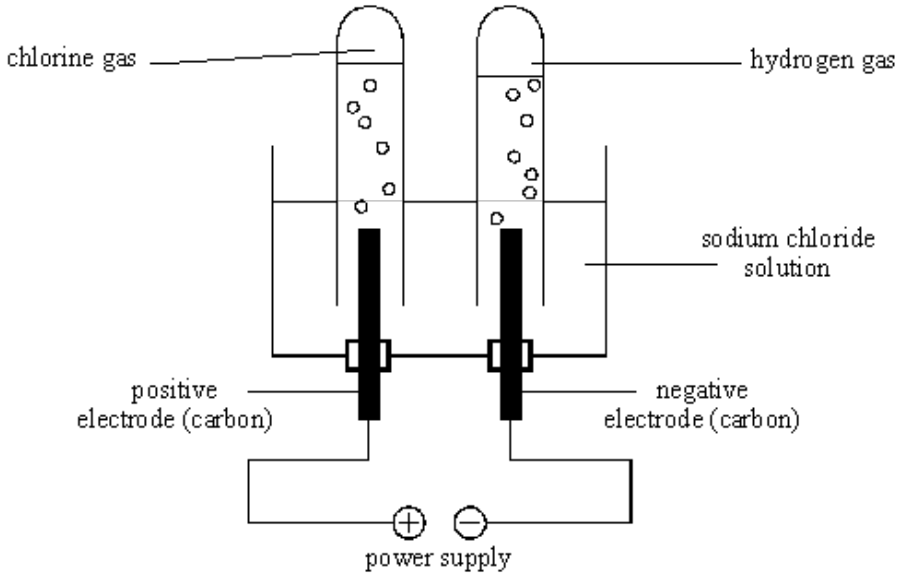
Q1. The diagram shows electrolysis of sodium chloride solution.



(a) Complete and balance these equations to show the reactions during electrolysis.

At the positive electrode

$$Cl^- \quad - \quad e^- \rightarrow \quad Cl_2$$

At the negative electrode

$$Na \quad \rightarrow \quad Na$$

(2)

(b) Silver halides such as silver chloride and silver bromide are used in photography. The equation shows a reaction to prepare a silver halide.

reactants → product 1 + product 2

$$NaBr_{(aq)} + AgNO_{3(aq)} \longrightarrow AgBr_{(s)} + NaNO_{3(aq)}$$

Name and describe the products of this reaction, in words, as fully as you can.

product 1

.....

.....

product 2

.....

.....

(4)

(Total 6 marks)

Q2. The electrolysis of sodium chloride solution is an important industrial process. Three useful substances are produced:

- chlorine gas is formed at the positive electrode;
- hydrogen gas is formed at the negative electrode;
- an alkali is left in the solution.

The reactions which take place at the electrodes are represented by the equations shown below:

$$2Cl^- - 2e^- \rightarrow Cl_2$$

$$2H^+ + 2e^- \rightarrow H_2$$

(a) Name the important alkali which is left in the solution.

.....

(1)

(b) State why chloride ions move towards the positive electrode.

.....

(1)

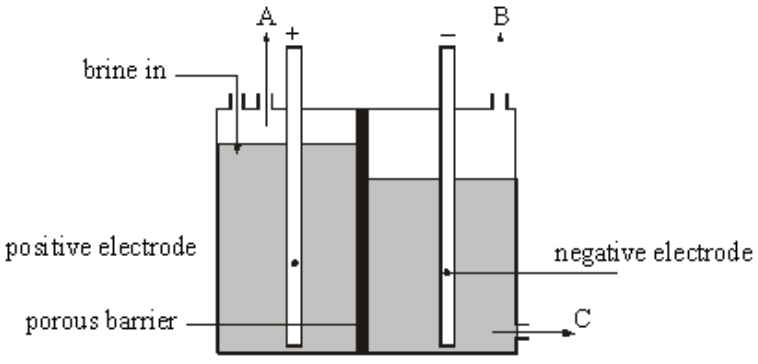
(c) Why is the formation of chlorine at this electrode said to be an oxidation reaction?

