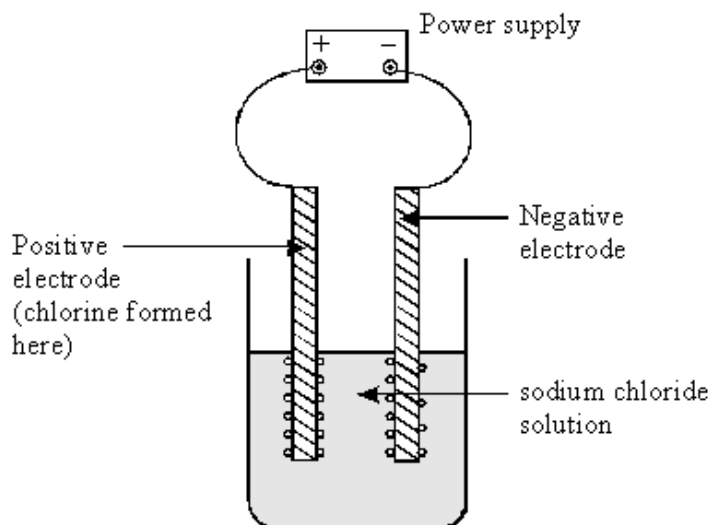


Q1. The diagram below shows the electrolysis of sodium chloride solution, in the laboratory.



(a) Which gas forms at the negative electrode?

(1)

(b) Explain why chlorine gas forms at the positive electrode.

.....
.....
.....

(2)

(c) State **one** use of chlorine gas.

.....

(1)

(Total 4 marks)

Q2. Sea water is a good source of bromine. To obtain the bromine from the bromide ions dissolved in sea water, it is displaced by reacting with chlorine. The bromine is removed by blowing air through the mixture to carry away the bromine. Bromine and chlorine are both in Group 7 of the Periodic Table.

Write a balanced ionic equation for the reaction between chlorine molecules and bromide ions.

.....

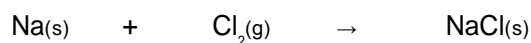
(Total 3 marks)

Q3. This question is about sodium chloride (common salt) which is an important chemical.

Sodium chloride can be made by burning sodium in chlorine gas.

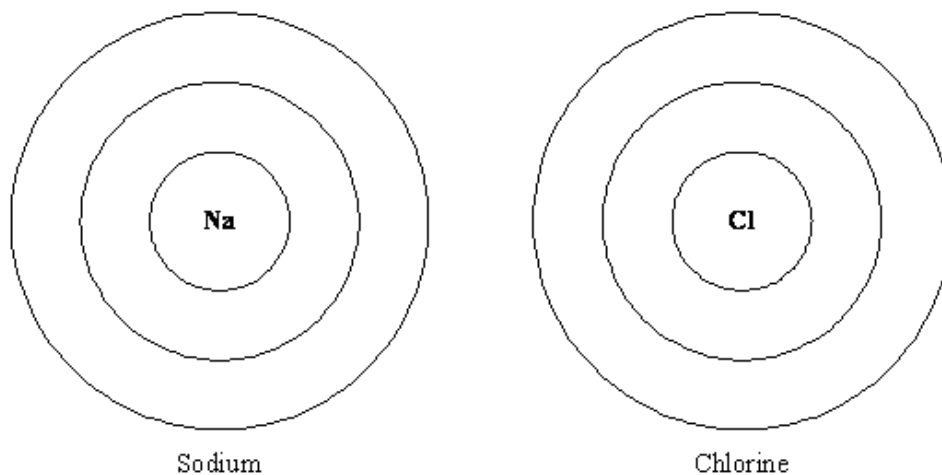


(a) Balance the symbol equation for the reaction of sodium with chlorine.



(1)

(b) (i) Complete the diagrams below to show the electronic structures of a sodium and a chlorine atom. (Atomic number of sodium = 11 and chlorine = 17.)



(3)

(ii) When sodium reacts with chlorine the sodium atoms are changed into sodium ions (Na^+) and the chlorine atoms are changed into chlorine ions (Cl^-).

Explain how:

1. a sodium atom changes into a sodium ion;

.....
.....

(2)

2. a chlorine atom changes into a chloride ion.

.....
.....

(2)

- (c) The element potassium is in the same group of the Periodic Table as sodium. Potassium reacts with chlorine to make potassium chloride which is sometimes used instead of common salt in cooking.

(i) Predict the formula of potassium chloride.

.....

(1)

By reference to the electronic structures of potassium and sodium explain:

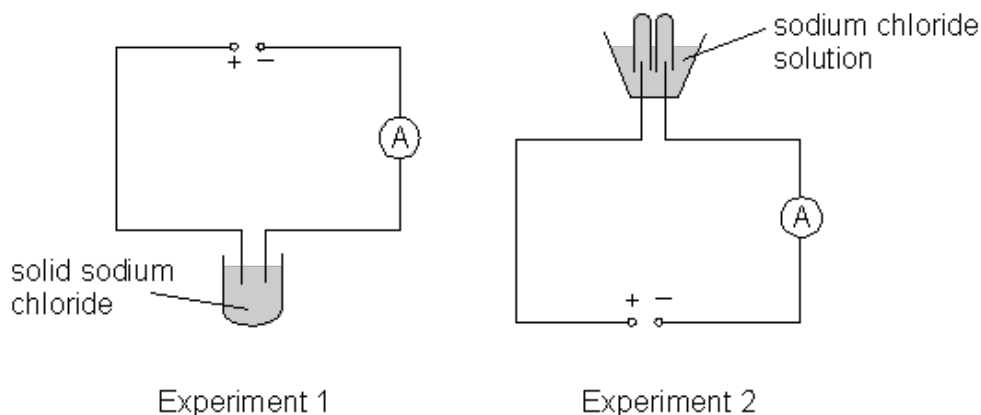
(ii) Why the reaction of potassium with chlorine is similar to the reaction of sodium with chlorine.

.....

.....

(1)

- (d) The electrolysis of sodium chloride solution is an important industrial process. The diagrams below show two experiments set up during an investigation of the electrolysis of sodium chloride.



(i) What would be the reading on the ammeter in experiment 1?

..... A

(ii) Explain your answer.

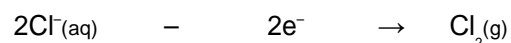
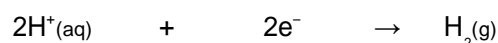
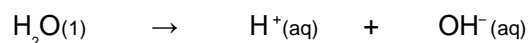
.....

