Cambridge Assessment International Education

The electrolysis of molten zinc chloride – Topic questions

The questions in this document have been compiled from a number of past papers, as indicated in the table below.

Use these questions to formatively assess your learners' understanding of this topic.

Question	Year	Series	Paper number
2(c)(d)	2017	November	32
5	2018	June	31
5(c)	2018	November	31
4	2017	March	42
2(b)	2018	March	42
6(a)(c)	2017	November	41
5(b)	2014	June	32
4(d)	2014	November	31
5(b)	2014	November	33

The mark scheme for each question is provided at the end of the document.

You can find the complete question papers and the complete mark schemes (with additional notes where available) on the School Support Hub at www.cambridgeinternational.org/support

(c) The atmosphere of Saturn contains small amounts of ammonia.

(i) Describe a test for ammonia.

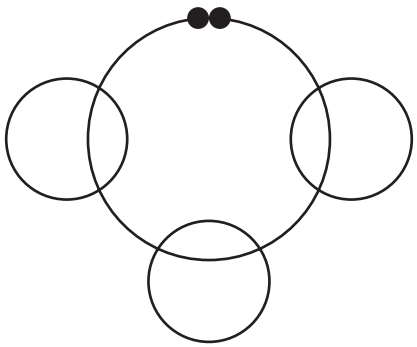
test .....

result .....
[2]

(ii) Ammonia is a covalent compound.

Complete the diagram to show
- the arrangement of electrons in a molecule of ammonia,
- the symbols of the atoms present.

Show outer electrons only.



[2]

(d) Saturn's atmosphere also contains small amounts of ammonium hydrosulfide.

Calculate the relative molecular mass of ammonium hydrosulfide, NH_4SH.
Use your Periodic Table to help you.

relative molecular mass = ... [2]

5 **(a)** Complete the sentence about electrolysis using words from the list.

breakdown **compound** **electricity** **electroplating**

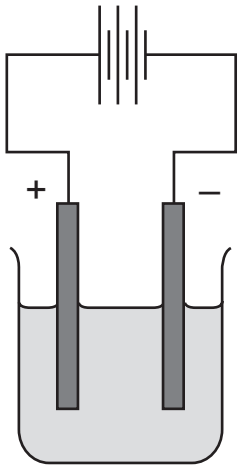
element **gaseous** **heat** **molten**

Electrolysis is the ..... of an ionic ..... when

..... or in aqueous solution by the passage of ..... .

[4]

(b) Molten zinc iodide can be electrolysed using the apparatus shown.



On the diagram, label:

- the anode
- the cathode
- the electrolyte

[2]

(c) Why are the electrodes made of graphite?

..... [1]

(d) Predict the products of the electrolysis of molten zinc iodide at:

the negative electrode .....

the positive electrode. .....

[2]

(e) When chlorine is bubbled through a colourless aqueous solution of zinc iodide, the solution turns brown.

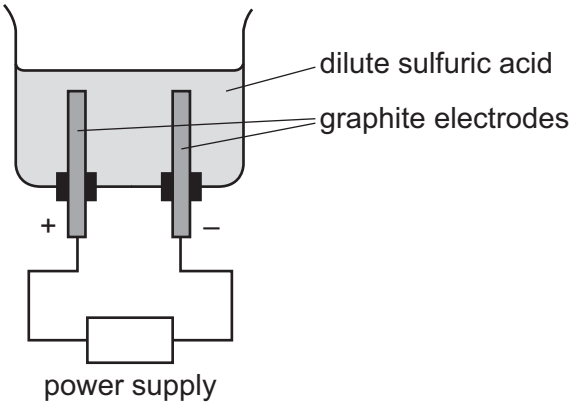
Name the brown substance. Suggest, using ideas about reactivity of the halogens, why this reaction occurs.

.....

..... [2]

[Total: 11]

(c) Dilute sulfuric acid can be electrolysed using the apparatus shown.