.....

(1)

(Total 3 marks)

Q3. Sodium hydroxide, hydrogen and chlorine can all be made in one industrial process. Electricity is passed through aqueous sodium chloride solution (brine). The diagram below shows a cell that can be used for this process.



(a) Name A, B and C.

Gas A .....

Gas B .....

Solution C .....

(2)

(b) Balance the equations for the reactions at the electrodes.

(i) ..... Cl^- – ..... e^- → Cl_2

(ii) ..... H^+ + ... e^- → H_2

(2)

(c) Name the compound in this cell which produces the hydrogen ions.

.....

(1)

(d) Which type of particles must be able to pass through the barrier to allow the electrolysis to take place?

.....

(1)

(Total 6 marks)

##

Sando-K is a medicine. It is given to people whose bodies contain too little of a particular element.

Sando-K is a mixture of two compounds. The formulae of the two compounds are given below.

$KHCO_3$ **KC1**

(a) Which metal do people given Sando-K need?

.....

(1)

(b) Sando-K contains the ion, CO_3^{2-}. Which gas would be produced if a dilute acid was added to Sando-K? (The Data Sheet may help you to answer this question.)

.....

(1)

(c) The compounds in Sando-K contain ions.

Complete the two sentences below.

Atoms change into positive ions by ..... one or more

..... .

Atoms change into negative ions by ..... one or

more ..... .

(4)

(d) Electricity can be used to show that an aqueous solution of Sando-K contains ions.

(i) Draw a diagram of an apparatus that you could use to prove that Sando-K contains ions.

(4)

(ii) Explain, as fully as you can, what would happen when the electricity is switched on.

.....

.....

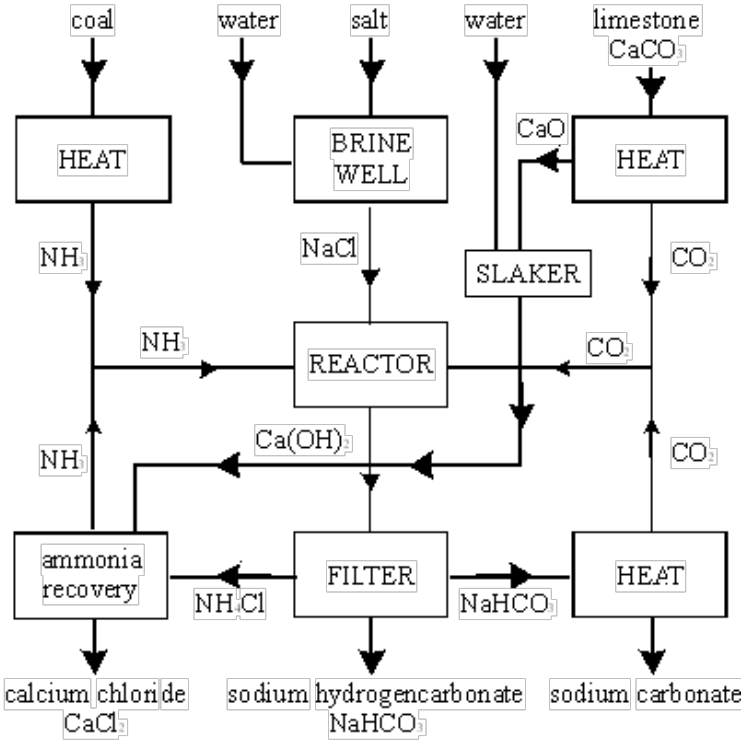
.....

.....

(3)
(Total 13 marks)

Q5. Sodium carbonate is a useful chemical that can be made from sodium chloride.

(a) The flow chart below shows one way in which sodium carbonate can be made.



(i) Write the formula of sodium carbonate.
Use the Data Sheet to help you to answer this question.