.....

.....

(3)

- (e) The equations below show the reactions which take place in experiment 2.



- (i) Which substance provides hydrogen ions?

.....

(1)

- (ii) Name the product formed at:

(A) the positive electrode;

.....

(B) the negative electrode.

.....

(1)

(Total 15 marks)

Q4. Many everyday substances can be classified as acids, bases or salts. For example, car batteries contain sulphuric acid, oven cleaners contain sodium hydroxide and table salt contains sodium chloride.

- (a) A solution of each of these substances was tested with universal indicator.

Solution	Colour of universal indicator
Sulphuric acid (H_2SO_4)	red
Sodium hydroxide (NaOH)	purple
Sodium chloride (NaCl)	green

- (i) Explain how these universal indicator colours and the corresponding pH values could be used to identify each of these solutions.

.....

.....

.....

.....

.....

(3)

- (ii) Name and give the formula of the ion which causes the solution to be acidic.

Name of ion

Formula of ion

(2)

- (b) Sodium chloride can be made by reacting sodium hydroxide with hydrochloric acid in the presence of an indicator.

(i) What is the name of this type of reaction?

.....

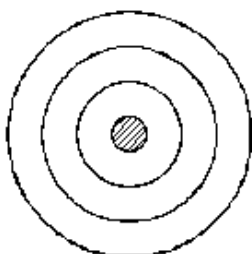
(1)

(ii) Write a balanced chemical equation for this reaction.

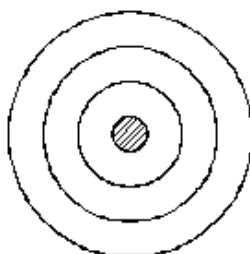
.....(aq) +(aq) →(aq) +(l)

(2)

- (c) The atomic number for sodium is 11 and for chlorine is 17.



Sodium atom



Chlorine atom

(i) Complete the diagrams to show the electron arrangements for a sodium atom and a chlorine atom.

(2)

(ii) These atoms form different particles by one electron transferring from the sodium atom to the chlorine atom. What is the name given to the particles formed?

.....

(1)

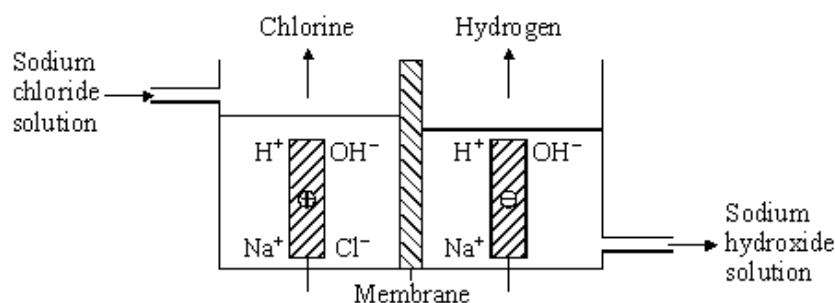
(iii) Why do these sodium and chloride particles bond?

.....

.....

(1)

- (d) Sodium chloride solution is electrolysed to form three products, hydrogen, chlorine and sodium hydroxide.



Describe how each of these products are formed.

.....

.....

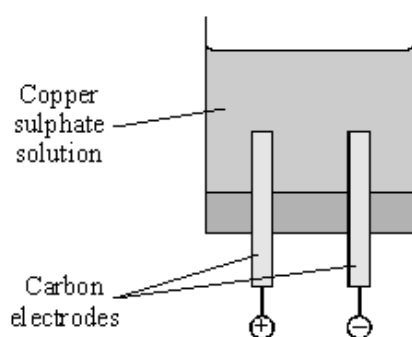
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(3)
(Total 15 marks)

Q5. An investigation into the *electrolyte* copper sulphate solution was carried out as shown.



(a) What does *electrolyte* mean?

.....

.....

.....

(2)

(b) These were the observations.

Negative electrode	solid formed
Positive electrode	gas given off

(i) Name the solid formed.

.....

(1)

(ii) Name the gas given off.

.....

(1)

(c) How could a sample of gas be collected at the positive electrode?

.....
.....

(2)

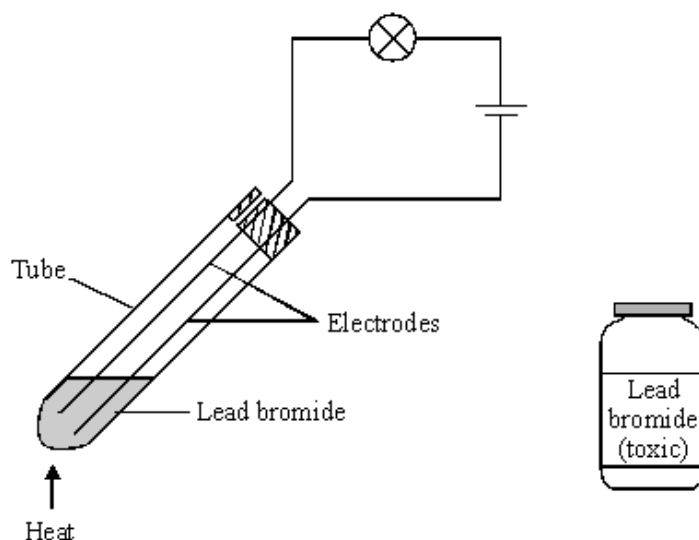
(d) Suggest why the blue colour of copper sulphate becomes paler during the investigation.

.....
.....

(2)

(Total 8 marks)

Q6. A student investigated the *electrolysis* of lead bromide.



Lead bromide was placed in the tube and the circuit was switched on. The light bulb did not light up.

The tube was heated and soon the bulb lit up. The observations are shown in the table.

Positive electrode	Negative electrode
red-brown gas	silver liquid

(a) What is meant by *electrolysis*?

.....

(2)

(b) Why did the lead bromide conduct electricity when the tube was heated?

.....

(1)

(c) Name the substances formed at the:

positive electrode;

negative electrode.

