

# Electrolysis, Electrode Potentials & Cells

## Question Paper

<b>Level</b>	International A Level
<b>Subject</b>	Chemistry
<b>Exam Board</b>	CIE
<b>Topic</b>	Electrochemistry
<b>Sub-Topic</b>	Electrolysis, Electrode Potentials & Cells
<b>Paper Type</b>	Multiple Choice
<b>Booklet</b>	Question Paper

**Time Allowed:** 32 minutes

**Score:** /26

**Percentage:** /100

**Grade Boundaries:**

A*	A	B	C	D	E	U
>85%	77.5%	70%	62.5%	57.5%	45%	<45%

**Section A**

For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

- 1 In the industrial electrolysis of brine to manufacture chlorine, the diaphragm used is a porous screen which allows the flow of electrolytes but keeps other chemicals separate.

Which substance needs to be kept separate from the chlorine by the diaphragm?

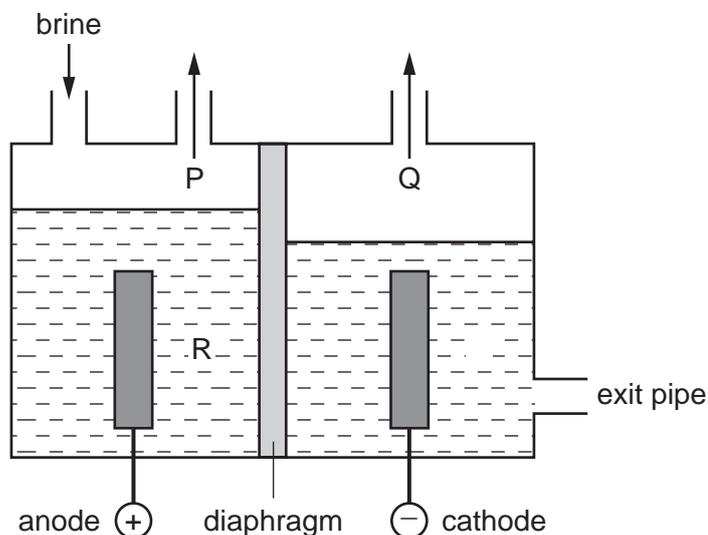
- A** hydrogen
- B** sodium chloride
- C** sodium hydroxide
- D** water

- 2 In industry, copper metal is purified by electrolysis.

Which changes occur to the masses of the electrodes and to the colour of the electrolyte during this process?

	mass of anode	mass of cathode	colour of electrolyte
<b>A</b>	decrease	increase	little or no change occurs
<b>B</b>	decrease	increase	pale blue to blue
<b>C</b>	increase	decrease	little or no change occurs
<b>D</b>	increase	decrease	blue to pale blue

- 3 The diagram shows a diaphragm cell used for the electrolysis of brine. Brine is concentrated aqueous sodium chloride.



A solution of sodium chlorate(I), commonly used as bleach, can be made by mixing which two substances?

- A** P and R      **B** P and S      **C** Q and R      **D** Q and S
- 4 Brine is concentrated aqueous sodium chloride. Brine is electrolysed in a diaphragm cell.

What is the purpose of the diaphragm?

- A** to prevent  $Cl_2$  reacting with  $H_2$   
**B** to prevent  $HCl$  reacting with  $Na$   
**C** to prevent  $NaOH$  reacting with  $Cl_2$   
**D** to prevent  $NaOH$  reacting with  $HCl$
- 5 Barium is a more reactive metal than aluminium.
- Which method could be suitable for the extraction of barium?
- A** electrolysing aqueous barium chloride  
**B** electrolysing molten barium chloride  
**C** reducing barium oxide with aluminium  
**D** reducing barium oxide with carbon

- 6 The electrolysis of brine using the diaphragm cell is an important industrial process.

What happens at the anode?