.....

(1)

(ii) 1. Give **one** example of a thermal decomposition reaction shown in the flow chart.

.....

.....

(1)

2. Explain what is meant by a thermal decomposition reaction.

.....

.....

(2)

(iii) Name **one** substance that is recycled in this process.

.....

(1)

(b) When sodium carbonate solution is added to zinc sulphate solution a white solid is precipitated.

(i) Use the Data Sheet to help you to name the white solid that is produced in this reaction.

.....

(1)

(ii) State why this solid is formed.

.....

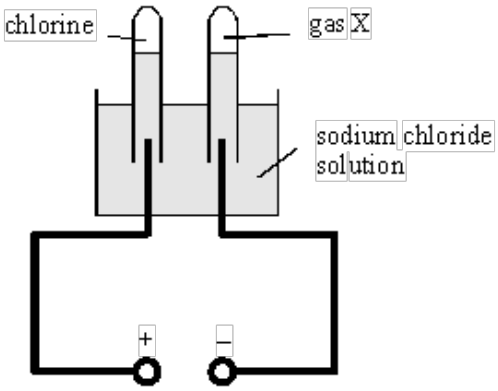
.....

.....

(1)

(Total 7 marks)

Q6. (a) In an industrial process electricity is passed through a solution of sodium chloride in water. A student set up the apparatus shown below to investigate this process.



(i) Name gas X.

.....

(1)

(ii) Complete the half equation for the production of chlorine gas during the electrolysis.

..... Cl^- → ..... e^- → Cl_2

(1)

(iii) The student found that the solution left in the cell was alkaline.

Which ion makes the solution alkaline?

.....

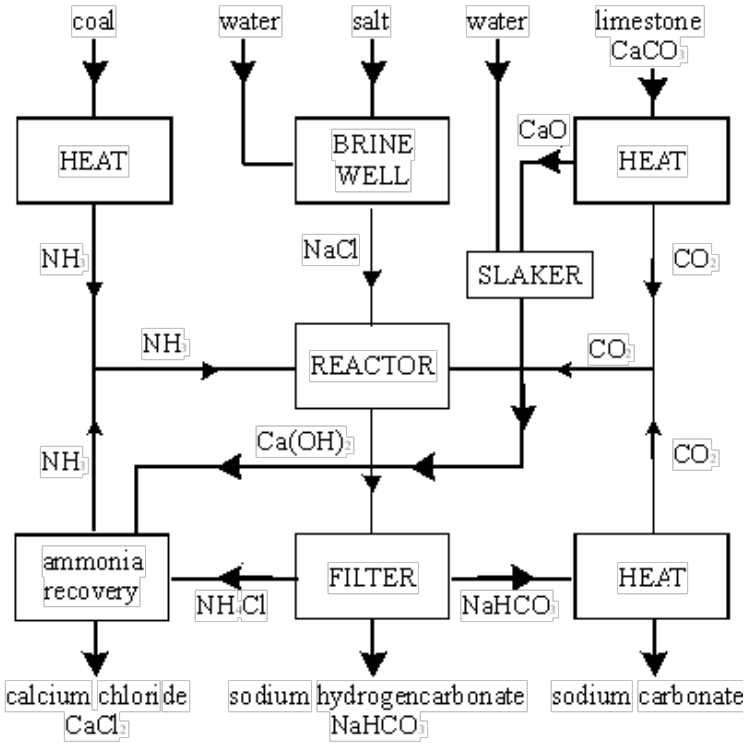
(1)

(iv) Name the useful substance that can be obtained from the solution in the cell.

.....

(1)

(b) Sodium carbonate is another useful chemical that can be made from sodium chloride. The flow chart below shows one way in which sodium carbonate can be made.



(i) Write the formula of sodium carbonate.
Use the Data Sheet to help you to answer this question.

.....

(1)

(ii) Salt is one raw material used in this process.

Name **one** other raw material used in this process.

.....