(2)

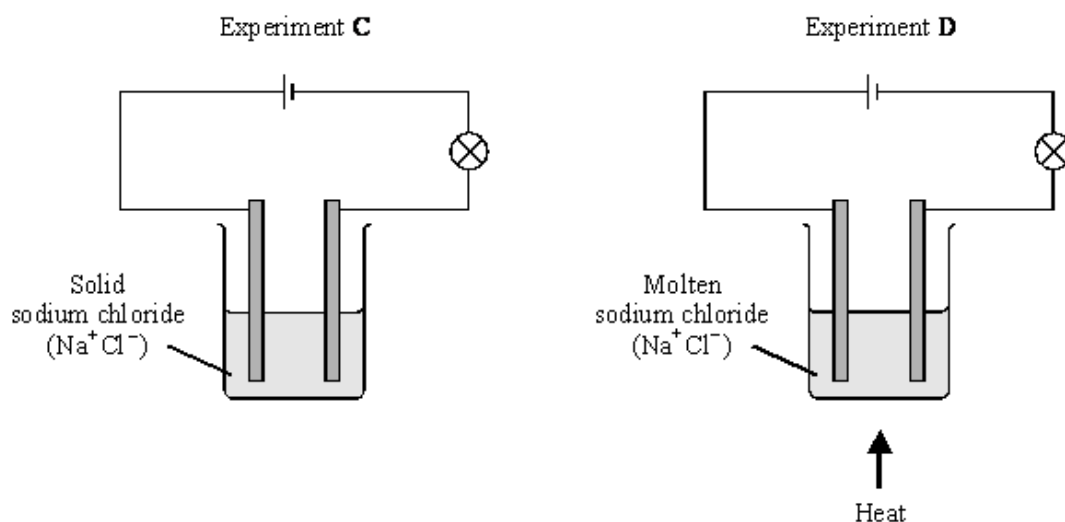
(d) Suggest **one** safety precaution that should be taken during this investigation.

.....

(1)

(Total 6 marks)

Q7. (a) Two experiments were set up as shown.



(i) Give **two** observations which would be seen only in Experiment **D**.

1

2

(2)

(ii) Explain why in Experiment **C** no changes would be seen.

.....

.....

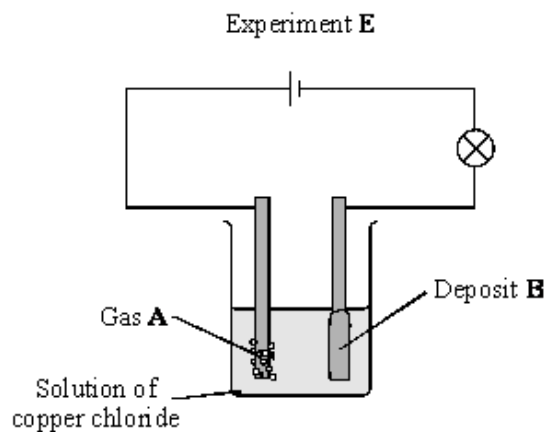
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.....

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(2)

- (b) Another *electrolysis* experiment used an aqueous solution of copper chloride.



- (i) What does *electrolysis* mean?

.....
.....
.....

(2)

- (ii) Name the gas **A** and the deposit **B**.

Gas **A**

Deposit **B**

(2)

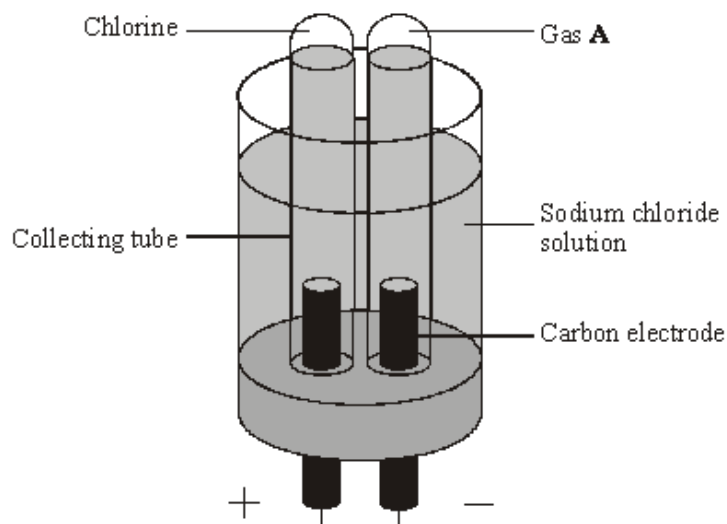
- (c) Give **one** industrial use of electrolysis.

.....

(1)

(Total 9 marks)

- Q8.** The electrolysis of sodium chloride solution is an important industrial process. The apparatus shown below can be used to show this electrolysis in the laboratory.



- (a) Name gas A. (1)
- (b) Chlorine is produced at the positive electrode. Describe and give the result of a chemical test to prove that the gas is chlorine.
.....
.....
.....
..... (2)
- (c) Chloride ions move to the positive electrode. Explain why.
.....
..... (1)
- (d) A small quantity of chlorine is added to drinking water. Explain why.
.....
..... (1)

- (e) The solution around the negative electrode becomes alkaline. Name the ion which makes the solution alkaline.

.....
.....

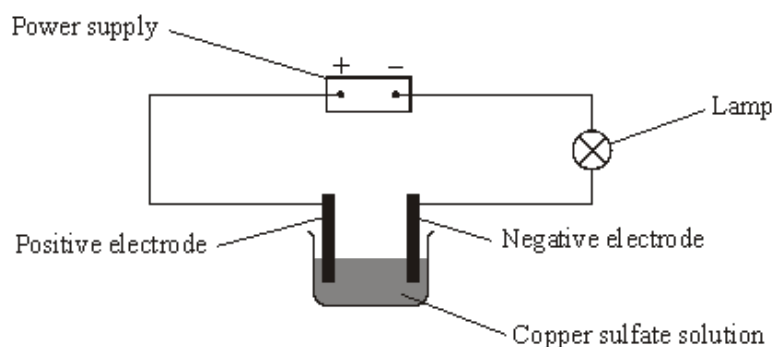
(1)
(Total 6 marks)

##

A student investigated the electrolysis of copper sulfate solution.
The student's method is shown below.

Two clean pieces of copper were weighed. One piece was used as the positive electrode and the other piece was used as the negative electrode.

The circuit was set up as shown in the diagram.



After the electrolysis, the pieces of copper were:

- washed with distilled water
- washed with propanone (a liquid with a lower boiling point than water)
- allowed to dry
- weighed.

- (a) Explain why the electrode would dry faster when washed with propanone instead of water.

.....
.....

(1)

- (b) The student's results are given in the table.

	Positive electrode	Negative electrode
mass of electrode before electrolysis, in grams	16.41	15.46
mass of electrode after electrolysis, in grams	16.10	15.75

The mass of the positive electrode decreased by 0.31 g.

