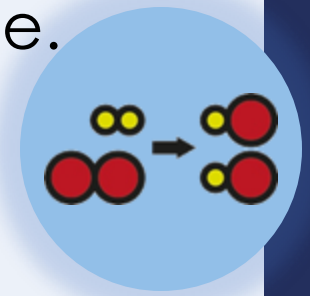
Electrolysis in Solutions

Answer the questions below.

1. Which is produced at the electrode in electrolysis? **ions** or **elements**?
   Elements
2. True or false? A metal is produced at the anode.
   False, the metal is produced at the cathode
3. *(HT only) Write a half equation for the production of oxygen gas at the anode.*
   $2O^{2-} \rightarrow O_2 + 4e^-$
4. State the ions that make up lead bromide.
   Lead (Pb^{2+}) and bromide (Br^-)
5. *(HT only)* Complete the balanced half equation for the process that occurs at the cathode, in the electrolysis of molten lead bromide.

$$Pb^{2+} + \underline{\quad 2e^- \quad} \rightarrow Pb$$

Do Now



Electrolysis in Solutions

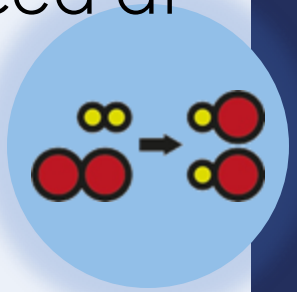
Do Now:

1. Which is produced at the electrode in electrolysis? **ions** or **elements**?
2. True or false? A metal is produced at the anode.
3. *(HT only)* Write a half equation for the production of oxygen gas at the anode.
4. State the ions that make up lead bromide.
5. *(HT only)* Complete the balanced half equation for the process that occurs at the cathode, in the electrolysis of molten lead bromide.

$$Pb^{2+} + \_\_\_\_\_ \rightarrow Pb$$

Drill:

1. Molten magnesium chloride is electrolysed. State what is produced at the anode and cathode.
2. Explain how magnesium is formed at the negative electrode (cathode).



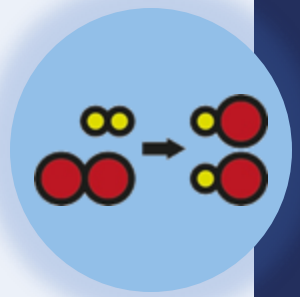
Do Now

Electrolysis in Solutions

Read Now:

In the late 18th century, scientists were fascinated by electricity. Ben Franklin conducted a famous experiment where he used a kite to draw electricity from lightning in 1752. Leyden jars, invented in 1746, could store charge and produce a spark of electricity. Doctors were treating patients with electric shocks for many different ailments. However, to really make progress, scientists would need to be able to produce a continuous flow of current. This was not available until 1800, when Alessandro Volta invented the electric pile, which led to the development of the first ever battery. Soon afterwards, Willian Nicholson and Anthony Carlisle used the current generated by this battery to decompose water into hydrogen and water.

1. What did Ben Franklin do with a kite?
2. What did Leyden jars do?
3. How did doctors use electricity in the late 18th century?
4. Who invented the electric pile?
5. What did William Nicholson and Anthony Carlisle use a battery for?



Do Now

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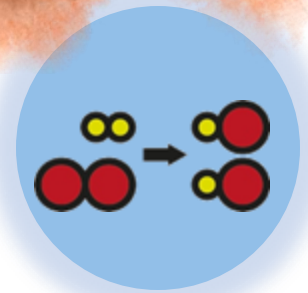
Electrolysis in Solutions

