1 The diagram shows the elements in Period 3 of the Periodic Table.

Na	Mg	Al	Si	P	S	Cl	Ar

(a) (i) Identify an element in Period 3 that forms a basic oxide.

(1)

.....

(ii) Identify an element in Period 3 that forms an acidic oxide.

(1)

.....

(b) Magnesium and chlorine react together to form magnesium chloride, a compound with ionic bonding.

The equation for the reaction is

$$Mg + Cl_2 \rightarrow MgCl_2$$

(i) Complete the dot and cross diagram to show the arrangement of the outer electrons in the magnesium and chloride ions formed.

Show the charge on each ion.

(3)



(ii) State what is meant by the term **ionic bonding**.

(2)

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(iii) Explain why magnesium chloride has a high melting point.

(3)

(c) Aluminium is extracted from aluminium oxide using electrolysis.

Calculate the mass, in grams, of aluminium formed when a charge of 20 faradays is passed through aluminium oxide dissolved in molten cryolite.

The ionic half-equation for the formation of aluminium is

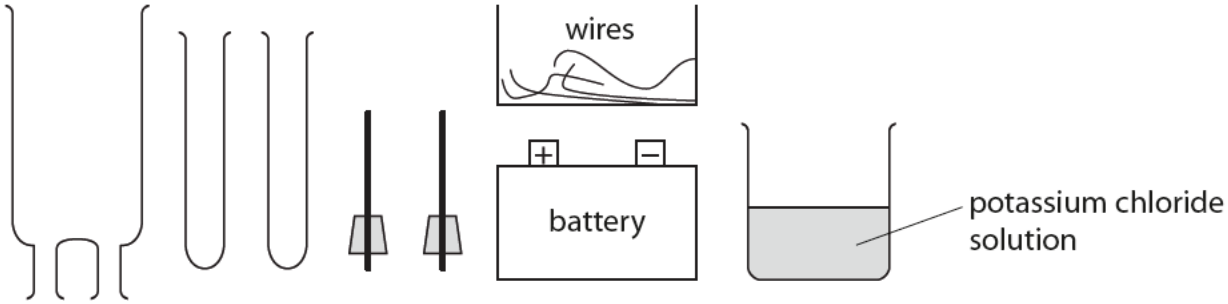
$$Al^{3+} + 3e^- \rightarrow Al$$

(2)

mass of aluminium = ... g

(Total for Question 1 = 12 marks)

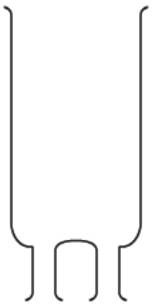
2 A student investigates electrolysis using this apparatus.



(a) The student electrolyses KCl(aq) and collects samples of any gases formed.

Complete the following diagram to show how to assemble the apparatus.
Label the diagram to show the potassium chloride solution.

(3)



(b) The table shows the half-equation for the reaction at one electrode.

Complete the table to show the half-equation for the reaction at the other electrode and the polarity (+ or –) of each electrode.

(2)

Polarity	Equation
	$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$

(c) Describe a test to show that the gas collected is hydrogen.

(1)

.....

.....

(Total for Question 2 = 6 marks)

3 Magnesium and its compounds have many uses.

Magnesium is never found as an element in the Earth's crust, but its compounds occur naturally in rocks and seawater.

(a) Suggest why magnesium is not found as an element in the Earth's crust.

(1)

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(b) Magnesium can be extracted from seawater by a multi-stage process.

stage 1 calcium hydroxide reacts with magnesium chloride in seawater to form a precipitate of magnesium hydroxide

stage 2 the magnesium hydroxide is filtered off and converted into magnesium chloride solution by reacting it with hydrochloric acid

stage 3 the magnesium chloride solution is converted into solid magnesium chloride

stage 4 the solid magnesium chloride is melted and electrolysed

(i) Which stage involves a neutralisation reaction?

(1)

☒ **A** stage 1

☒ **B** stage 2

☒ **C** stage 3

☒ **D** stage 4

(ii) Suggest the name of the other product formed in stage 1.

(1)

.....

(iii) What happens to the ions in magnesium chloride during melting?

(1)

.....

.....

(iv) The ionic half-equation for the reaction at the negative electrode in stage 4 is

$$Mg^{2+} + 2e^- \rightarrow Mg$$

Write the ionic half-equation for the reaction at the positive electrode.

(1)

.....

(c) A manufacturer makes a batch of magnesium by electrolysing magnesium chloride.

(i) Calculate the mass of magnesium chloride ($MgCl_2$) needed to make 48 kg of magnesium.

(2)

mass of magnesium chloride = ... kg

(ii) Calculate the amount, in moles, of electrons needed to make 48 kg of magnesium.

(2)

amount of electrons = ... mol

(d) Magnesium oxide can be used to make magnesium sulfate by this reaction.

$$MgO(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2O(l)$$

A student is provided with a beaker of dilute sulfuric acid.

Outline the steps she should use to obtain a pure sample of hydrated magnesium sulfate crystals using this reaction.