(1)

(iii) Sodium carbonate is one of the products of this process.

Name **one** other product.

.....

(1)

(iv) 1. Give **one** example of a thermal decomposition reaction shown in the flow chart.

.....

.....

(1)

2. Explain what is meant by a thermal decomposition reaction.

.....

.....

(2)

(v) Name **one** substance that is recycled in this process.

.....

(1)

(c) When sodium carbonate solution is added to zinc sulphate solution a white solid is precipitated.

(i) Use the Data Sheet to help you to name the white solid that is produced in this reaction.

.....

(1)

(ii) State why this solid is formed.

.....

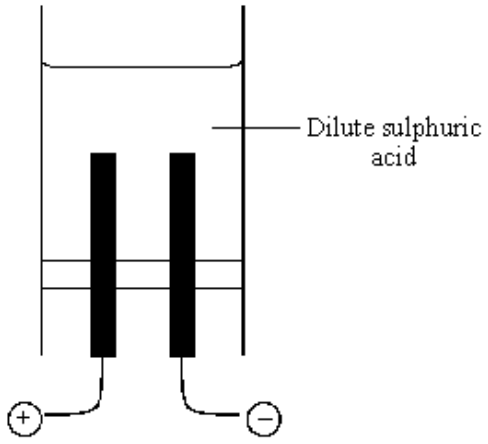
.....

.....

(1)

(Total 13 marks)

Q7. An electric current was passed through dilute sulphuric acid. The apparatus used is shown. Oxygen was formed at the anode.



(a) What name is given to solutions which decompose when electricity is passed through them?

.....

(1)

(b) The ionic equation for the reaction at the anode is:

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

Explain this type of reaction.

.....

.....

(2)

(c) Write a **balanced** ionic equation for the reaction at the cathode.

.....

(2)

(d) What happens to the concentration of the sulphuric acid as the electricity is passed through it? Explain your answer.

.....

.....

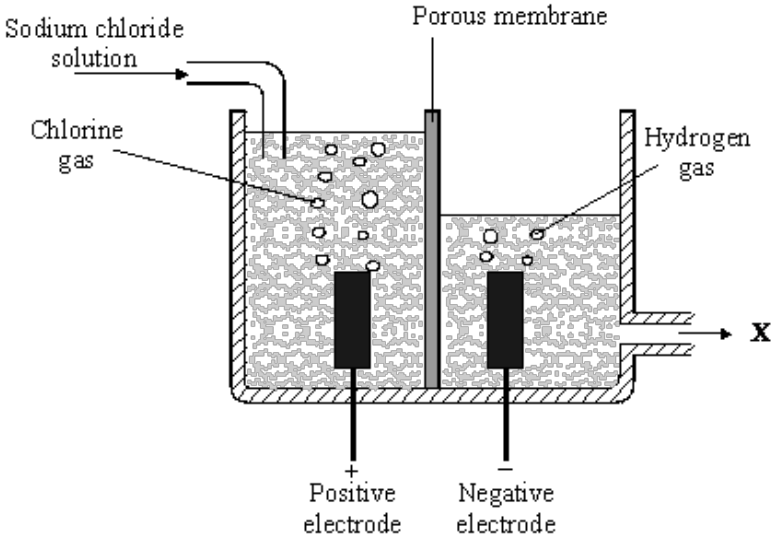
.....

.....

(3)

(Total 8 marks)

Q8. Sodium chloride solution is a useful raw material for the manufacture of other substances.



(i) What is the name of the process shown?

.....

(1)

(ii) Chloride ions lose electrons at the positive electrode. What is the name of this type of reaction?

.....

(1)

(iii) The solution formed at **X** is alkaline. What causes this solution to be alkaline?

.....

.....

.....

(2)

(iv) Give a balanced ionic equation for the formation of hydrogen gas at the negative electrode.