C4.2.10

Science Mastery

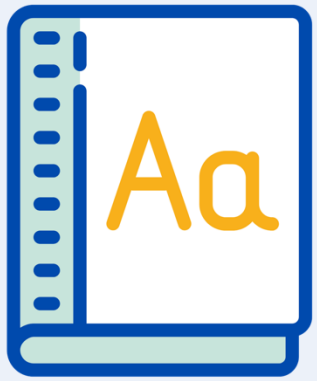


C4.2.1 PKR: The Reactivity Series
C4.2.2 Extracting Less Reactive Metals
C4.2.3 PKR: Ions, Ionic Bonding and Deducing Ionic Formulae
C4.2.4 (HT) Ionic Equations and Displacement Reactions
C4.2.5 (HT) Writing Half Equations
C4.2.6 (HT) Ionic Equations for the Reactions of Acids and Metals
C4.2.7 Introduction to Electrolysis
C4.2.8 Extracting Metals by Electrolysis
C4.2.9 Electrolysis of Molten Ionic Compounds
➢ **C4.2.10 Electrolysis in Solutions**
C4.2.11RP: Electrolysis of Aqueous Solutions 1
C4.1.12 RP: Electrolysis of Aqueous Solutions 2
C4.1.13 TIF: Corrosion and its Prevention
C4.2.14 (HT) Obtaining Raw Materials
C4.2.15 Recycling Metals
C4.2.16 Feedback Lesson

Following this lesson, students will be able to:

- List the ions present in the electrolytes of molten salts and salt solutions.
- Explain which ions are discharged at the anode and cathode.
- Predict what will be observed at the anode and cathode.
- Write half equations for the discharge of ions at each electrode.

Key Words:



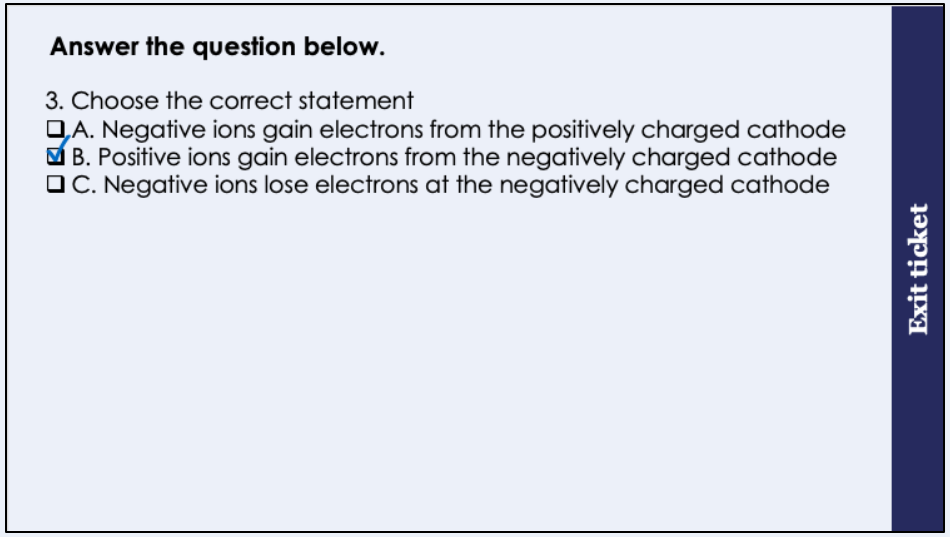
discharged	**hydroxide ion**
anode	**cathode**

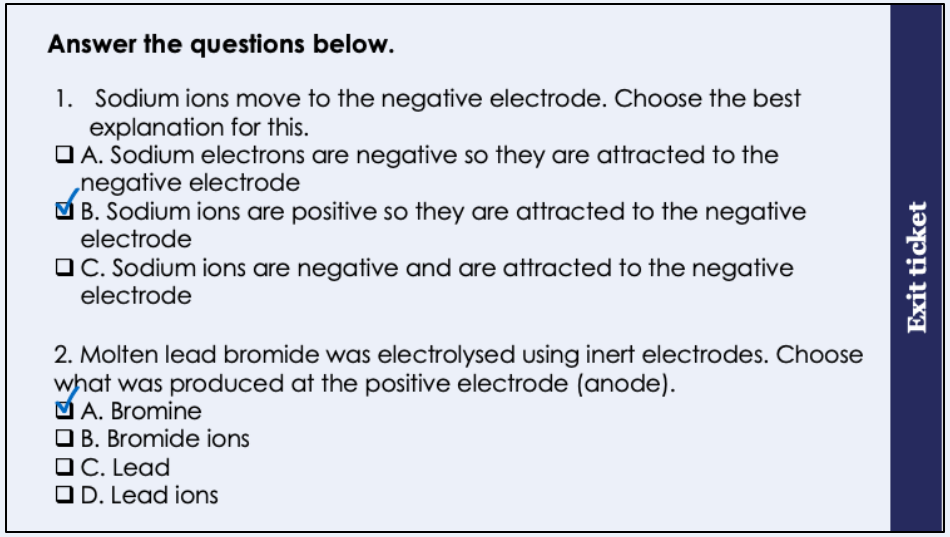
Lesson Objectives

This is the fix-it portion of the lesson

The **fix-it** is an opportunity to respond to gaps in knowledge, especially those identified by the previous lesson's exit ticket.