(5)

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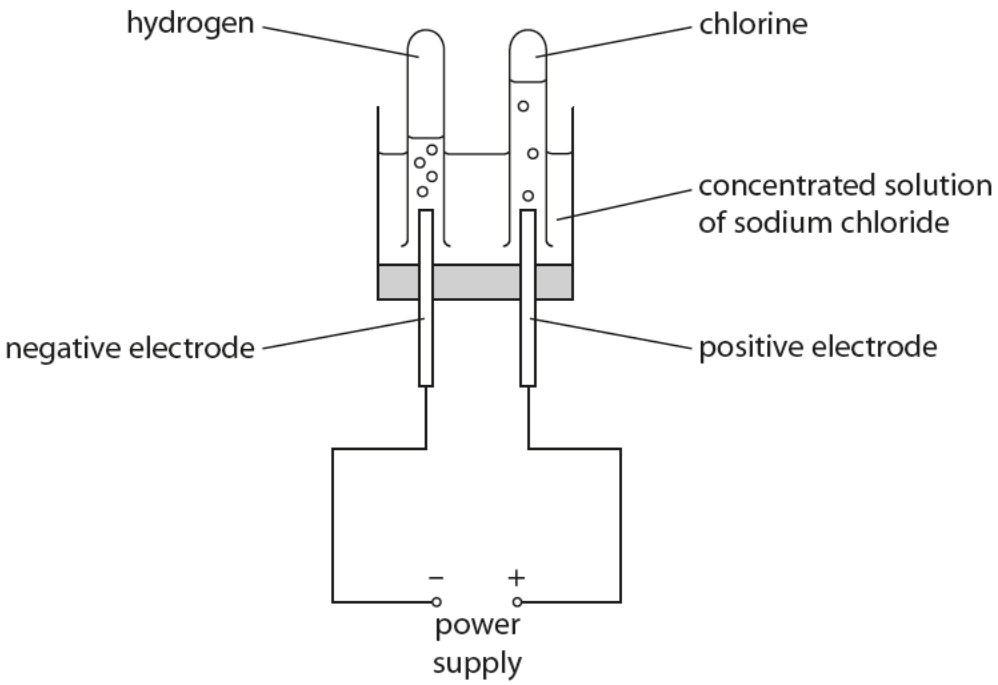
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(Total for Question 3 = 14 marks)

4 This apparatus is used to electrolyse a concentrated solution of sodium chloride.



(a) The ionic half-equations for the reactions at the electrodes are

negative electrode $2H_2O(l) + 2e^- \rightarrow 2OH^-(aq) + H_2(g)$

positive electrode $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$

(i) State how these ionic half-equations show that equal volumes of the two gases should be collected.

(1)

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(ii) Suggest why the volume of chlorine collected is less than expected.

(1)

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(iii) A sample of the solution near to the negative electrode is tested with phenolphthalein indicator.

Explain why the phenolphthalein turns pink.

(2)

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(b) The table shows two methods of testing for chlorine.

Complete the table by giving the observation made in each test.

(2)

Test	Observation
add damp blue litmus paper	
bubble chlorine into a solution of potassium iodide	

(c) (i) State why chlorine is sometimes added to water supplies.

(1)

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.....

(ii) Chlorine is used to manufacture hydrogen chloride gas, HCl(g).

Write a chemical equation to show the formation of hydrogen chloride from hydrogen and chlorine.

(1)

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(iii) How is hydrogen chloride gas converted into hydrochloric acid?

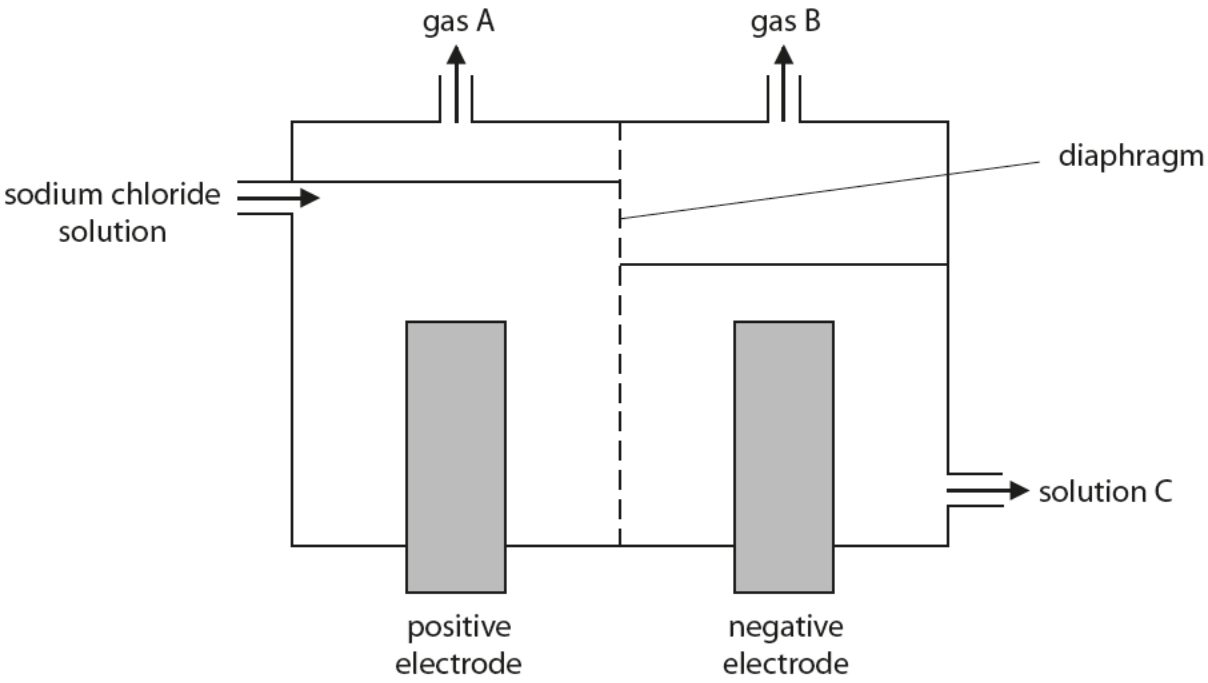
(1)