(i) State the products of this electrolysis at:

the positive electrode (anode) .....

the negative electrode (cathode). .....
[2]

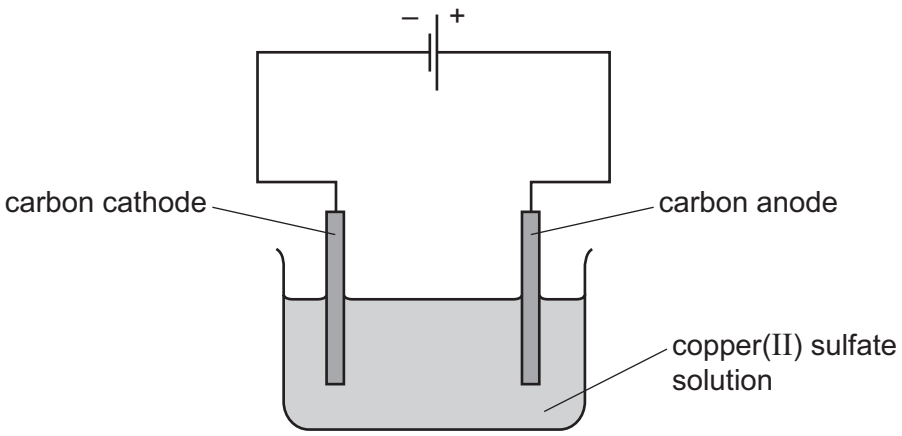
(ii) What observation is made at the electrodes?

..... [1]

(iii) Suggest **one** reason why graphite is used for the electrodes rather than magnesium.

..... [1]

4 Copper(II) sulfate solution was electrolysed using the apparatus shown.



(a) (i) Draw an arrow on the diagram to show the direction of movement of electrons in the wire. Label the arrow **A**. [1]

(ii) Draw an arrow on the diagram to show the direction of movement of positive ions in the copper(II) sulfate solution. Label the arrow **B**. [1]

(b) Oxygen was formed at the anode and copper was formed at the cathode.

(i) The ionic half-equation for the formation of oxygen is shown.

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

Explain why this reaction is oxidation.

..... [1]

(ii) Write the ionic half-equation for the formation of copper at the cathode.

..... [2]

(c) The electrolysis was repeated using copper electrodes in place of carbon electrodes.

State and explain what happens to the masses of the anode and the cathode during this electrolysis.

.....

.....

.....

.....

..... [4]

[Total: 9]

2 Sodium chloride is a typical ionic compound.

(b) Electrolysis of concentrated aqueous sodium chloride is an important industrial process.

(i) What is meant by the term *electrolysis*?

.....

..... [2]

(ii) Name the products of the electrolysis of concentrated aqueous sodium chloride.

1 .....

2 .....

3 .....
[3]

(iii) Write an ionic half-equation for the reaction at the cathode.
Include state symbols.

..... [2]

6 Aluminium is extracted from aluminium oxide by electrolysis.

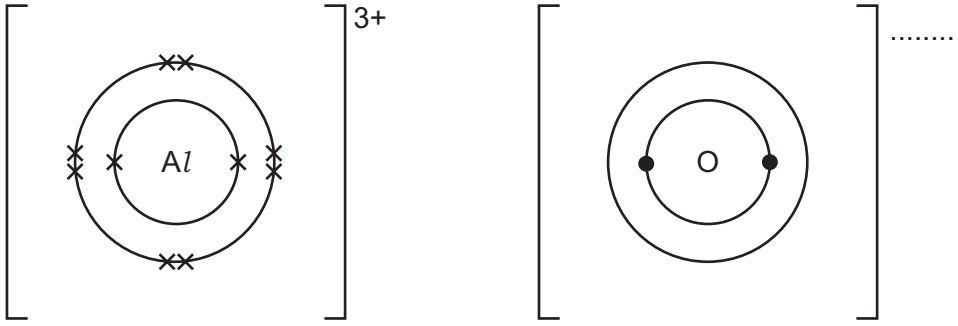
(a) Why is aluminium **not** extracted by heating aluminium oxide with carbon?

