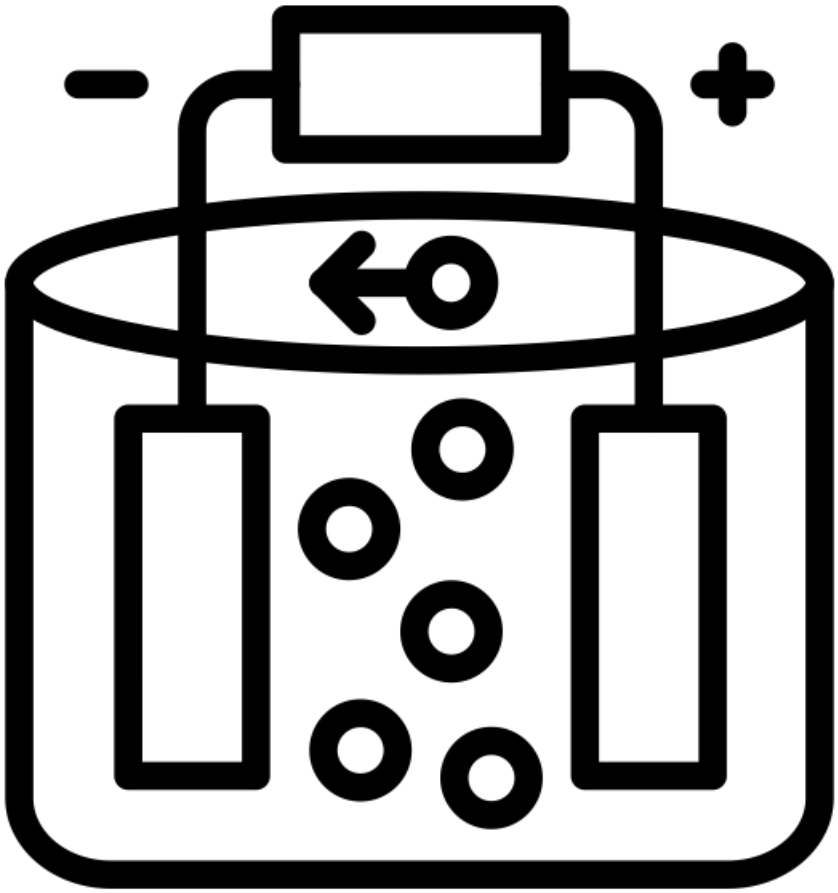
Electrolysis



Name _____

Class _____

Teacher _____

L1 The process of electrolysis

Electrolysis is a method that splits up a substance into its basic parts using electricity. It's like using a special key (electricity) to unlock and separate the components of a compound (a substance made of two or more elements).

Two metal sticks called electrodes, are put into a liquid called an electrolyte. The electrolyte is usually a solution or melted substance that can conduct electricity. The electrodes are connected to a power source, like a battery. The battery has a positive side (anode) and a negative side (cathode). When you turn on the power, electricity flows through the electrolyte. This causes chemical reactions at the electrodes, breaking the compound into different parts.

Example: Splitting Water

- Water (H_2O) is made of hydrogen and oxygen.

- During electrolysis, electricity splits water into its elements: hydrogen gas (H_2) and oxygen gas (O_2).

- The hydrogen gas collects at the negative electrode (cathode), and the oxygen gas collects at the positive electrode (anode).

4. Why is it Useful?

Electrolysis is important because it helps produce useful substances. For example:

Hydrogen Production: For fuel cells and as a clean energy source.

Metal Extraction: Like getting pure aluminium from its ore.

Electroplating: Coating objects with a thin layer of metal to protect them or make them look nice.

Independent practice

1. What is electrolysis?

2. What are the two metal sticks used in electrolysis called?

3. What is the liquid called that conducts electricity during electrolysis?

4. What happens at the cathode during the electrolysis of water?

5.What happens at the anode during the electrolysis of water?

6. Why is electrolysis useful? Name one application.

7. What are the positive and negative sides of a power source called?

8. During electrolysis, where do positive ions move and why?

9. During electrolysis, where do negative ions move and why?

10. What is one example of a substance that can be produced by electrolysis?

L2 Half equations (HT ONLY)

Half equations show the changes that happen to the individual ions or molecules during a redox (reduction-oxidation) reaction. They focus on either the oxidation part or the reduction part of the reaction separately. They help us understand and balance the overall reaction by looking at the details of how electrons are gained or lost.