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(Total for Question 4 = 9 marks)

5 The diagram shows the diaphragm cell used in the electrolysis of concentrated sodium chloride solution, NaCl(aq).



(a) Explain what is meant by the term **electrolysis**.

(2)

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(b) Identify gas A, gas B and solution C.

(3)

gas A .....

gas B .....

solution C .....

(c) Sodium is manufactured by the electrolysis of molten sodium chloride, NaCl(l).

Sodium is produced at the negative electrode and chlorine is produced at the positive electrode.

(i) Why does the sodium chloride have to be molten before it will conduct electricity?

(1)

.....

.....

(ii) The ionic half-equation for the formation of sodium is

$$Na^+ + e^- \rightarrow Na$$

Write the ionic half-equation for the formation of chlorine from chloride ions.

(2)

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(Total for Question 5 = 8 marks)

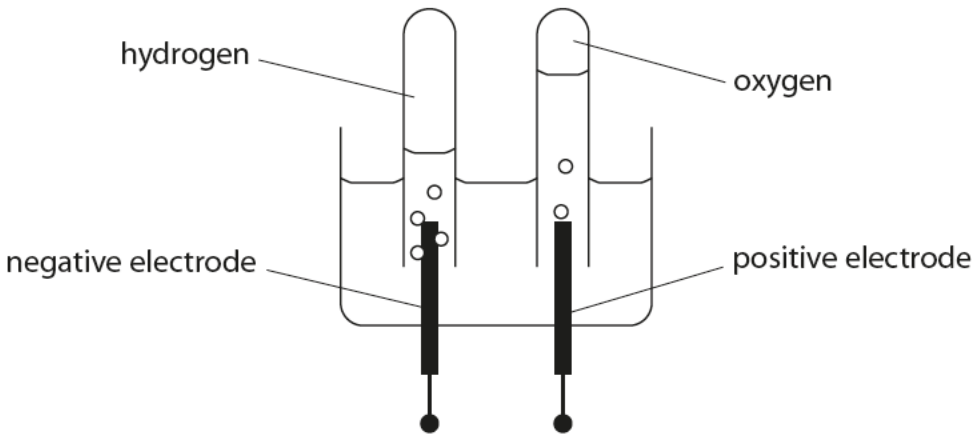
6 (a) The table shows some results of the electrolysis of aqueous solutions using inert electrodes. The solutions were electrolysed under the same conditions.

Use the information given to complete the table.

(3)

Solution	Product at the negative electrode	Product at the positive electrode	Substance left in solution at the end of the electrolysis
copper(II) sulfate	copper	oxygen	sulfuric acid
potassium sulfate	hydrogen	oxygen	potassium sulfate
silver nitrate	silver	oxygen	nitric acid
silver sulfate		oxygen	sulfuric acid
potassium nitrate	hydrogen		

(b) Water can be decomposed by electrolysis using this apparatus.



(i) Suggest a suitable element for the inert electrodes.

(1)

.....

(ii) Suggest why a small amount of dilute acid is added to the water before it is electrolysed.

(1)

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(c) (i) The overall equation for the decomposition of water is

$$2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$$

Use this equation to explain why the volume of hydrogen collected should be twice that of the volume of oxygen.

(1)

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(ii) The volume of oxygen collected is always slightly less than expected, even though there are no leaks in the apparatus.

Suggest a reason for this.

(1)

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.....

(d) The equation represents the formation of hydrogen gas at the negative electrode.

$$2H_2O(l) + 2e^- \rightarrow 2OH^-(aq) + H_2(g)$$

During electrolysis, 482 500 coulombs were passed through the solution.

Calculate the amount, in moles, of hydrogen gas formed.

[One faraday = 96 500 coulombs]

(2)

Amount of hydrogen gas formed = ... mol

(Total for Question 6 = 9 marks)