- (i) What is the change in mass of the negative electrode? g

(1)

- (ii) The mass lost by the positive electrode should equal the mass gained by the negative electrode.

Suggest **two** reasons why the results were **not** as expected.

- 1
-
- 2
-

(2)

- (c) Describe and explain how electrolysis is used to make pure copper from a lump of impure copper.

.....

.....

.....

.....

.....

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.....

.....

(4)

(Total 8 marks)

Q10. The *electrolysis* of sodium chloride solution produces useful substances.

(a) Explain the meaning of *electrolysis*.

.....

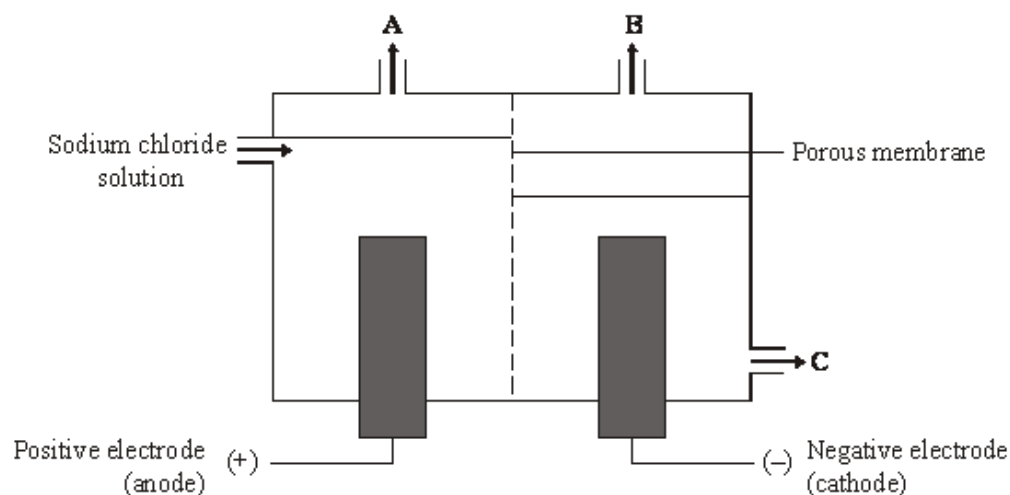
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(2)

(b) The diagram shows an apparatus used for the electrolysis of sodium chloride solution.



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The electrolysis produces two gases, chlorine and Gas A.

Name Gas A

(1)

(c) The electrodes used in this process can be made of graphite. Explain why graphite conducts electricity.

.....

.....

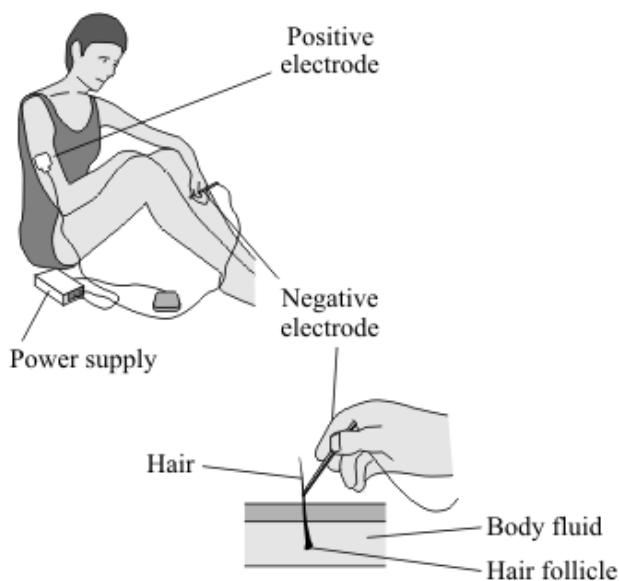
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(2)

(Total 5 marks)

Q11. Electrolysis can be used to remove unwanted hair from the skin.



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

The negative electrode is connected to the hair.

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

- (a) In this solution hydrogen ions move to the negative electrode.

Complete the sentence using **one** word from the box.

negative	neutral	positive
-----------------	----------------	-----------------

Hydrogen ions move to the negative electrode because they have a charge.

(1)

- (b) Draw a ring around the name of the gas produced at the positive electrode during the electrolysis of sodium chloride solution.

chlorine **hydrogen** **nitrogen**

(1)

- (c) The electrolysis of the sodium chloride solution forms a strong alkali around the hair follicle.

- (i) Complete the name of this strong alkali using **one** of the words from the box.

chlorine **hydrogen** **nitrogen**

The name of this strong alkali is sodium

(1)

(ii) Suggest how this strong alkali helps to remove the hair.

.....
.....

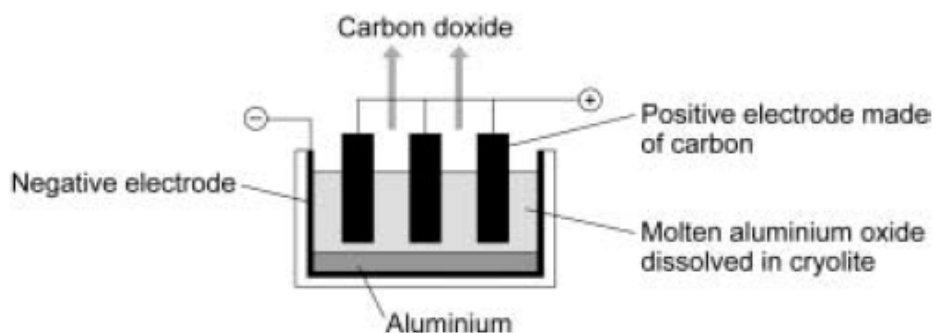
(1)
(Total 4 marks)

Q12. Read the information in the box and then answer the question.

Aluminium is made by the electrolysis of aluminium oxide.

Aluminium oxide is an ionic compound containing aluminium ions (Al^{3+}) and oxide ions (O^{2-}).

The diagram below shows the apparatus used to electrolyse aluminium oxide.



- (a) *In this question you will get marks on using good English, organising information clearly and using specialist terms correctly.*

Use information in the box and your knowledge and understanding of this process to answer this question.

Explain, as fully as you can, how aluminium and carbon dioxide are formed in this process.

.....

.....

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.....

(6)

- (b) Aluminium is a metal.

Explain why aluminium conducts electricity.

.....

.....

.....

.....

