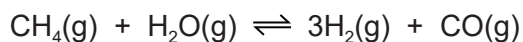
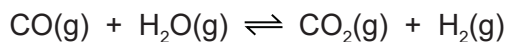


1 At present the most important method of manufacturing hydrogen is steam reforming of methane.

(a) In the first stage of the process, methane reacts with steam at 800 °C.



In the second stage of the process, carbon monoxide reacts with steam at 200 °C.



(i) Explain why the position of equilibrium in the first reaction is affected by pressure but the position of equilibrium in the second reaction is not.

.....
.....
..... [2]

(ii) Suggest why a high temperature is needed in the first reaction to get a high yield of products but in the second reaction a high yield is obtained at a low temperature.

.....
..... [2]

(b) Two other ways of producing hydrogen are cracking and electrolysis.

- (i) Hydrogen can be a product of the cracking of long chain alkanes. Complete the equation for the cracking of C_8H_{18} .



- (ii) There are three products of the electrolysis of concentrated aqueous sodium chloride. Hydrogen is one of them. Write an equation for the electrode reaction which forms hydrogen.

..... [2]

- (iii) Name the other **two** products of the electrolysis of concentrated aqueous sodium chloride and give a use of each one.

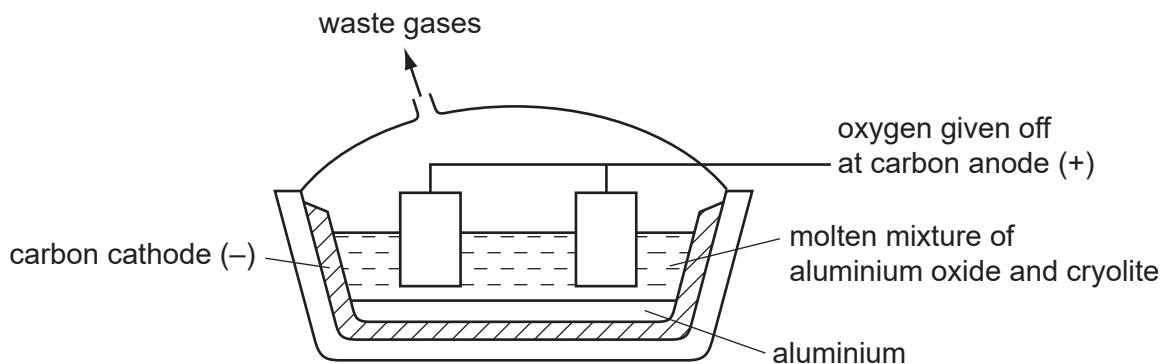
product use

product use [4]

[Total: 11]

2 Aluminium is an important metal with a wide range of uses.

(a) Aluminium is obtained by the electrolysis of aluminium oxide dissolved in molten cryolite.



(i) Solid aluminium oxide is a poor conductor of electricity. It conducts either when molten or when dissolved in molten cryolite. Explain why.

.....
.....
..... [2]

(ii) Why is a solution of aluminium oxide in molten cryolite used rather than molten aluminium oxide?

..... [1]

(iii) Explain why the carbon anodes need to be replaced periodically.

..... [1]

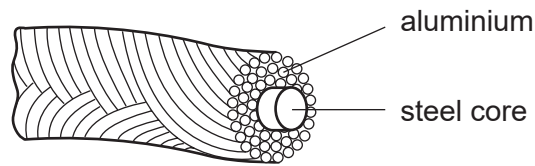
(iv) One reason why graphite is used for the electrodes is that it is a good conductor of electricity. Give another reason.

..... [1]

(b) Aluminium is used to make food containers because it resists corrosion. Explain why it is not attacked by the acids in food.

.....
..... [2]

(c) Aluminium is used for overhead power (electricity) cables which usually have a steel core.



(i) Give **two** properties of aluminium which make it suitable for this use.

.....
..... [2]

(ii) Explain why the cables have a steel core.

.....
..... [1]

[Total: 10]

- (iii) A method being developed to produce iron with lower emissions of carbon dioxide is by electrolysis. Hematite, Fe_2O_3 , is dissolved in molten lithium carbonate and electrolysed. The ore is spilt into its constituent elements.

Write an equation for the reaction at the negative electrode (cathode).

.....

Complete the equation for the reaction at the positive electrode (anode).



[Total: 13]

4 The ore of aluminium is bauxite which is impure aluminium oxide. Alumina, pure aluminium oxide, is obtained from bauxite. Aluminium is formed at the cathode when a molten mixture of alumina and cryolite, Na_3AlF_6 , is electrolysed.

(a) Name **two** products formed at the anode in this electrolysis.

..... [2]

(ii) All the aluminium formed comes from the alumina not the cryolite. Suggest **two** reasons why the electrolyte must contain cryolite.

.....
..... [2]

(iii) The major impurity in bauxite is iron(III) oxide. Iron(III) oxide is basic, aluminium oxide is amphoteric. Explain how aqueous sodium hydroxide can be used to separate them.

.....
.....
..... [2]

(b) The purification of bauxite uses large amounts of sodium hydroxide.