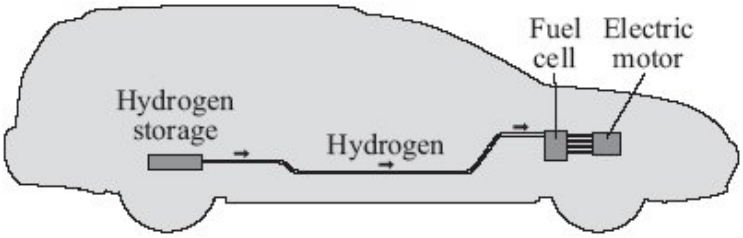
.....

(3)

(Total 7 marks)

Q9. Read the article and then answer the questions that follow.

Hydrogen fuel for cars?



Hydrogen is an excellent fuel. It can be made by the electrolysis of potassium hydroxide solution.

Hydrogen gas can be stored under pressure in a cylinder but a leak of the gas could cause an explosion.

It has been found that lithium nitride can absorb and then release large volumes of hydrogen. A chemical reaction takes place between the hydrogen and the lithium nitride. The hydrogen is held in the resulting compounds by chemical bonds.

The problem is that the rate at which hydrogen is absorbed and then released from normal sized particles of lithium nitride is slow.

Recently scientists have made 'nanosized' particles of lithium nitride. These particles absorb hydrogen in the same way as normal sized lithium nitride particles. The 'nanosized' particles have the advantage that they absorb and release the hydrogen much faster when needed in the fuel cell.

It is hoped that 'nanosized' particles of lithium nitride may provide a safe method of storing hydrogen in the future.

(a) Hydrogen is produced at the negative electrode during the electrolysis of potassium hydroxide solution.

(i) Why are hydrogen ions attracted to the negative electrode?

.....

.....

.....

(1)

(ii) Potassium ions are also attracted to the negative electrode.

Explain why hydrogen gas is formed but not potassium.

.....

.....

.....

(1)

(b) Lithium nitride is made by reacting lithium with nitrogen.

Balance the equation for this reaction.

..... $Li + N_2 \rightarrow$ ..... Li_3N

(1)

(c) (i) The equation for the reaction of lithium nitride with hydrogen is:

$$Li_3N + 2H_2 \rightleftharpoons LiNH_2 + 2LiH$$

What feature of this reaction allows the hydrogen to be released?

.....

.....

(1)

(ii) Hydrogen stored in a fuel tank filled with lithium nitride would be safer in an accident than a cylinder full of hydrogen.

Suggest and explain why.

.....

.....

.....

.....

.....

(2)

(d) Lithium nitride is an ionic compound which contains lithium ions (Li^+) and nitride ions (N^{3-}).

(i) The formation of a lithium ion from a lithium atom is an oxidation reaction.

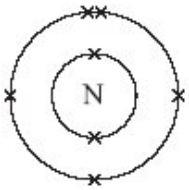
Explain why.

.....

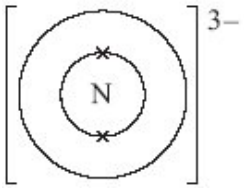
.....

(1)

(ii) The diagram shows the electronic structure of a nitrogen atom.

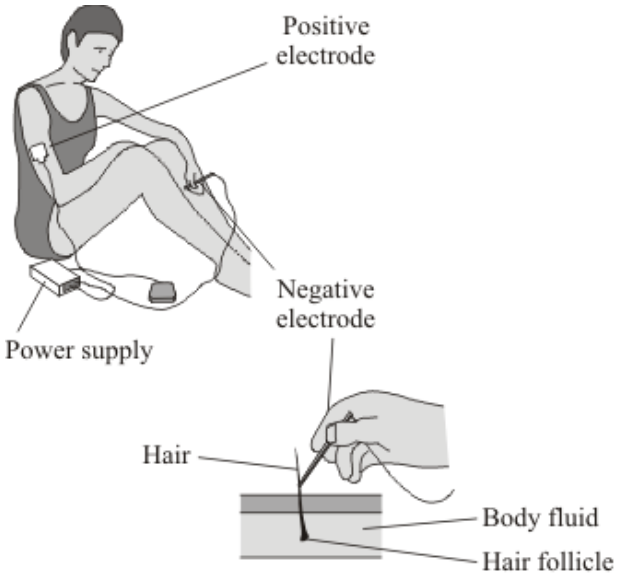


Complete the diagram below to show the electronic structure of a nitride ion (N^{3-}).