- The teacher should customise this slide as needed, to facilitate
  - **reteach**, **explanation, demonstration** or **modelling** of ideas and concepts that students have not yet grasped or have misunderstood.
  - **practise** answering specific questions or of key skills.
  - **redrafting** or **improving** previous work.





Fix-it

The electrolysis of water

This piece of apparatus is called the **Hoffman Voltameter**.

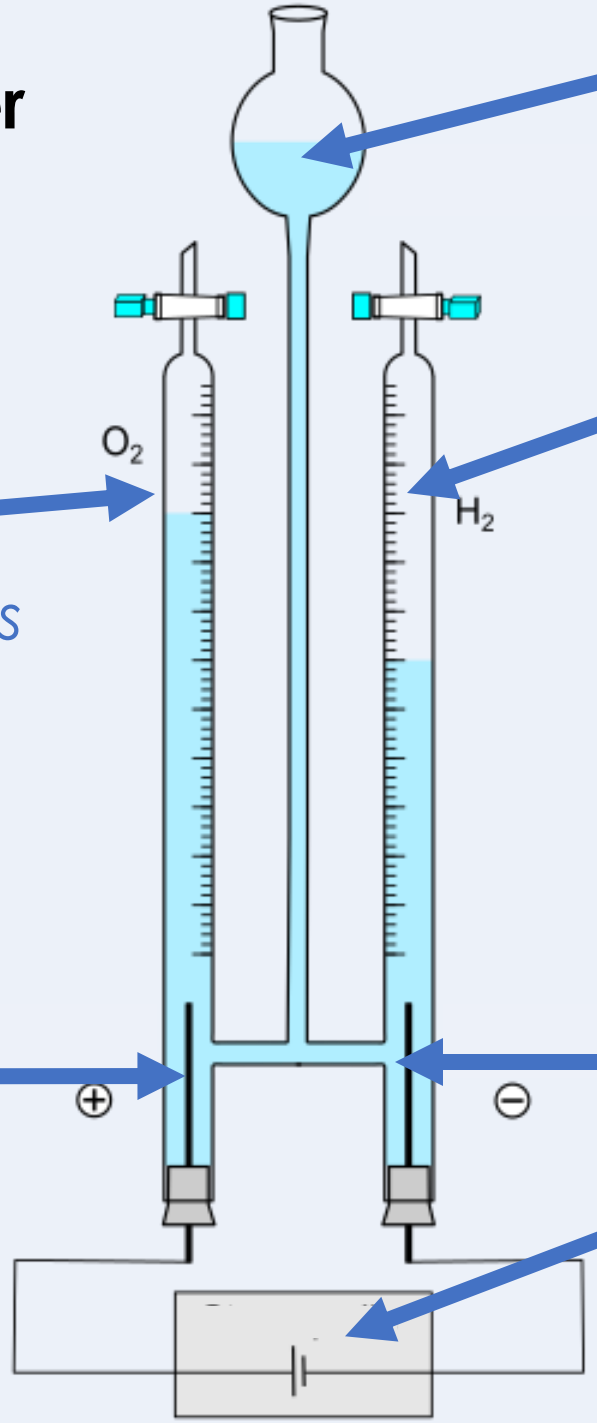
Electrolyte
*Usually water (H_2O), consisting of **H^+** and **OH^-** ions*

