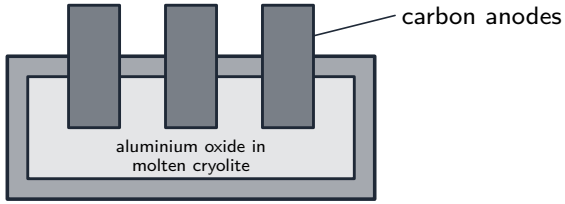


2.2

- cathode: **potassium**; anode: **iodine**

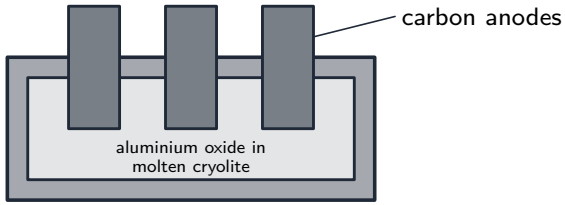
Exercise 2.3

2.3 Aluminium oxide is dissolved in molten cryolite before electrolysis. Explain why. [2]



Exercise 2.3

2.3 Aluminium oxide is dissolved in molten cryolite before electrolysis. Explain why. [2]

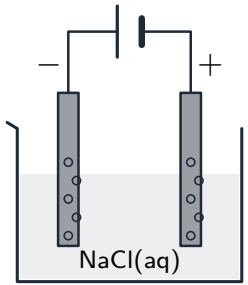


2.3

- the mixture has a much lower melting point than aluminium oxide; so less energy is needed, which saves money

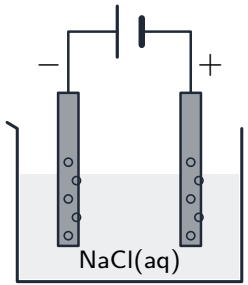
Exercise 3.1

3.1 Sodium chloride solution is electrolysed. Name the product at each electrode, and the solution left at the end. [3]



Exercise 3.1

3.1 Sodium chloride solution is electrolysed. Name the product at each electrode, and the solution left at the end. [3]

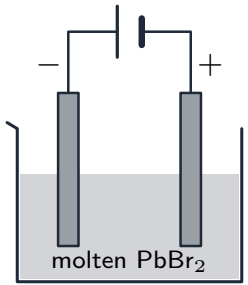


3.1

- cathode: **hydrogen** (sodium is more reactive than hydrogen); anode: **chlorine** (chloride ions are present); **sodium hydroxide** solution is left

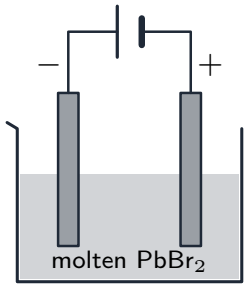
Exercise 3.2

3.2 Molten lead bromide is electrolysed. Write the half-equations at the cathode and at the anode. Explain which one is reduction. [3]



Exercise 3.2

3.2 Molten lead bromide is electrolysed. Write the half-equations at the cathode and at the anode. Explain which one is reduction. [3]



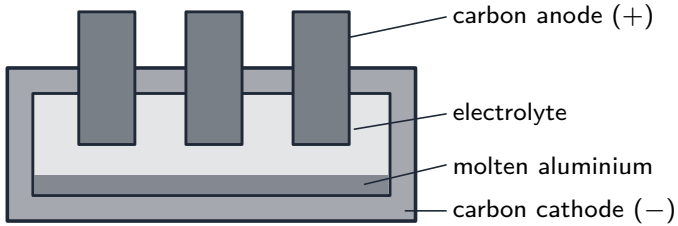
3.2

- cathode: $Pb^{2+} + 2e^- \rightarrow Pb$; anode: $2Br^- \rightarrow Br_2 + 2e^-$; the cathode reaction is reduction, as lead ions gain electrons

Exercise 3.3 (a)

3.3 Aluminium is made by the electrolysis of aluminium oxide: $2Al_2O_3 \rightarrow 4Al + 3O_2$

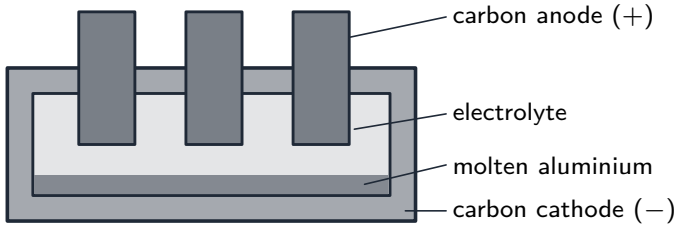
(a) Explain why the carbon anodes must be replaced often. [2]



Exercise 3.3 (a)

3.3 Aluminium is made by the electrolysis of aluminium oxide: $2Al_2O_3 \rightarrow 4Al + 3O_2$

(a) Explain why the carbon anodes must be replaced often. [2]



(a) oxygen forms at the anodes; it reacts with the hot carbon to form CO_2, so the anodes burn away

Exercise 3.3 (b)

3.3 Aluminium is made by the electrolysis of aluminium oxide: $2Al_2O_3 \rightarrow 4Al + 3O_2$

(b) Calculate the mass of aluminium made from 102 tonnes of aluminium oxide. (M_r: Al_2O_3 102; A_r: Al 27) [3]

Exercise 3.3 (b)

3.3 Aluminium is made by the electrolysis of aluminium oxide: $2Al_2O_3 \rightarrow 4Al + 3O_2$

(b) Calculate the mass of aluminium made from 102 tonnes of aluminium oxide. (M_r: Al_2O_3 102; A_r: Al 27) [3]

(b) 1 mol Al_2O_3 (102 g) gives 2 mol Al; $2 \times 27 = 54$ g of Al per 102 g; so **54** tonnes

Exercise 3.3 (c)

3.3 Aluminium is made by the electrolysis of aluminium oxide: $2Al_2O_3 \rightarrow 4Al + 3O_2$

(c) Write the half-equation for the reaction at the cathode. [2]

Exercise 3.3 (c)

3.3 Aluminium is made by the electrolysis of aluminium oxide: $2Al_2O_3 \rightarrow 4Al + 3O_2$

(c) Write the half-equation for the reaction at the cathode. [2]

(c) $Al^{3+} + 3e^- \rightarrow Al$: species, balanced

Exercise 3.3 (d)

3.3 Aluminium is made by the electrolysis of aluminium oxide: $2Al_2O_3 \rightarrow 4Al + 3O_2$

(d) Explain why aluminium is extracted by electrolysis and not by heating with carbon, and why the process is expensive. [6]

Exercise 3.3 (d)

3.3 Aluminium is made by the electrolysis of aluminium oxide: $2Al_2O_3 \rightarrow 4Al + 3O_2$

(d) Explain why aluminium is extracted by electrolysis and not by heating with carbon, and why the process is expensive. [6]

(d) points to include:

- aluminium is more reactive than carbon, so carbon cannot reduce aluminium oxide; electrolysis is needed
- aluminium oxide melts above 2000 °C, so it is dissolved in cryolite to lower the melting point
- a lot of energy is still needed to keep the mixture molten
- a very large electric current is needed, which costs a lot
- the carbon anodes burn away and must be replaced

Levels: **5–6** a full, logical answer with correct chemistry and correct terms; **3–4** several correct points, partly linked; **1–2** one or two relevant points.