(1)
(Total 8 marks)

Q10. Electrolysis can be used to remove unwanted hair from the skin.



The hair is first coated with a layer of gel containing ions in solution.

The positive electrode is connected by a patch to the skin.

The negative electrode is connected to the hair. Electricity flows through the gel and causes electrolysis of the body fluid around the hair follicle.

(a) Metal wires conduct electricity to the electrodes.

Explain how metals conduct electricity.

.....

.....

.....

.....

(2)

(b) Explain why the gel containing ions in solution can conduct electricity.

.....

.....

(1)

(c) The body fluid is a solution that contains sodium chloride. The electricity causes the electrolysis of a small amount of this solution.

This solution contains hydrogen ions that move to the negative electrode.

(i) The half equation represents the reaction at the negative electrode.

$2H^+ + 2e^- \rightarrow H_2$

Explain why this reaction is a reduction.

.....

.....

(1)

(ii) As a result of the electrolysis of sodium chloride solution, an alkali forms which kills the hair follicle.

What is the name of this alkali? .....

(1)

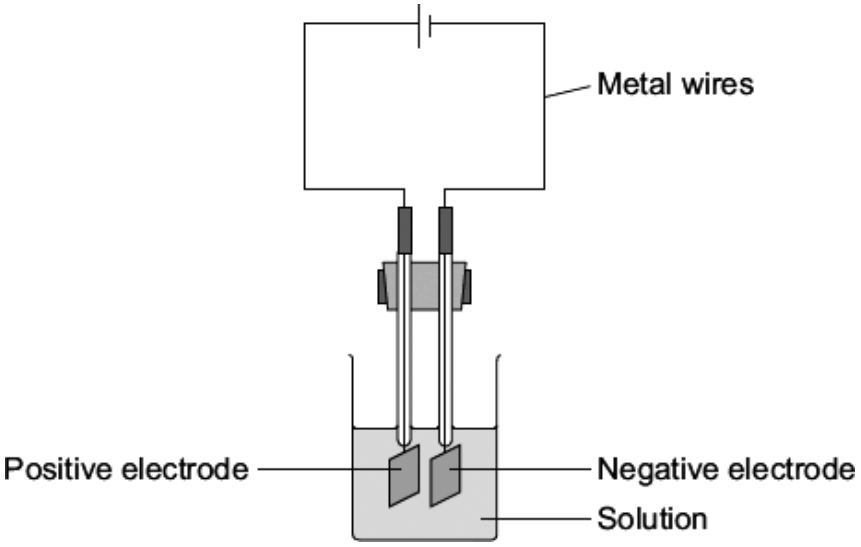
(iii) Complete the half equation for the reaction at the positive electrode.

$Cl^- \rightarrow Cl_2$

(1)

(Total 6 marks)

Q11. The diagram shows apparatus used by a student to investigate electrolysis.



The student was given a solution by the teacher. The solution contained a mixture of ionic compounds.

(a) Name the particles which carry the electric current through:

(i) the metal wires .....

(1)

(ii) the solution. .....

(1)

(b) The table shows the ions in the solution.

Positive ions in the solution	**Negative ions in the solution**
Zinc ion (Zn^{2+})	Chloride ion (Cl^{-})
Iron(III) ion (Fe^{3+})	Hydroxide ion (OH^{-})
Hydrogen ion (H^{+})	Nitrate ion (NO_3^{-})
Copper(II) ion (Cu^{2+})	Sulfate ion (SO_4^{2-})

The reactivity series on the Data Sheet may help you to answer this question.