.....

..... [1]

(b) Aluminium oxide is an ionic compound with a high melting point.

(i) Complete the dot-and-cross diagram to show the electron arrangement in **one** of the oxide ions present in aluminium oxide. Include the charge on the oxide ion.
One of the aluminium ions is shown.



[2]

(ii) The melting point of aluminium oxide is above 2000 °C.

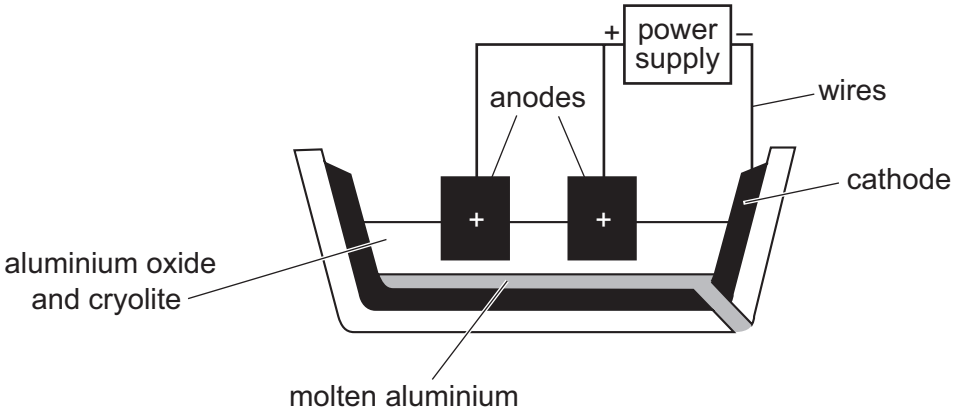
Explain why aluminium oxide has a high melting point.

.....

.....

..... [2]

(c) Aluminium can be extracted by electrolysis using the apparatus shown.



(i) Name the type of particle responsible for the transfer of charge in

the wires, ...

the electrolyte. .....
[2]

(ii) Give **two** reasons why cryolite is used.

1 .....

2 .....
[2]

(iii) Write the ionic half-equation for the formation of aluminium during the electrolysis.

..... [1]

(iv) Explain how carbon dioxide gas is formed at the anodes.

.....

.....

..... [3]

5 **(b)** Chlorine is made by the electrolysis of concentrated aqueous sodium chloride.
Describe this electrolysis. Write ionic equations for the reactions at the electrodes and name the sodium compound formed.

.....

.....

.....

.....

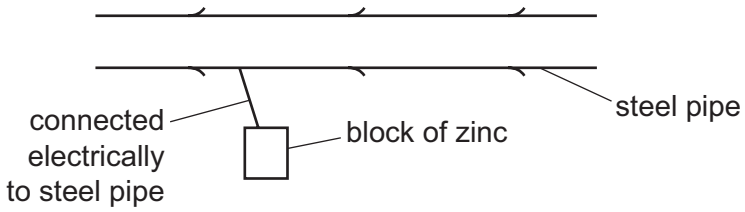
.....

..... [5]

(d) There are two electrochemical methods of rust prevention.

(i) The first method is sacrificial protection.

Explain why the steel article does not rust.