Oxidation and Reduction:

Oxidation is when a substance loses electrons. Think of it as losing negative charges.

Reduction is when a substance gains electrons. Think of it as gaining negative charges.

How to Write Half Equations:

Let's use a common example: the electrolysis of water, which splits water into hydrogen and oxygen.

At the negative electrode (cathode) a reduction reaction occurs.

$4H^+(aq) + 4e^- \rightarrow 2H_2(g)$

At the positive electrode (anode) an oxidation reaction occurs.

$4OH^-(aq) \rightarrow 2H_2O(l) + O_2(g) + 4e^-$

Independent practice

1. What is a half equation in the context of electrolysis?
2. Write the half equation for the reduction of hydrogen ions (H^+) at the cathode during the electrolysis of water.
3. Write the half equation for the oxidation of water at the anode during the electrolysis of water.
4. In the electrolysis of sodium chloride (NaCl) solution, what is the half equation for the reaction at the cathode?
5. In the electrolysis of sodium chloride (NaCl) solution, what is the half equation for the reaction at the anode?
6. Explain why the electrons in the half equations for electrolysis must balance out in the overall reaction.

L3 Electrolysis of molten ionic compounds

Electrolysis is a process that uses electricity to break down a substance. When we talk about molten ionic compounds, we mean compounds that have been heated until they are melted and are in a liquid form.

Electrolysis of Molten Sodium Chloride (NaCl)

At the Cathode (Negative Electrode):

- Sodium ions (Na^+) gain electrons from the cathode.

- The half equation for this reaction is:

$Na+ + e- \longrightarrow Na$

- This means each sodium ion gains one electron to become a neutral sodium atom. This forms molten sodium metal.

At the Anode (Positive Electrode):

Chloride ions (Cl^-) lose electrons at the anode.

The half equation for this reaction is:

$2Cl- \longrightarrow Cl2 + 2e-$

- This means each pair of chloride ions loses two electrons to form chlorine gas (Cl_2).

Overall Reaction:

Combining these half equations, the overall reaction is:

$2NaCl \longrightarrow 2Na + Cl2$

Why is This Important?

Producing Elements: Electrolysis of molten ionic compounds can produce pure elements like sodium metal and chlorine gas.

Industrial Uses: This process is used in industries to extract metals from their ores and to produce chemicals.

Independent practice

Electrolysis of Molten Ionic Compounds

1. What is electrolysis?

2. What is meant by a molten ionic compound?

3. What are electrodes and how are they connected in the electrolysis setup?

4. What happens to an ionic compound when it is melted?

5. In the electrolysis of molten sodium chloride (NaCl), what ions are present?

6. Where do the sodium ions (Na^+) move during electrolysis of molten NaCl and why?

7. Where do the chloride ions (Cl^-) move during electrolysis of molten NaCl and why?

8. Write the half equation for the reduction reaction that occurs at the cathode during the electrolysis of molten NaCl.

9. Write the half equation for the oxidation reaction that occurs at the anode during the electrolysis of molten NaCl.

10. What is the overall balanced chemical equation for the electrolysis of molten sodium chloride?

11. Why is electrolysis important in industrial processes?

12. What is produced at the cathode during the electrolysis of molten NaCl?

13. What is produced at the anode during the electrolysis of molten NaCl?

14. Explain why the electrons must balance out in the overall reaction for the electrolysis of molten ionic compounds.

L4 Using electrolysis to extract metals

Some metals are very reactive and can't be extracted from their ores (natural mineral sources) just by heating them with carbon. Instead, we use electrolysis to get these metals in their pure form. One common example is aluminium.

Process

1. Prepare the Metal Ore:

- A metal ore is a rock that contains enough of the metal to make it worth extracting.

- For example, aluminium ore is called bauxite. Bauxite is processed to make a substance called aluminium oxide, Al_2O_3.

2. Melt the Ore:

The ore is heated until it becomes molten (liquid). This is necessary because the ions in the solid ore can't move freely, but in the molten state, they can.

Aluminium oxide is melted, often with the help of another substance called cryolite to lower the melting point.

3. Set Up the Electrolysis Cell:

- Electrodes: Two metal rods are placed in the molten aluminium oxide. These are called electrodes.