(i) Which element is most likely to be formed at the negative electrode?

.....

(1)

(ii) Explain, as fully as you can, why you have chosen this element.

.....

.....

.....

.....

(2)

(c) The electrolysis of sodium chloride solution is an industrial process.

(i) The reaction at one of the electrodes can be represented by the equation shown below.

$$2Cl^- \rightarrow Cl_2 + 2e^-$$

The chloride ions (Cl^-) are oxidised.

Explain why.

.....

.....

(1)

(ii) The reaction at the other electrode can be represented by an equation.

Complete and balance the equation for the reaction at the other electrode.

$$H^+ \rightarrow H_2$$

(1)
(Total 7 marks)

Q12. Aluminium is extracted from aluminium oxide.

(a) The formula of aluminium oxide is Al_2O_3

The relative formula mass (M_r) of aluminium oxide is 102.

Calculate the percentage of aluminium in aluminium oxide.

Relative atomic masses (A_r): O = 16; Al = 27.

.....

.....

.....

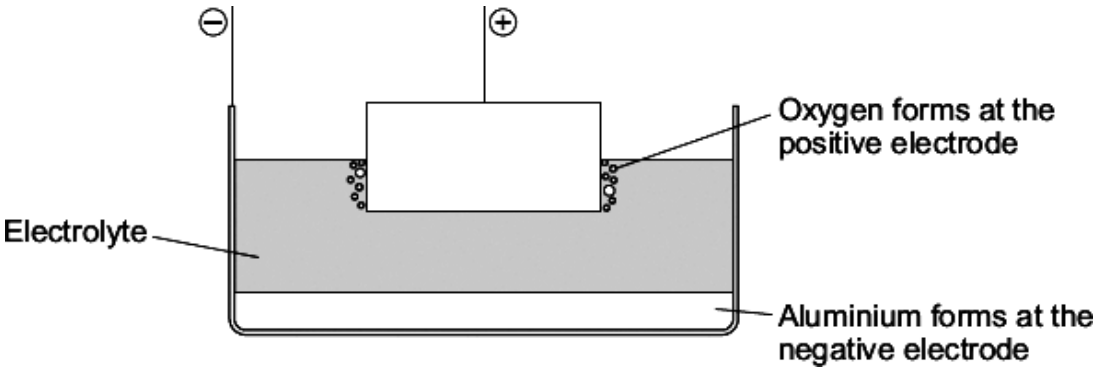
.....

Percentage of aluminium = ... %

(2)

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

The diagram shows a cell used for the extraction of aluminium.



(i) The electrolyte contains cryolite.

Explain why.

.....

.....

.....

.....

(2)

(ii) Oxygen is formed at the positive electrode. Complete and balance the equation for this reaction.

... O^{2-} → O_2 + ...

(2)

(iii) The positive electrode in the cell is used up during the process.

Explain why.

.....

.....

.....

.....

.....

.....

(2)
(Total 8 marks)

Q13. Kelp is a seaweed.

Kelp can be used in foods and as a renewable energy source.

© Ethan Daniels/Shutterstock

(a) Scientific experiments, on their own, **cannot** fully answer one of the following questions. Which one?

Tick (✓) **one** box.

Questions	Tick (✓)
How much carbon dioxide is produced when 100 g of kelp is burned?	
Does kelp give out more heat energy than coal?	
Will kelp last longer than coal as an energy source?	
Which fuel, kelp or coal, produces the most ash when burned?	

(1)

(b) Scientists cannot answer the question 'should people use kelp instead of coal as an energy source?'

Give **two** reasons why.

.....

.....

.....

.....

(2)

(c) Sodium iodide can be produced from kelp.

(i) How many electrons are in the outer shell of an iodine atom? ☐

(1)

(ii) Sodium iodide contains sodium ions (Na^+) and iodide ions (I^-).

Describe, as fully as you can, what happens when sodium atoms react with iodine atoms to produce sodium iodide.

You may use a diagram in your answer

.....