(2)

(Total 8 marks)

- Q13.** (a) Read the article about the mineral strontianite.

Strontianite is a mineral that was discovered near the village of Strontian in Scotland. At first some scientists thought that strontianite was barium carbonate.

Strontianite



In 1790, Professor Adair Crawford and William Cruikshank were both lecturers in chemistry and doctors of medicine. They investigated the properties of strontianite. They found that strontianite had different properties from barium carbonate. They concluded that strontianite contained a new element.

After this, other scientists also showed that strontianite and barium carbonate had different properties. Strontianite is now known to be strontium carbonate.

Rob Lavinsky, iRocks.com – CC-BY-SA-3.0 [CC-BY-SA-3.0], via Wikimedia Commons

- (i) What evidence did Crawford and Cruikshank use to prove that strontianite was **not** barium carbonate?

.....
.....

(1)

- (ii) Crawford and Cruikshank's conclusion was immediately accepted by other scientists. Suggest why.

.....
.....

(1)

- (iii) How was the reliability of the work of Crawford and Cruikshank confirmed?

.....
.....

(1)

- (b) One of Crawford and Cruikshank's experiments was repeated in a school laboratory.

Samples of strontianite and barium carbonate were reacted with hydrochloric acid to produce strontium chloride and barium chloride.

Solid strontium chloride and solid barium chloride were separately added to water. The change in temperature of the water was measured.

The results of the experiments are shown below.

	Experiment 1 Strontium chloride dissolved in water	Experiment 2 Barium chloride dissolved in water
Temperature of water before adding the chloride in °C	19.5	19.6
Temperature of water after adding the chloride in °C	21.2	17.5

- (i) State **one** variable that should be controlled to make it a fair test.

.....

(1)

- (ii) Which experiment, **1** or **2**, is endothermic?

Explain how you know.

Experiment because

.....

(1)

- (iii) The results prove that strontium chloride and barium chloride must be different even if all of the variables had not been controlled when they were dissolved. Explain why.

.....

(1)

- (c) In 1808, Humphry Davy was the first person to extract strontium. He did this by the electrolysis of molten strontium chloride. Strontium formed at the negative electrode.

Suggest why strontium ions are attracted to the negative electrode.

.....

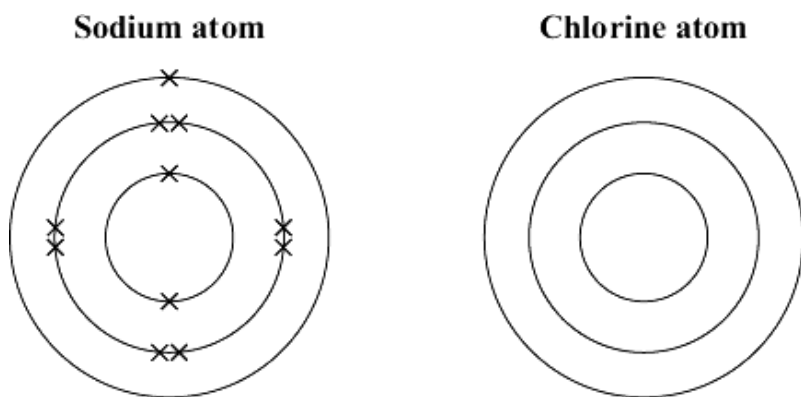
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(1)
(Total 7 marks)

Q14. Sodium chloride is a raw material.

- (a) The electronic structure of a sodium atom is shown below.

Complete the diagram for the electronic structure of a chlorine atom. A chlorine atom has 17 electrons.



(1)

- (b) When sodium and chlorine react to form sodium chloride they form sodium ions (Na^+) and chloride ions (Cl^-).

How does a sodium atom change into a sodium ion?

.....

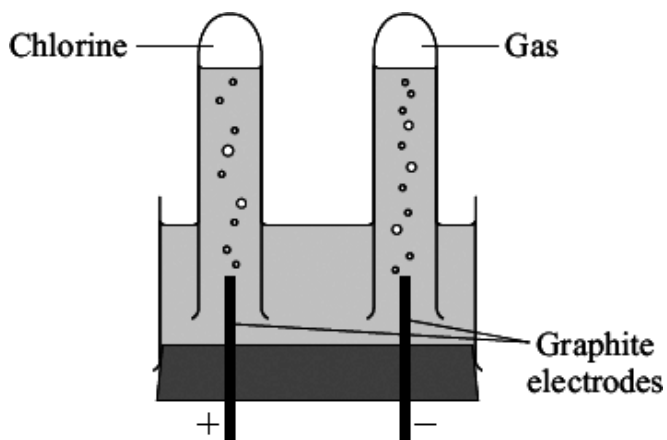
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(2)

- (c) The diagram shows apparatus used in a school laboratory for the electrolysis of sodium chloride solution.



The solution contains sodium ions (Na^+), chloride ions (Cl^-), hydrogen ions (H^+) and hydroxide ions (OH^-).

- (i) Why do chloride ions move to the positive electrode?

.....

(1)

- (ii) Name the gas formed at the negative electrode.

.....

(1)

- (d) Chlorine and chlorine compounds are used to bleach wood pulp that is used to make paper.

The article below is from a newspaper.

Local people have been protesting outside a paper factory. They say:
'We want the company to stop using chlorine compounds. Chlorine compounds release poisons into the environment. The company should use safer compounds.'

The company replied:
'Chlorine has been used safely for many years to treat drinking water. Only tiny amounts of chlorine are released, which cause no harm. Using other compounds will be more expensive and may put us out of business.'

- (i) Why are some local people worried about the use of chlorine compounds?

.....

.....

(1)

- (ii) Why might other local people want the company to continue to use chlorine compounds?

.....

.....

(1)

- (iii) It is decided to have an inquiry.
Why should this be done by independent scientists?

.....
.....