Hydrogen gas
Produced when H+ ions are discharged at the cathode

$2H^+ + 2e^- \rightarrow \mathbf{H_2}$

Oxygen gas
Produced when OH- ions are discharged at the anode

$4OH^- \rightarrow \mathbf{O_2} + 2H_2O + 4e^-$

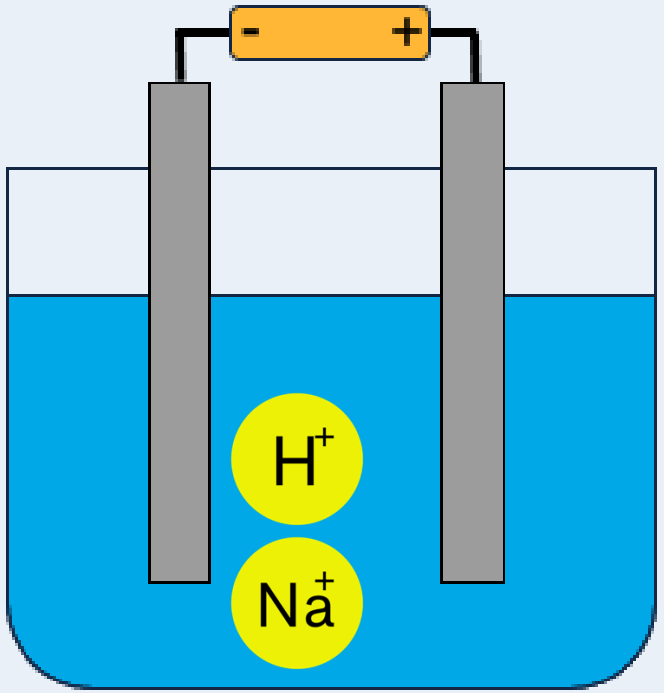


Anode
Positively charged

Cathode
Negatively charged

A cell
Generates electricity to pass through the electrolyte

What if there are <u>two types of positive ion</u> in the electrolyte?



Let's take the example of **sodium chloride solution.**

Sodium chloride contains the ions **Na^+** and **Cl^-**.

Water contains the ions **H^+** and **OH^-**.

So which positive ion is discharged at the cathode?

At the cathode, **the least reactive positive ion is discharged**

- Therefore, in this example, H+ ions will be discharged at the cathode.
- The sodium ions remain behind in the electrolyte.
- Bubbles of hydrogen gas will be observed at the cathode.

Complete the boxes highlighted in orange.

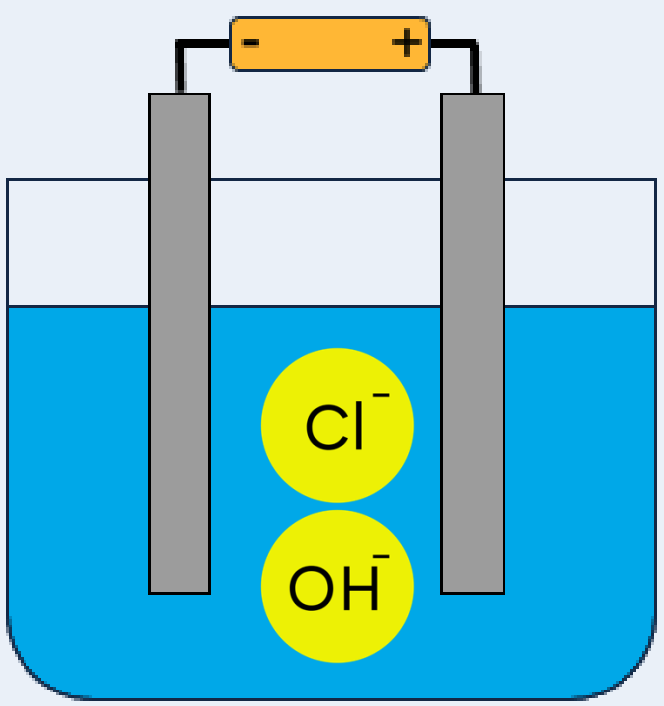
Electrolyte name	Positive ions in the electrolyte	Negative ions in the electrolyte	Ion discharged at the cathode	Ion discharged at the anode
Molten sodium chloride	Na^+	Cl^-	Na^+ $Na^+ + e^- \rightarrow Na$	
Sodium chloride solution	Na^+ H^+	Cl^- OH^-	H^+ $2H^+ + 2e^- \rightarrow H_2$	

(HT only) Can you write half equations for each ion discharged?