- A** Chloride ions are oxidised.  
**B** Hydrogen gas is produced.  
**C** Hydroxide ions are formed.  
**D** The electrode reaction is  $2\text{Cl}^-(\text{aq}) + 2\text{e}^- \rightarrow \text{Cl}_2(\text{g})$ .
- 7 Which row correctly describes the electrodes used in the electrolysis cell for the production of aluminium?

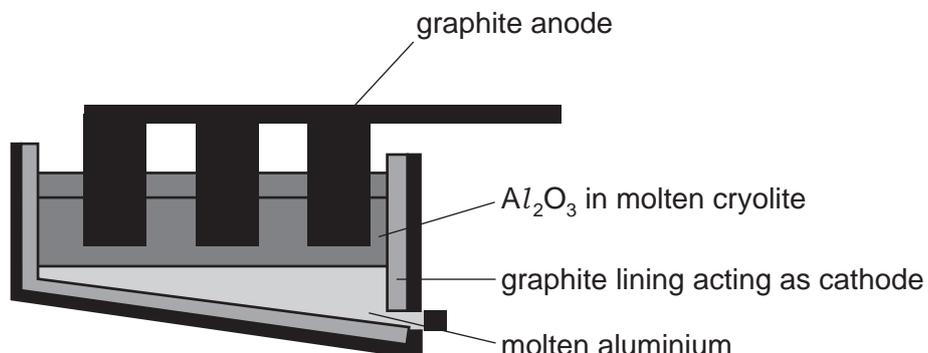
	anode	cathode
<b>A</b>	carbon	carbon
<b>B</b>	carbon	steel
<b>C</b>	steel	carbon
<b>D</b>	steel	steel

- 8 Impure copper is purified by electrolysis. The electrolyte used in this process is aqueous copper(II) sulfate.

Which reaction takes place at the anode?

- A**  $\text{Cu}(\text{s}) \rightarrow \text{Cu}^{2+}(\text{aq}) + 2\text{e}^-$   
**B**  $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu}(\text{s})$   
**C**  $2\text{OH}^-(\text{aq}) \rightarrow \frac{1}{2}\text{O}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) + 2\text{e}^-$   
**D**  $2\text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq})$

- 9 The diagram shows an electrolytic cell for the extraction of aluminium.



Which statement is correct?

- A Aluminium ions are oxidised in this process.
  - B Aluminium is liberated at the anode by the reaction  $Al^{3+} + 3e^{-} \rightarrow Al$ .
  - C Cryolite is purified aluminium oxide.
  - D The graphite anode burns away.
- 10 During the electrolysis of molten aluminium oxide to produce aluminium, using carbon electrodes, two consecutive reactions occur at the anode, each producing a different gas.

How does the oxidation number of oxygen change in these reactions?

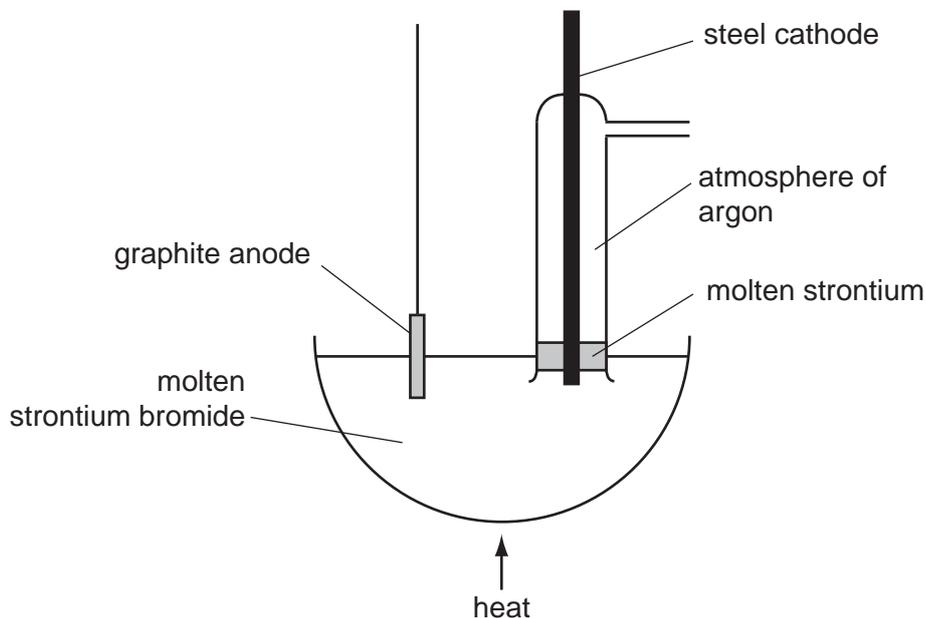
- A decreases by 2, then increases by 2
- B increases by 2, then decreases by 2
- C increases by 2, then decreases by 4
- D no change, then decreases by 2