(1)
(Total 8 marks)

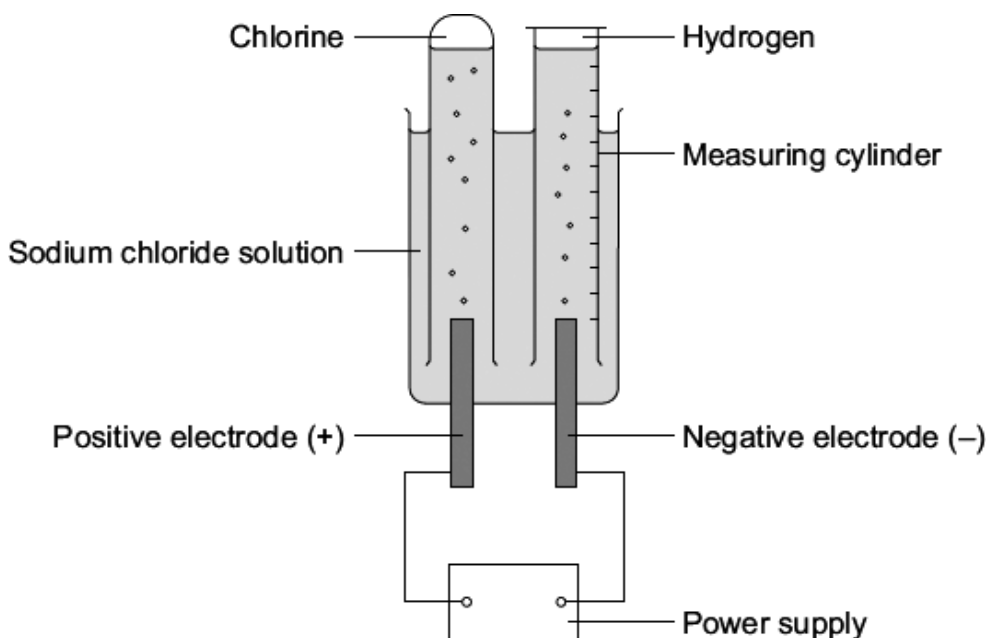
Q15. A student investigated the electrolysis of sodium chloride solution.

Five sodium chloride solutions were made. Each solution had a different concentration.

To make each solution the student:

- weighed the amount of sodium chloride needed
- dissolved it in water
- added more water until the total volume was one cubic decimetre (1 dm^3).

The solutions were placed one at a time in the apparatus shown below.



The student measured the volume of hydrogen gas produced in ten minutes.

The results are shown on the graph below.

- (a) Sodium chloride does not conduct electricity when it is solid.

Explain, in terms of ions, why sodium chloride solution conducts electricity.

.....
.....

(1)

- (b) Chlorine is produced at the positive electrode.

Why are chloride ions attracted to the positive electrode?

.....

(1)

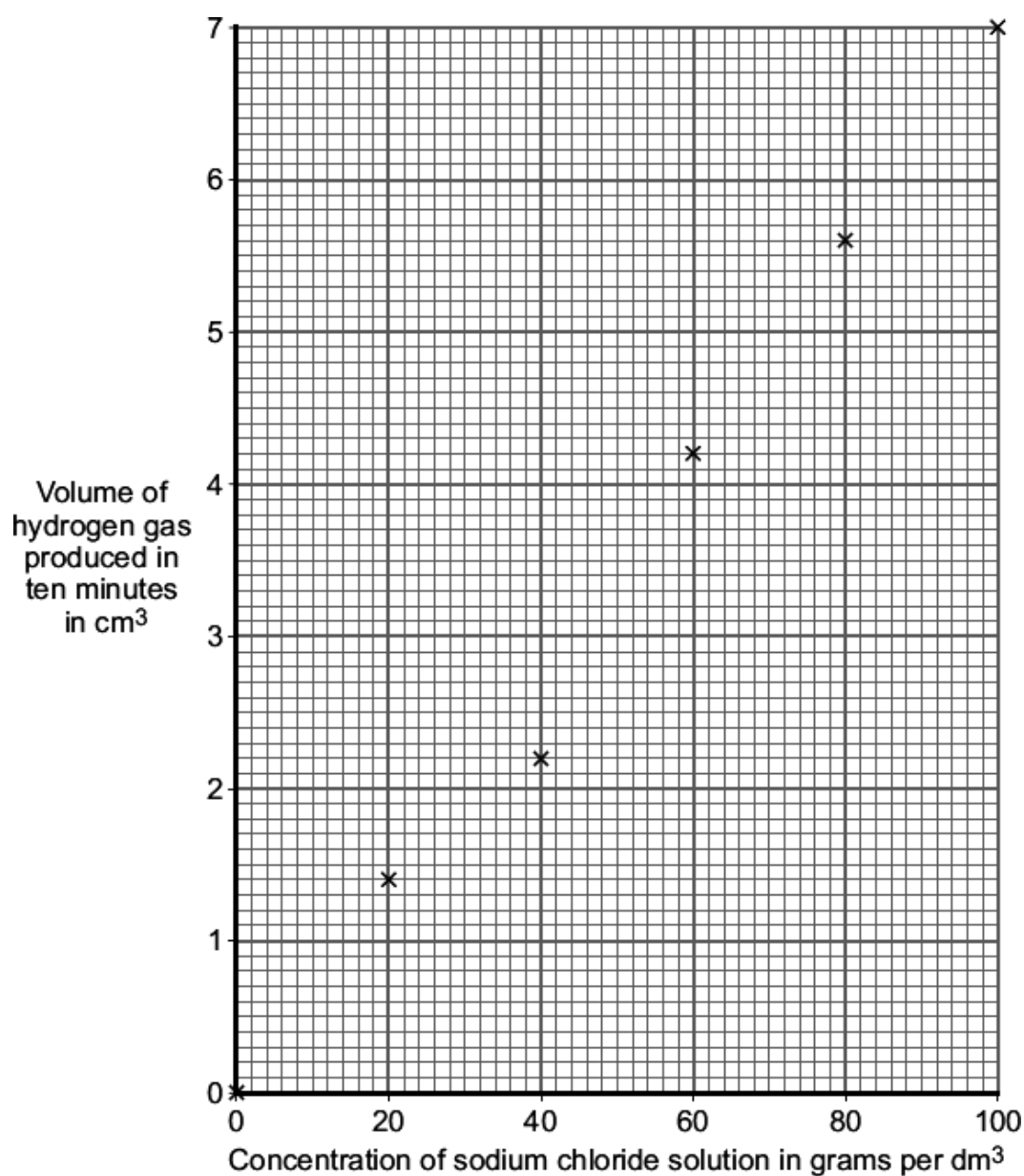
- (c) The solution left at the end of each experiment contains sodium hydroxide.

Draw a ring around **one** number which could be the pH of this solution.

2 5 7 13

(1)

- (d) The results for the experiment above are shown on the graph.



- (i) Draw a line of best fit on the graph.

(1)

- (ii) The result for one concentration is anomalous.
Which result is anomalous?