PANIC

Positive **A**node **N**egative **I**s **C**athode

What if there are <u>two types of negative ion</u> in the electrolyte?



Let's take the example of **sodium chloride solution** again.

Sodium chloride contains the ions **Na^+** and **<u>Cl^-</u>**.

Water contains the ions **H^+** and **<u>OH^-</u>**.

So which negative ion is discharged at the anode?

At the anode, **hydroxide ions are usually discharged unless there is a halide ion (group 7 ion) present.**

- Therefore, in this example, Cl^- ions will be discharged at the cathode, because these are halide ions.
- The hydroxide ions remain behind in the electrolyte.
- Bubbles of chlorine gas will be observed at the anode.

Complete the boxes highlighted in orange.

Electrolyte name	Positive ions in the electrolyte	Negative ions in the electrolyte	Ion discharged at the cathode	Ion discharged at the anode
Molten sodium chloride	Na^+	Cl^-	Na^+ $Na^+ + e^- \rightarrow Na$	Cl^- $2Cl^- \rightarrow Cl_2 + 2e^-$
Sodium chloride solution	Na^+ H^+	Cl^- OH^-	H^+ $2H^+ + 2e^- \rightarrow H_2$	Cl^- $2Cl^- \rightarrow Cl_2 + 2e^-$

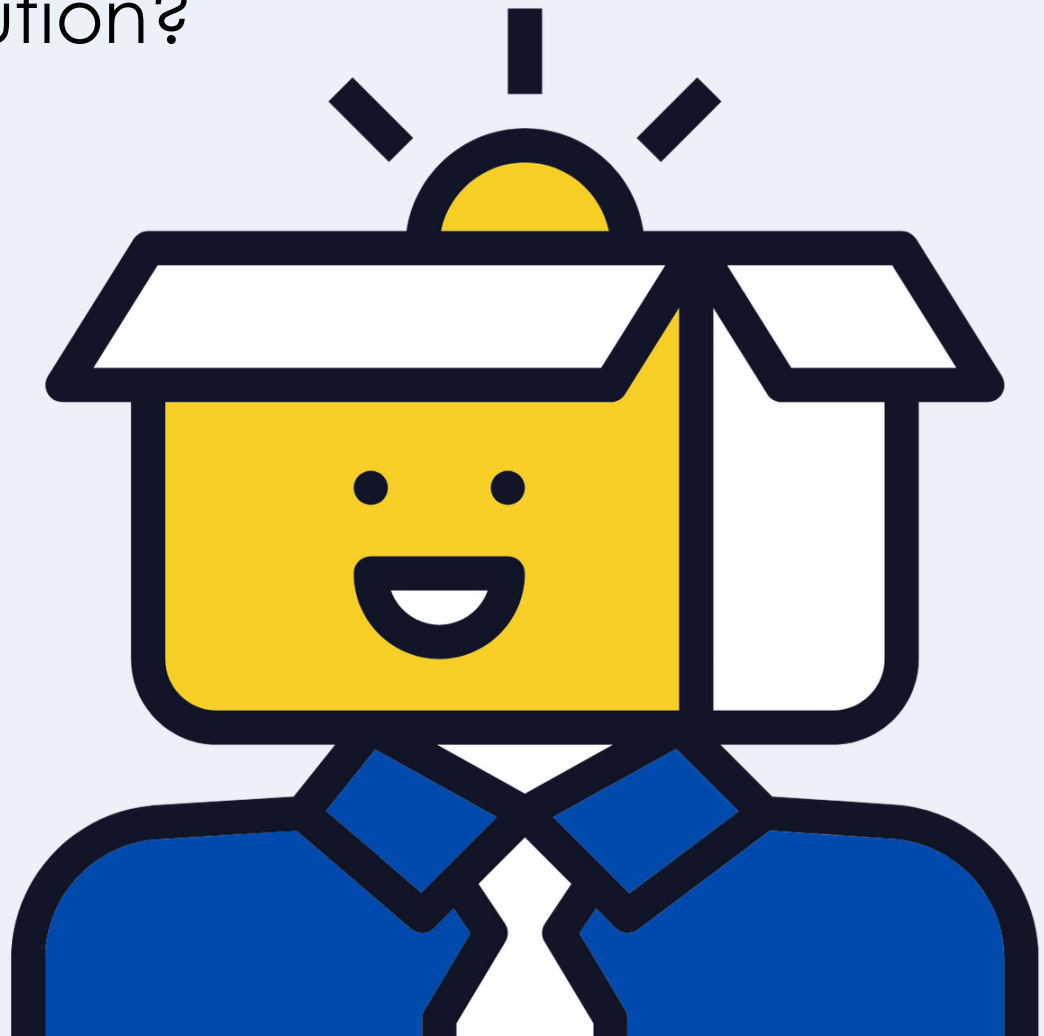
(HT only) Can you write half equations for each ion discharged?