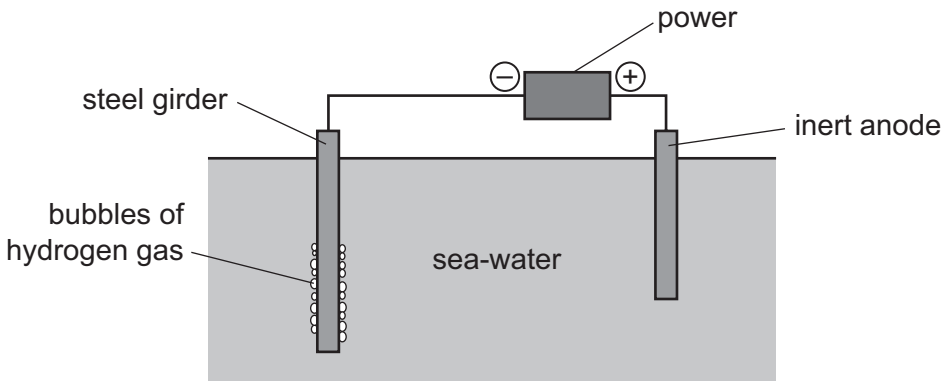
.....

.....

.....

..... [4]

The second method is to make the steel article the cathode in a circuit for electrolysis.



(ii) Mark on the diagram the direction of the electron flow. [1]

(iii) The steel girder does not rust because it is the cathode. Reduction takes place at the cathode. Give the equation for the reduction of hydrogen ions.

..... [2]

(b) The ions present in aqueous sodium chloride are $Na^+(aq)$, $Cl^-(aq)$, $H^+(aq)$ and $OH^-(aq)$.

The electrolysis of concentrated aqueous sodium chloride forms three products. They are hydrogen, chlorine and sodium hydroxide.

(i) Explain how these **three** products are formed. Give ionic equations for the reactions at the electrodes.

.....

.....

.....

.....

..... [4]

(ii) If the solution of the electrolyte is stirred, chlorine reacts with sodium hydroxide to form sodium chlorate(I), sodium chloride and water.
Write an equation for this reaction.

Cl_2 + ...NaOH $\rightarrow$ ..... + ... + ...

[2]

Question	Answer	Marks
2(c)(i)	(damp) red litmus	**1**
	turns blue	**1**
2(c)(ii)	labels ‘N’ and ‘H’ in the correct circles	**1**
	one pair of electrons in each overlap area and no non-bonding electrons or extra bonding electrons added	**1**
2(d)	51 IF full credit is not awarded, allow 1 mark for (S =) 32, (N =) 14 and (H =) 1	**2**

Question	Answer	Marks
5(a)	breakdown	**1**
	compound	**1**
	molten	**1**
	electricity	**1**
5(b)	+ electrode labelled anode **and** – electrode labelled cathode	**1**
	liquid labelled electrolyte	**1**
5(c)	graphite / it conducts electricity	**1**
5(d)	negative electrode: zinc / Zn	**1**
	positive electrode: iodine / I_2	**1**
5(e)	iodine	**1**
	chlorine is more reactive than iodine ORA	**1**

Question	Answer	Marks
5(c)	graphite / it conducts electricity	**1**
5(d)	negative electrode: zinc / Zn	**1**
	positive electrode: iodine / I_2	**1**
5(e)	iodine	**1**
	chlorine is more reactive than iodine ORA	**1**

Question	Answer	Marks
6(a)	One mark each for any 5 of: • protons in the nucleus / centre (of the atom) • neutrons in the nucleus / centre (of the atom) • electrons outside the nucleus / electrons surrounding the nucleus / electrons orbiting the nucleus • 9 protons • 9 electrons • 10 neutrons	**5**
6(b)	element	**1**
	atomic	**1**
	nucleons	**1**
6(c)	any suitable e.g. treating cancer / checking thyroid function / tracer (in the body)	**1**

Question	Answer	Marks
5(c)(i)	positive electrode: oxygen (1) negative electrode: hydrogen (1)	**2**
5(c)(ii)	bubbles / effervescence (1)	**1**
5(c)(iii)	graphite is inert / unreactive / does not react with the electrolyte ORA	**1**