The result at concentration grams per dm³

(1)

- (iii) Suggest **two** possible causes of this anomalous result.

1

.....

2

.....

(2)

- (iv) Suggest how the student could check the reliability of the results.

.....

.....

(1)

- (iv) How did an increase in the concentration of the sodium chloride solution affect the volume of hydrogen gas produced in ten minutes?

.....

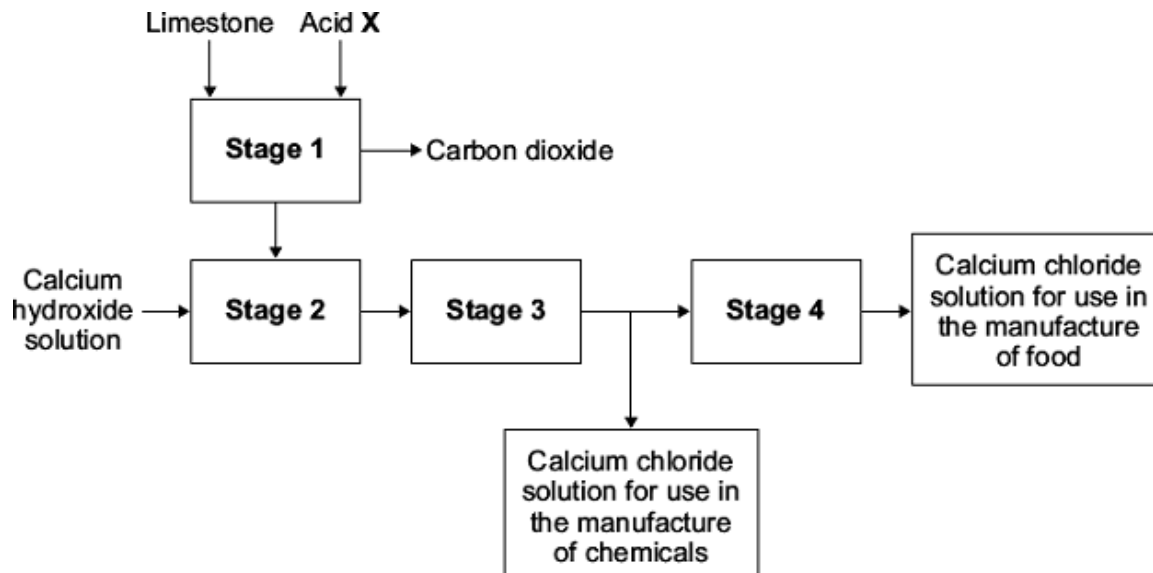
.....

(1)

(Total 9 marks)

Q16.

- (a) Calcium chloride is made from limestone. The limestone used contains mainly calcium carbonate and a small amount of magnesium carbonate.



- (i) In **stage 1** calcium carbonate reacts with acid **X** to form calcium chloride.

Name acid **X**.

.....

(1)

- (ii) **Stage 1** produces a concentrated solution of calcium chloride. The solution also contains magnesium chloride.

Calcium hydroxide solution is added to remove the magnesium chloride:



This is an example of a *precipitation* reaction.

What is the meaning of the term *precipitation* reaction?

.....

(1)

- (iii) The magnesium hydroxide can be separated from the calcium chloride solution.

State how.

.....

(1)

- (iv) Suggest why **stage 4** is needed.

.....
.....

(1)

- (v) Name a method that can be used to change calcium chloride solution into solid calcium chloride.

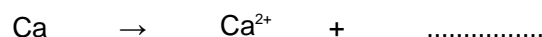
.....

(1)

- (b) Calcium chloride can also be made by reacting calcium with chlorine.

Calcium chloride is an ionic compound. It contains calcium ions (Ca^{2+}).

- (i) Complete the equation for the formation of calcium ions.



(1)

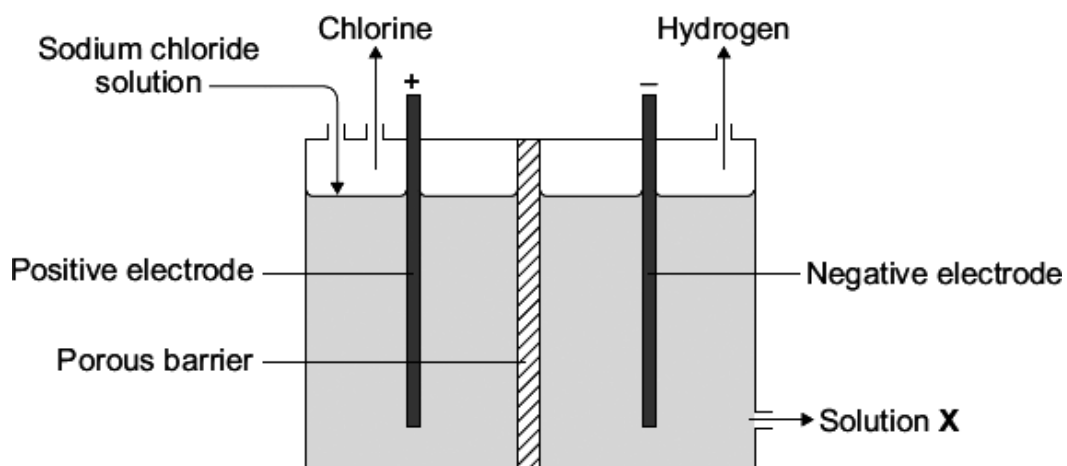
- (ii) Why can the formation of calcium ions from calcium atoms be described as oxidation?

.....
.....

(1)

(Total 7 marks)

Q17. The electrolysis of sodium chloride solution is an industrial process.



- (a) Why do chloride ions move to the positive electrode?

.....

(1)

- (b) Sodium chloride solution contains two types of positive ions, sodium ions (Na^+) and hydrogen ions (H^+).

Tick (✓) the reason why hydrogen is produced at the negative electrode and **not** sodium.

Reason	Tick (✓)
Hydrogen is a gas.	
Hydrogen is less reactive than sodium.	
Hydrogen is a non-metal.	
Hydrogen ions travel faster than sodium ions.	

(1)

- (c) Solution **X** is alkaline.

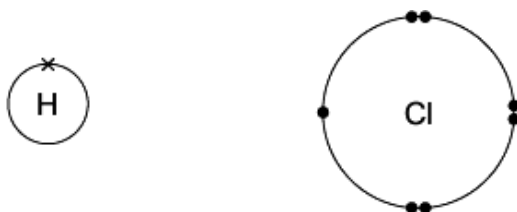
Which ion makes solution **X** alkaline?