PANIC

Positive **A**node **N**egative **I**s **C**athode

Think outside the box!

What would be observed if you carried out electrolysis of copper sulfate ($CuSO_4$) solution?



Talk Task

Drill

1. What is the charge on an anode?
2. What is the charge on a cathode?
3. List the ions in molten lithium fluoride.
4. List the ions in lithium fluoride solution.
5. If the two positive ions in solution are K^+ and H^+, which positive ion would be discharged at the cathode?
6. Explain your answer to question 5.
7. If the two negative ions in solution are OH^- and SO_4^{2-}, which negative ion would be discharged at the anode?
8. Explain your answer to question 7.
9. List the ions present in water.
10. *(HT only) Write two half equations to show what happens at the electrodes in the electrolysis of molten sodium chloride.*

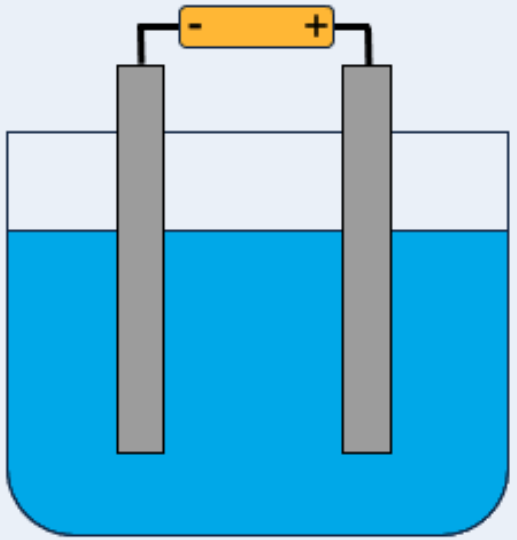
Check for understanding

Drill answers

1. The anode is positively charged.
2. The cathode is negatively charged.
3. Molten lithium fluoride contains Li^+ and F^- ions
4. Lithium fluoride solution contains Li^+ , F^- , H^+ and OH^- ions
5. The H^+ ion would be discharged
6. Hydrogen is less reactive than potassium, therefore the hydrogen ion would be discharged
7. The hydroxide ion (OH^-) would be discharged
8. Hydroxide ions are always discharged at the anode unless a halide ion is present. There is no halide ion present.
9. H^+ and OH^-
10. At the anode: $2Cl^- \rightarrow Cl_2 + 2e^-$
    At the cathode: $Na^+ + e^- \rightarrow Na$

Check for understanding

I: Deducing the ions discharged in electrolysis



A student carries out the electrolysis of a solution of sodium chloride.

(a) List the ions present in the electrolyte.

Na^+, Cl^-, H^+, OH^-

(b) Explain which ions will be discharged at each electrode.

At the cathode: Of the two positive ions, hydrogen is the least reactive. This means that H^+ ions will be discharged at the cathode.

At the anode: Hydroxide ions are usually discharged, unless a halide ion is present. In this reaction halide ions are present (Cl- ions). Therefore, the chloride ions will be discharged at the anode.