- 11 At the age of 17, in a woodshed in Ohio, Charles Martin Hall discovered the commercial process for the production of aluminium metal by the electrolysis of a mixture of bauxite,  $Al_2O_3$ , and cryolite,  $Na_3AlF_6$ .

What is the main purpose of the cryolite?

- A**  $Al_2O_3$  is covalent, and  $AlF_6^{3-}$  ions interact with it to produce  $Al^{3+}$  ions which can be discharged at the cathode.
- B** Cryolite is a base, forming  $NaAlO_2$  with bauxite, enabling aluminium to be discharged at the anode.
- C** Cryolite minimises the release of  $O^{2-}$  ions at the graphite anodes, which are otherwise burnt away to CO.
- D** Cryolite reduces the melting point of the bauxite.
- 12 In which reaction does a single nitrogen atom have the greatest change in oxidation number?
- A**  $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$
- B**  $3NO_2 + H_2O \rightarrow 2HNO_3 + NO$
- C**  $2NO + O_2 \rightarrow 2NO_2$
- D**  $4NH_3 + 6NO \rightarrow 5N_2 + 6H_2O$

- 13 Strontium metal can be obtained by the electrolysis of molten strontium bromide,  $\text{SrBr}_2$ , using the apparatus shown in the diagram.



Why is an atmosphere of argon used around the cathode?

- A A thin film of a compound of strontium and argon forms on the surface protecting the freshly formed metal.
  - B The argon keeps the strontium molten.
  - C The argon stops the molten strontium rising too high in the tube.
  - D Without the argon, strontium oxide would form in the air.
- 14 In the extraction of aluminium by electrolysis, why is it necessary to dissolve aluminium oxide in molten cryolite?
- A to reduce the very high melting point of the electrolyte
  - B cryolite is a base; aluminium oxide is amphoteric
  - C cryolite reacts with the aluminium oxide to form ions
  - D molten aluminium oxide alone would not conduct electricity

- 15 Aluminium is extracted by the electrolysis of a molten mixture containing aluminium oxide. By a similar method, magnesium is extracted by the electrolysis of a molten mixture containing magnesium chloride.

Which statement about the extraction of magnesium is correct?

- A** Magnesium ions travel to the anode and are oxidised to magnesium metal.
- B** Magnesium ions travel to the anode and are reduced to magnesium metal.
- C** Magnesium ions travel to the cathode and are oxidised to magnesium metal.
- D** Magnesium ions travel to the cathode and are reduced to magnesium metal.

- 16 Aluminium is extracted by the electrolysis of a molten mixture containing aluminium oxide.

By a similar method, magnesium is extracted by the electrolysis of a molten mixture containing magnesium chloride.

Which statement about this electrolysis is correct?

- A** Chloride ions travel to the anode and are oxidised to chlorine gas.
- B** Chloride ions travel to the anode and are reduced to chlorine gas.
- C** Chloride ions travel to the cathode and are oxidised to chlorine gas.
- D** Chloride ions travel to the cathode and are reduced to chlorine gas.

- 17 In the extraction of aluminium by the electrolysis of molten aluminium oxide, why is cryolite added to the aluminium oxide?