  - Cathode (Negative Electrode):This attracts positive ions.

  - Anode (Positive Electrode): This attracts negative ions.

- Power Source: The electrodes are connected to a power source, like a battery.

4. Run the Electrolysis Process:

- When the power is turned on, electricity flows through the molten aluminium oxide.

- At the Cathode (Negative Electrode):

  - Positive aluminium ions (Al^{3+}) gain electrons and turn into aluminium metal.

$Al\{3+\} + 3e- \longrightarrow Al$

  - This aluminium metal collects at the bottom of the cell.

- At the Anode (Positive Electrode):

  - Negative oxide ions (O^{2-}) lose electrons and turn into oxygen gas.

$2O\{2-\} \longrightarrow O2 + 4e-$

  - The oxygen gas bubbles away.

5. Collect the Pure Metal:

- The pure aluminium metal that forms at the cathode is collected and used to make products like aluminium foil, cans, and airplane parts.

Independent practice

1. What is electrolysis and how is it used in metal extraction?
2. Why can't some metals be extracted from their ores using just heat and carbon?
3. What is the name of the aluminium ore, and what is it processed into for electrolysis?
4. Why is aluminium oxide often mixed with cryolite before electrolysis?
5. In the electrolysis of aluminium oxide, what happens at the cathode? Write the half equation for this reaction.
6. In the electrolysis of aluminium oxide, what happens at the anode? Write the half equation for this reaction.
7. Why is it necessary to melt the metal ore before electrolysis?
8. What products are formed at the cathode and anode during the electrolysis of aluminium oxide?
9. How does the process of electrolysis ensure that the extracted aluminium is pure?
10. Give two examples of products that are made using aluminium extracted by electrolysis.

L5 Electrolysis of aqueous solutions

Electrolysis of aqueous solutions is a process that uses electricity to break down water and dissolved substances into their basic parts. An aqueous solution is simply a substance dissolved in water.

Example: Electrolysis of Aqueous Sodium Chloride (NaCl) Solution

1. At the Cathode (Negative Electrode):

Positive ions in the solution move to the cathode. These can be sodium ions (Na^+) and hydrogen ions (H^+) from water. The half equation for this reaction is:

$2H^+ + 2e^- \rightarrow H_2$

- Hydrogen gas (H_2) is produced at the cathode.

2. At the Anode (Positive Electrode)

- Negative ions in the solution move to the anode. These can be chloride ions (Cl^-) and hydroxide ions (OH^-) from water. Chloride ions (Cl^-) are oxidized (lose electrons) more easily than hydroxide ions.

- The half equation for this reaction is:

$2Cl^- \rightarrow Cl_2 + 2e^-$

- Chlorine gas (Cl_2) is produced at the anode.

Combining the half equations, the overall reaction is:

$2\,H_2O + 2\,NaCl \rightarrow 2NaOH + H_2 + Cl_2$

This means water and sodium chloride are converted into sodium hydroxide (NaOH), hydrogen gas (H_2), and chlorine gas (Cl_2).

Why is This Important?

Producing Chemicals: Electrolysis of aqueous solutions is used to produce important chemicals like hydrogen gas, chlorine gas, and sodium hydroxide.

Purifying Metals: It can also be used to purify metals or to electroplate objects (coating them with a thin layer of metal).

Independent practice

Sure! Here are 10 questions to test your understanding of the electrolysis of aqueous solutions:

1. What is an aqueous solution?

2. What are the roles of the cathode and anode in electrolysis?

3. Why is it necessary to use a power source in the electrolysis of aqueous solutions?

4. In the electrolysis of an aqueous sodium chloride (NaCl) solution, what ions are present in the solution?

5. Write the half equation for the reaction that occurs at the cathode during the electrolysis of an aqueous NaCl solution.

6. Write the half equation for the reaction that occurs at the anode during the electrolysis of an aqueous NaCl solution.

7. What gases are produced at the cathode and anode during the electrolysis of an aqueous NaCl solution?

8. What is the overall balanced chemical equation for the electrolysis of an aqueous NaCl solution?

9. Why do hydrogen ions (H^+) get reduced at the cathode instead of sodium ions (Na^+) during the electrolysis of an aqueous NaCl solution?

10. Name two practical applications of electrolysis of aqueous solutions.

L6 Title

Insert explanation.

Independent practice

Insert 14 questions including two extended writing questions.