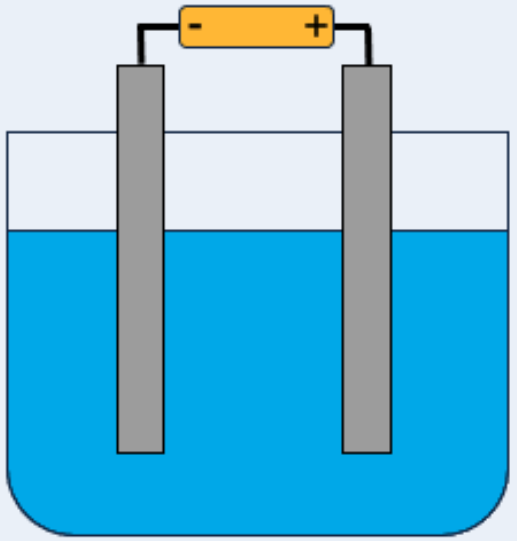
(c) Describe what the student would observe when carrying out their electrolysis.

At the cathode: Bubbles of hydrogen gas would be observed.

At the anode: Bubbles of chlorine gas would be observed.

Apply

We: Deducing the ions discharged in electrolysis



A student carries out the electrolysis of a solution of copper (II) sulfate ($CuSO_4$)

(a) List the ions present in the electrolyte.

Cu^{2+}, SO_4^{2-}, H^+, OH^-

(b) Explain which ions will be discharged at each electrode.

At the cathode: Of the two positive ions, copper is the least reactive. This means that Cu^{2+} ions will be discharged at the cathode.

At the anode: Hydroxide ions are usually discharged, unless a halide ion is present. In this reaction halide ions are not present. Therefore, the hydroxide ions will be discharged at the anode and oxygen produced.

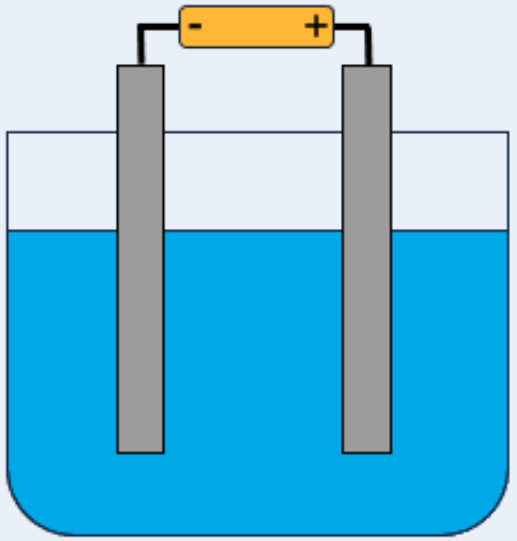
(c) Describe what the student would observe when carrying out their electrolysis.

At the cathode: Copper metal will be deposited on the electrode.

At the anode: Bubbles of oxygen gas will be observed.

Apply

You: Deducing the ions discharged in electrolysis



A student carries out the electrolysis of a solution of hydrochloric acid (HCl)

(a) List the ions present in the electrolyte.

H^+, Cl^-, OH^-

(b) Explain which ions will be discharged at each electrode.

At the cathode: There is only one positive ion in the solution, H^+. This means that H^+ ions will be discharged at the cathode.

At the anode: Hydroxide ions are usually discharged, unless a halide ion is present. In this reaction halide ions are present (Cl^- ions). Therefore, the chloride ions will be discharged at the anode.

(c) Describe what the student would observe when carrying out their electrolysis.

At the cathode: Bubbles of hydrogen gas will be observed.

At the anode: Bubbles of chlorine gas will be observed.

Apply

Answer the questions below.

1. A student carried out electrolysis of potassium chloride solution. What was produced at the negative electrode (cathode)?

- ☐ A. Potassium
- ☐ B. Chlorine gas
- ☑ C. Hydrogen gas
- ☐ D. Oxygen gas

2. In the electrolysis of copper chloride solution, which ions are in the electrolyte?

- ☐ A. Cu^{2+}, Cl^-, H^+, O^{2-}
- ☑ B. Cu^{2+}, Cl^-, H^+, OH^-
- ☐ C. $CuCl_2$, H_2O
- ☐ D. OH^-, H

Exit ticket

Answer the questions below.

3. Does water react during the electrolysis of an aqueous solution?

- ☑ A. Yes, always
- ☐ B. No
- ☐ C. Sometimes, it depends on the solution

Exit ticket

Feedback

Lesson C4.2.10	
What was good about this lesson?	What can we do to improve this lesson?

Send us your feedback by clicking this link
or by emailing sciencemastery@arkonline.org
Thank you!