(i) Describe the chemistry of how sodium hydroxide is made from concentrated aqueous sodium chloride. The description must include at least one ionic equation.

.....
.....
.....
.....
..... [5]

(ii) Making sodium hydroxide from sodium chloride produces two other chemicals. Name these two chemicals and state one use of each chemical.

chemical

use

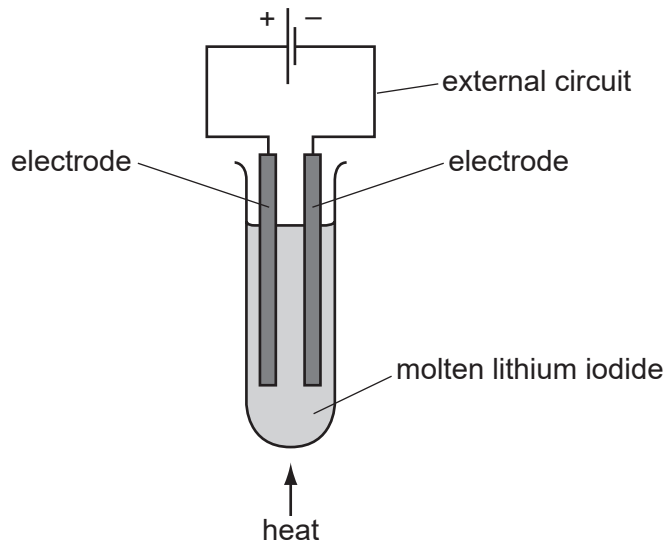
chemical

use [2]

[Total: 13]

5 During electrolysis, ions move in the electrolyte and electrons move in the external circuit. Reactions occur at the electrodes.

(a) The diagram shows the electrolysis of molten lithium iodide.



(i) Draw an arrow on the diagram to show the direction of the electron flow in the external circuit. [1]

(ii) Electrons are supplied to the external circuit. How and where is this done?

.....
 [2]

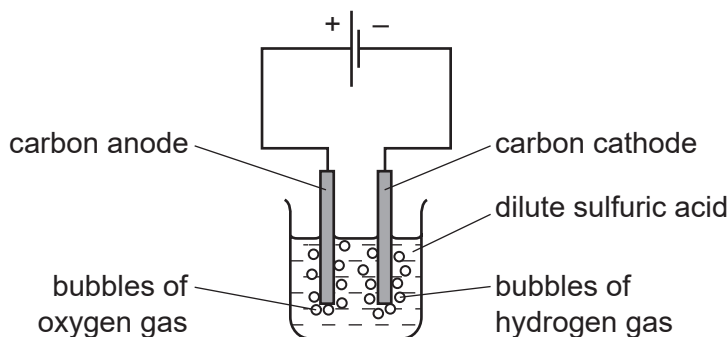
(iii) Explain why solid lithium iodide does not conduct electricity but when molten it is a good conductor.

.....
 [1]

(b) The results of experiments on electrolysis are shown in the following table. Complete the table. The first line has been done as an example.

electrolyte	electrodes	product at cathode	product at anode	change to electrolyte
molten lithium iodide	carbon	lithium	iodine	used up
aqueous copper(II) sulfate	platinum		oxygen	
concentrated aqueous potassium chloride	carbon		chlorine	

- (c) The diagram below shows the electrolysis of dilute sulfuric acid. Hydrogen is formed at the negative electrode (cathode) and oxygen at the positive electrode (anode) and the concentration of sulfuric acid increases.

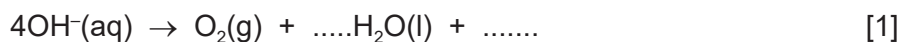


The ions present in the dilute acid are $\text{H}^+(\text{aq})$, $\text{OH}^-(\text{aq})$ and $\text{SO}_4^{2-}(\text{aq})$.

- (i) Write an equation for the reaction at the negative electrode (cathode).

..... [2]

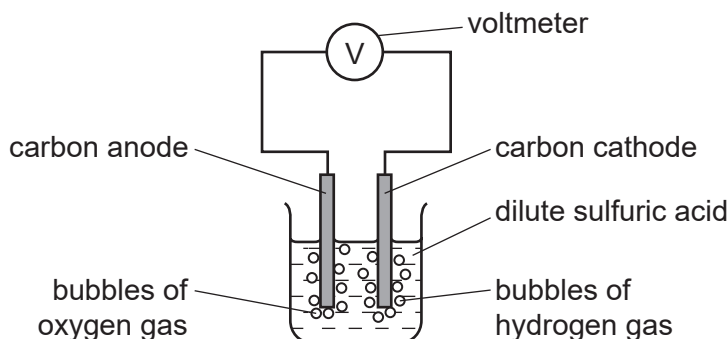
- (ii) Complete the equation for the reaction at the positive electrode (anode).



- (iii) Suggest an explanation of why the concentration of the sulfuric acid increases.

..... [1]

- (d) In the apparatus used in (c), the power supply is removed and immediately replaced by a voltmeter.



A reading on the voltmeter shows that electrical energy is being produced. Suggest an explanation for how this energy is produced.

.....

 [3]