- A** to ensure the aluminium is not oxidised
- B** to ensure the anode is not oxidised
- C** to lower the melting point of the aluminium oxide
- D** to prevent corrosion of the cathode

- 18 Aqueous sodium chloride (brine) is electrolysed by using inert electrodes in a cell which is stirred so that products of electrolysis react with each other. The cell is kept cold.

Which pair of substances is among the major products?

- A** hydrogen and chlorine
  - B** hydrogen and sodium chlorate(I)
  - C** hydrogen and sodium chlorate(V)
  - D** sodium hydroxide and chlorine
- 19 Every year millions of tonnes each of chlorine and sodium hydroxide are manufactured by the electrolysis of brine using a 'diaphragm cell'.

What is the purpose of the diaphragm in such a cell?

- A** to prevent chlorine gas escaping into the factory
  - B** to prevent the build up of pressure in the electrolysis cell
  - C** to provide a large surface area of electrode
  - D** to stop the products of electrolysis from reacting together
- 20 When copper is extracted from its ores, the metal is not pure enough for electrical uses. The impure copper, which contains small amounts of silver and gold, is purified by electrolysis. During this process a 'sludge' forms beneath the anode which is found to contain silver and traces of gold.

Why is silver found in this sludge?

- A** Silver is less electropositive than copper.
- B** Silver is more dense than copper and falls off the cathode.
- C** Silver reacts with the electrolyte to form an insoluble chloride salt.
- D** Silver reacts with the electrolyte to form an insoluble sulfate salt.

- 21 During electrolysis of brine in a diaphragm cell, chlorine, hydrogen and sodium hydroxide are produced.

What is the molar ratio of these products?

	chlorine	hydrogen	sodium hydroxide
A	1	1	1
B	1	1	2
C	2	1	1
D	2	2	1

- 22 In the extraction of aluminium by electrolysis, why is it necessary to dissolve aluminium oxide in molten cryolite?

- A to reduce the very high melting point of the electrolyte
- B cryolite provides the ions needed to carry the current
- C cryolite reacts with the aluminium oxide to form ions
- D molten aluminium oxide alone would not conduct electricity

- 23 During the electrolysis of brine using a diaphragm cell, which reaction occurs at the cathode?

- A  $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$
- B  $4OH^-(aq) \rightarrow O_2(g) + 2H_2O(l) + 4e^-$
- C  $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$
- D  $Na^+(aq) + e^- \rightarrow Na(s)$

24 Use of the Data Booklet is relevant to this question.

In the commercial electrolysis of brine, the products are chlorine, hydrogen and sodium hydroxide.

What is the maximum yield of each of these products when 58.5 kg of sodium chloride are electrolysed as brine?

	yield of chlorine / kg	yield of hydrogen / kg	yield of sodium hydroxide / kg
<b>A</b>	35.5	1	40
<b>B</b>	35.5	2	40
<b>C</b>	71	1	40
<b>D</b>	71	2	80

25 At the age of 17, in a woodshed in Ohio, Charles Martin Hall discovered the commercial process for the production of aluminium metal by the electrolysis of a mixture of bauxite,  $Al_2O_3$ , and cryolite,  $Na_3AlF_6$ .

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- C** Cryolite reduces the melting point of the bauxite.
- D** Cryolite minimises the release of  $O^{2-}$  ions at the graphite anodes, which are otherwise burnt away to CO.

**Section B**

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
<b>1, 2 and 3</b> are correct	<b>1 and 2</b> only are correct	<b>2 and 3</b> only are correct	<b>1 only</b> is correct

No other combination of statements is used as a correct response.

26 Aluminium is extracted from aluminium oxide by electrolysis.

Which statements are correct?

- 1** Aluminium oxide has an extremely high melting point.
- 2** Bauxite is added to the aluminium oxide to lower its melting point.
- 3** Oxygen produced at the graphite cathode reacts with the graphite to produce CO<sub>2</sub>.