4.3 Electrolysis

Name: _____ Class: _____ Date: _____ **Total: 35 marks**

KEY WORDS electrolysis • cathode • anode

Objective

Predict electrolysis products and write half-equations. Original questions for spec statements 4.4.3.1–4.4.3.5.

1 Key knowledge and worked examples

Electrolyte: molten or dissolved ionic compound – **ions free to move**, so it conducts. Cations (+) → **cathode** (−); anions (−) → **anode** (+); ions are **discharged** as elements.

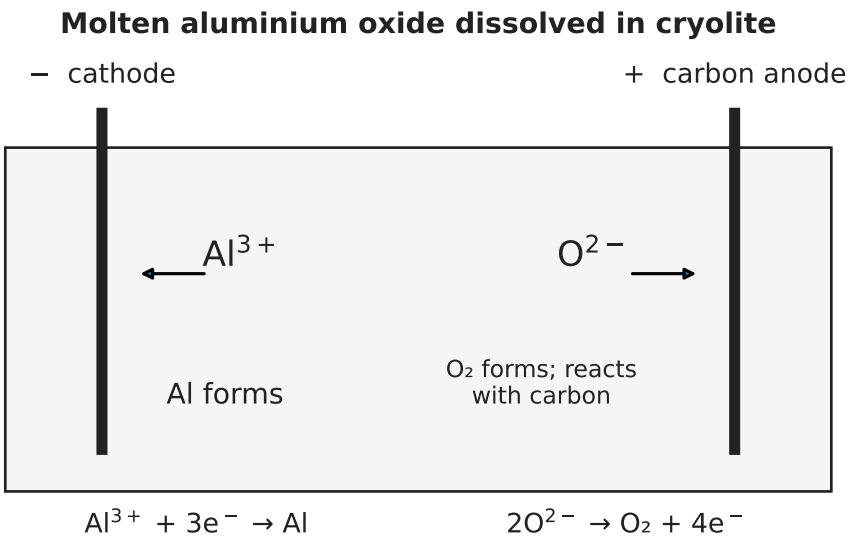
Molten binary compound ($PbBr_2$): **metal at the cathode, non-metal at the anode**.

Aluminium extraction: molten **Al_2O_3 + cryolite** – cryolite **lowers the melting point**, saving energy and cost; the **carbon anode reacts with the oxygen made** and must be replaced; electrolysis is used because aluminium is more reactive than carbon.

Aqueous solutions: at the **cathode** – **hydrogen** forms if the metal is more reactive than hydrogen, otherwise the metal; at the **anode** – **oxygen**, unless **halide ions** are present, then the halogen.

(HT) Half-equations:

- $Cu^{2+} + 2e^- \rightarrow Cu$; $Al^{3+} + 3e^- \rightarrow Al$; $2H^+ + 2e^- \rightarrow H_2$
- $2Br^- \rightarrow Br_2 + 2e^-$; $2Cl^- \rightarrow Cl_2 + 2e^-$; $4OH^- \rightarrow O_2 + 2H_2O + 4e^-$



Mobile ions carry charge in the melt; electrons move through the external circuit.

Worked example (3 marks, HT). Molten aluminium oxide is electrolysed. Give both half-equations.

Cathode: $Al^{3+} + 3e^- \rightarrow Al$. Anode: $2O^{2-} \rightarrow O_2 + 4e^-$. Charges balance – oxidation at the anode, reduction at the cathode.

2 Practice

2.1 Why does solid sodium chloride not conduct electricity but molten sodium chloride does? [2]

2.2 Name the product at each electrode when molten lead bromide is electrolysed. [2]

2.3 What forms at the anode when concentrated sodium chloride solution is electrolysed? [1]

3 Exam-style questions

3.1 Explain why cryolite is mixed with aluminium oxide in aluminium extraction, and why the carbon anodes need regular replacement. [4]

3.2 Predict the products of electrolysis of aqueous copper sulfate using inert electrodes, explaining the electrode processes. [4]

3.3 *(HT)* Write half-equations for the electrolysis of dilute sulfuric acid at each electrode. [4]

3.4 Using inert electrodes, predict both products for (a) molten NaCl, (b) aqueous NaCl, (c) aqueous $CuCl_2$ and (d) aqueous Na_2SO_4 under the specified GCSE rules. Explain why the cathode product differs between (a) and (b). [6]

3.5 Develop a hypothesis for electrolysis of aqueous copper(II) sulfate with inert electrodes. Describe evidence you would seek at each electrode, the relevant gas test, two conditions to control when comparing solutions, and one precaution concerning gases. Explain why the ions and the external wire carry charge in different ways. [7]

3.6 *(HT)* Complete and balance both half-equations for molten zinc chloride. Then correct $2OH^- \rightarrow O_2 + H_2O + 2e^-$ for oxygen formation from aqueous hydroxide ions. Show how both atoms and charge check in your corrected oxygen equation. [5]