Question	Answer	Marks
4(a)(i)	arrow labelled **A** on or near wire going in an anti-clockwise direction	**1**
4(a)(ii)	arrow labelled **B** in electrolyte pointing towards the cathode	**1**
4(b)(i)	electrons are lost	**1**
4(b)(ii)	**M1** Cu^{2+} ions on left	**1**
	M2 rest of equation correct and correctly balanced ($Cu^{2+} + 2e^- \rightarrow Cu$ scores [2])	**1**
4(c)	**M1** anode mass decreases	**1**
	M2 copper lost as <u>ions</u> **OR** copper (atoms) becomes <u>ions</u> **OR** $Cu \rightarrow Cu^{2+} + 2e^-$	**1**
	M3 cathode mass increases	**1**
	M4 copper deposited / layer of copper forms / copper collected at cathode **OR** $Cu^{2+} + 2e^- \rightarrow Cu$	**1**

Question	Answer	Marks
2(b)(i)	M1 breakdown of an ionic compound when molten or in aqueous solution M2 (by the passage of) electricity / electric current / electrical energy	**2**
2(b)(ii)	hydrogen chlorine sodium hydroxide	**3**
2(b)(iii)	$2H^+(aq) + 2e^- \rightarrow H_2(g)$ M1 H^+ on left hand side with e^- added M2 fully correct equation	**2**

Question	Answer	Marks
6(a)	aluminium is more reactive than carbon	**1**
6(b)(i)	oxide ion has an outer shell with six dots and two crosses	**1**
	oxide ion has a charge of 2^-	**1**
6(b)(ii)	(electrostatic) forces of attraction between ions	**1**
	(are) strong **OR** require lots of energy to overcome	**1**
6(c)(i)	*the wires:* electrons	**1**
	the electrolyte: ions	**1**
6(c)(ii)	any 2 from: • increases conductivity • as a solvent • lowers the operating temperature	**2**
6(c)(iii)	$Al^{3+} + 3e^- \rightarrow Al$	**1**
6(c)(iv)	oxygen is made at the anode	**1**
	the anodes are made of carbon	**1**
	oxygen (made) reacts with carbon	**1**

5 (b) hydrogen **and** chlorine / H_2 **and** Cl_2 (1)

sodium hydroxide / NaOH / Na^+OH^- (1)

$2H^+ + 2e \rightarrow H_2$ / $2H^+ \rightarrow H_2 - 2e$ (1)

$2Cl^- \rightarrow Cl_2 + 2e$ / $2Cl^- - 2e \rightarrow Cl_2$ (1)

Hydrogen / H_2 / H / H^+ at cathode **and** chlorine / chloride / Cl_2 / Cl / Cl^- at anode (1) [5]

(d) (i) zinc more reactive (than iron/steel) [1]
loses electrons [1]
electrons move (from zinc) to iron [1]
Zinc reacts (with air and water) **or** zinc corrodes **or** zinc is oxidised **or** zinc is anodic **or** zinc forms positive ions **or** zinc forms Zn^{2+} **or** iron and steel don't react with air/water **or** iron and steel are not oxidised **or** iron and steel do not form ions **or** iron and steel do not lose electrons **or** iron and steel are cathodic [1]

(ii) R to L in wire [1]

(iii) $2H^+ + 2e^- \rightarrow H_2$
species (1) balancing (1)

5 **(b)** **(i)** $2Cl^- \rightarrow Cl_2 + 2e(^-)$ / $2Cl^- - 2e(^-) \rightarrow Cl_2$ [1]

$2H^+ + 2e(^-) \rightarrow H_2$ / $2H^+ \rightarrow H_2 - 2e(^-)$ [1]

hydrogen formed at cathode/– and chlorine at anode/+ [1]

Na^+ and OH^- **or** sodium ions and hydroxide ions left in solution/form/become sodium hydroxide [1]

(ii) $Cl_2 + 2NaOH \rightarrow NaClO/NaOCl + NaCl + H_2O$ [2]
Species (1) Balancing (1)