Worksheet 5.4.3: Electrolysis of Aqueous Solutions

ChemistrySheets

Specification: GCSE Chemistry (AQA 5.4.3 / Edexcel SC12)

Core Concepts: Understand the rules for predicting products at the anode and cathode during electrolysis of aqueous solutions, including the role of water and the reactivity series. Recall half-equations for common electrode reactions.

Section A: Key Terms & Basic Understanding

A1. The diagram below shows an electrolysis cell. Label the components using the terms provided.

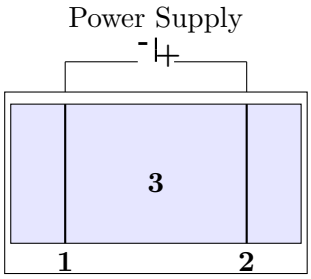

Figure 1: An electrolysis cell.

Match the numbers to the correct terms:

- **1: Cathode / Negative electrode**
- **2: Anode / Positive electrode**
- **3: Electrolyte**

A2. Complete the sentences below using appropriate scientific terms.

(i) Electrolysis is the process of using **electrical energy** to break down an **ionic compound**.

(ii) The substance being electrolysed must be molten or dissolved in water so that its **ions** are free to **move**.

(iii) The positive electrode is called the **anode** and the negative electrode is called the **cathode**.

(iv) At the cathode, **reduction** occurs, which is the **gain** of electrons. At the anode, **oxidation** occurs, which is the **loss** of electrons.

Section B: Core Concepts & Explanations

B1. Explain why solid ionic compounds do not conduct electricity, but molten ionic compounds do.

Model Answer:
Solid ionic compounds have ions held in fixed positions in a lattice structure, so they cannot move to carry charge. When molten, the ions are free to move and can carry electrical charge, allowing conduction.

B2. Describe what happens to positive ions (cations) and negative ions (anions) during electrolysis.

Model Answer:
During electrolysis, positive ions (cations) are attracted to the negative electrode (cathode) where they gain electrons (reduction). Negative ions (anions) are attracted to the positive electrode (anode) where they lose electrons (oxidation).

B3. When electrolysing an aqueous solution, explain the rule for predicting the product at the cathode.

Model Answer:
At the cathode (negative electrode), there are positive metal ions and hydrogen ions (from water). If the metal is more reactive than hydrogen (e.g., Group 1/2 metals), hydrogen gas is produced. If the metal is less reactive than hydrogen, the metal itself is produced.

B4. When electrolysing an aqueous solution, explain the rule for predicting the product at the anode.

Model Answer:
At the anode (positive electrode), there are negative non-metal ions and hydroxide ions (from water). If halide ions (Cl^-, Br^-, I^-) are present, the halogen element is produced, unless the solution is very dilute. If no halide ions are present, or if the solution is very dilute, oxygen gas is produced from the hydroxide ions.

Section C: Exam Application & Extended Writing

C1. Aqueous copper(II) sulfate ($CuSO_4$) is electrolysed using inert electrodes.

(i) List all the ions present in the aqueous copper(II) sulfate solution.

Model Answer:
Cu^{2+} (from copper(II) sulfate), SO_4^{2-} (from copper(II) sulfate), H^+ (from water), OH^- (from water).

(ii) Predict the products formed at the cathode and anode, giving a reason for each prediction.

Model Answer:
At the cathode: Copper metal (Cu) is produced because copper is less reactive than hydrogen. At the anode: Oxygen gas (O_2) is produced because sulfate ions are present, and hydroxide ions are discharged in preference to sulfate ions (as sulfate is not a halide).

C2. Aqueous sodium chloride (NaCl) is electrolysed using inert electrodes. Describe the processes occurring at both electrodes, including the half-equations and observations you would expect to see. (6 marks)

Model Answer:
At the cathode (negative electrode): Sodium ions (Na^+) and hydrogen ions (H^+) are present. Hydrogen is less reactive than sodium, so hydrogen ions are preferentially discharged. Hydrogen gas is produced. The half-equation is: $2H^+(aq) + 2e^- \rightarrow H_2(g)$. Observation: Bubbles of a colourless gas are seen.
At the anode (positive electrode): Chloride ions (Cl^-) and hydroxide ions (OH^-) are present. Chloride ions are halide ions, so they are preferentially discharged over hydroxide ions (unless the solution is very dilute). Chlorine gas is produced. The half-equation is: $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$. Observation: Bubbles of a pale green gas are seen.