.....

.....

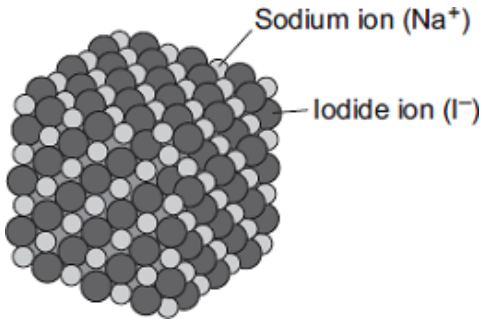
.....

.....

.....

(3)

(iii) The diagram shows the structure of sodium iodide.



Solid sodium iodide does not conduct electricity.

Why does sodium iodide solution conduct electricity?

.....

.....

(1)

(iv) When sodium iodide solution is electrolysed, iodine is formed at the positive electrode.

Complete and balance the half equation for the formation of iodine.

$$\text{.....}I^- \rightarrow I_2 + \text{.....}e^-$$

(1)

(v) What is formed at the negative electrode when sodium iodide solution is electrolysed?

Explain why.

.....

.....

.....

.....

(2)
(Total 11 marks)

Q14. This question is about potassium.

(a) Humphrey Davy was a professor of chemistry.

In 1807 Davy did an electrolysis experiment to produce potassium.

(i) Davy first tried to electrolyse a solid potassium salt to produce potassium.

Explain why this electrolysis did **not** work.

.....

.....

.....

.....

(2)

(ii) Humphrey Davy was the first person to produce potassium.

Humphrey Davy's experiment to produce this new element was quickly accepted by other scientists.

Suggest why.

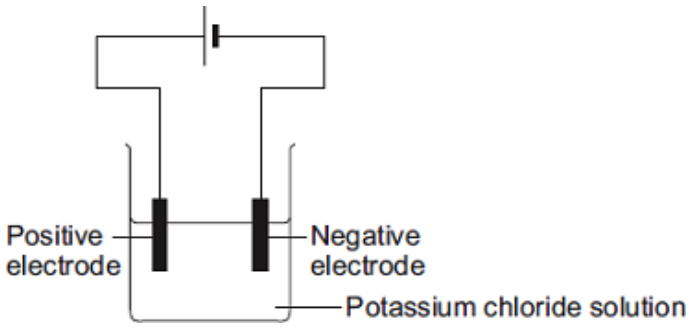
.....

.....

(1)

(b) A student dissolved some potassium chloride in water. The student tried to electrolyse the potassium chloride solution to produce potassium.

The apparatus the student used is shown in the diagram.



The student expected to see potassium metal at the negative electrode, but instead saw bubbles of a gas.

- Name the gas produced at the negative electrode.
- Explain why this gas was produced at the negative electrode **and** why potassium was not produced.

The reactivity series of metals on the Chemistry Data Sheet may help you to answer this question.

.....

.....

.....

.....

.....

.....

(3)

(c) The student tried to electrolyse molten potassium chloride to produce potassium.

(i) Potassium metal was produced at the negative electrode.

Describe how potassium atoms are formed from potassium ions.

.....

.....

.....

.....

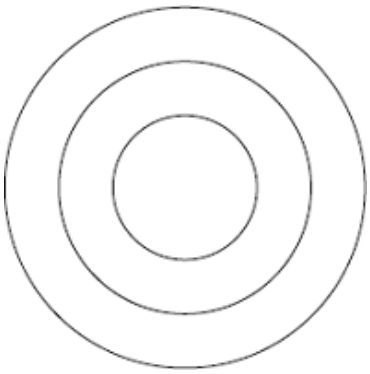
(2)

(ii) Complete and balance the equation for the reaction at the positive electrode.

.....Cl^- $\longrightarrow$ Cl_2 + ...

(1)

(iii) Complete the diagram to show the electronic structure of a chloride ion (Cl^-).



(1)

(Total 10 marks)