.....

(1)

- (d) Electrolysis of sodium chloride solution produces hydrogen and chlorine. The hydrogen and chlorine can be used to make hydrogen chloride.

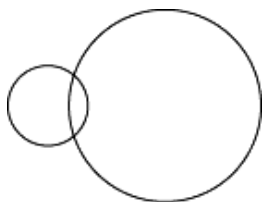
- (i) The diagrams show how the outer electrons are arranged in atoms of hydrogen and chlorine.



Hydrogen atom

Chlorine atom

Complete the diagram to show how the electrons are arranged in a molecule of hydrogen chloride (HCl).



(1)

- (ii) Name the type of bond between the hydrogen and the chlorine atoms in a molecule of hydrogen chloride.

.....

(1)

(iii) Some hydrogen chloride was bubbled into water. This made a solution with a pH of 1.

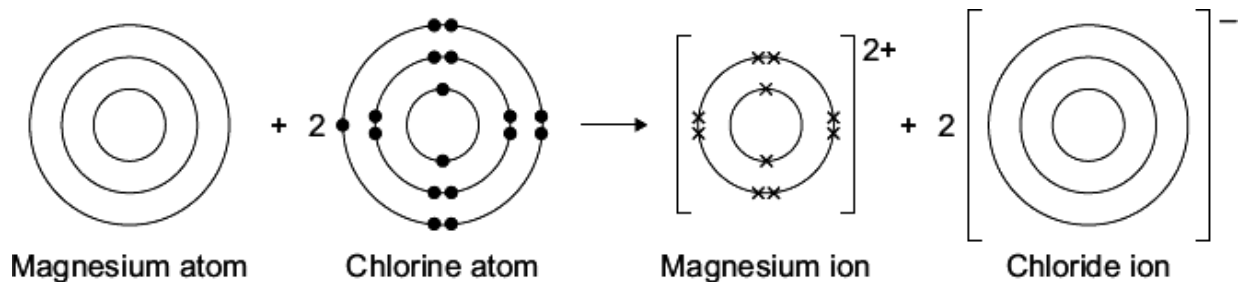
Which ion gave the solution a pH of 1?

.....

(1)
(Total 6 marks)

Q18. Magnesium reacts with chlorine to make the ionic compound called magnesium chloride.

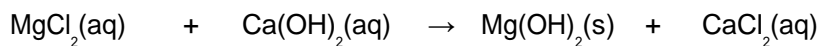
- (a) Complete the diagram by adding the electronic structures of the magnesium atom and the chloride ion.



(2)

- (b) Magnesium metal can be extracted from sea water.
Sea water contains magnesium chloride, MgCl_2

- (i) Calcium hydroxide, Ca(OH)_2 , is added to the sea water.
Magnesium hydroxide, Mg(OH)_2 , is produced.



Name a method that could be used to separate magnesium hydroxide from the solution.

.....

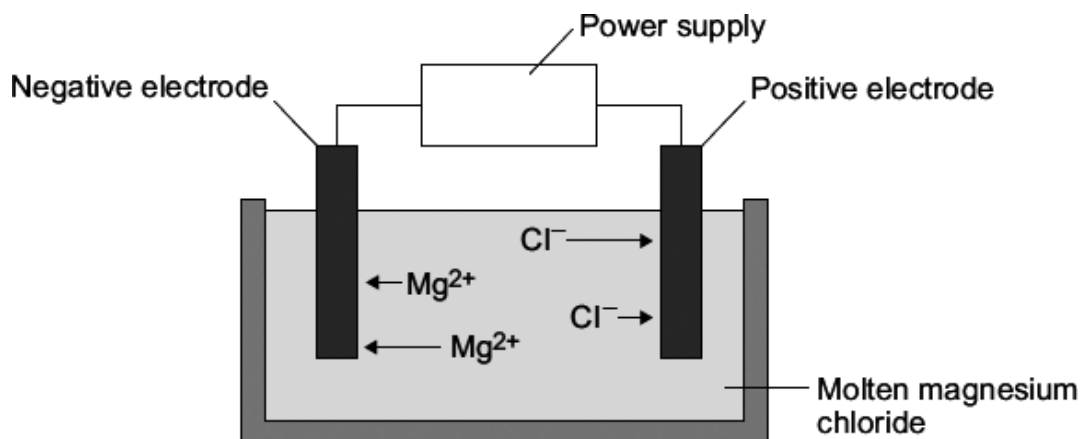
(1)

- (ii) An acid is then added to the magnesium hydroxide to make magnesium chloride.

Name this acid.

(1)

- (c) Electrolysis is used to extract magnesium metal from magnesium chloride.



- (i) Why must the magnesium chloride be molten?

.....
.....

(1)

- (ii) The equation shows the reaction that takes place at the positive electrode.



Why is this reaction an oxidation reaction?

.....

(1)

- (iii) Complete the equation for the reaction at the negative electrode.

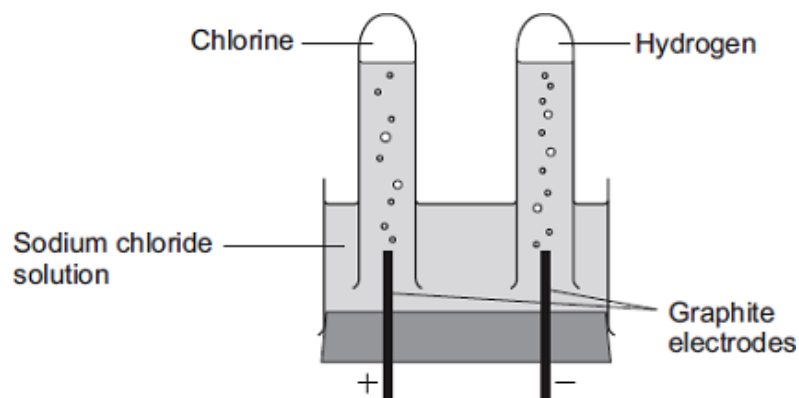


(1)

(Total 7 marks)

Q19. The electrolysis of sodium chloride solution is an industrial process.

The diagram shows the apparatus used in a school experiment.



(a) One of the products of the electrolysis of sodium chloride solution is hydrogen.

(i) Why do hydrogen ions move to the negative electrode?

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(1)

(ii) How does a hydrogen ion change into a hydrogen atom?

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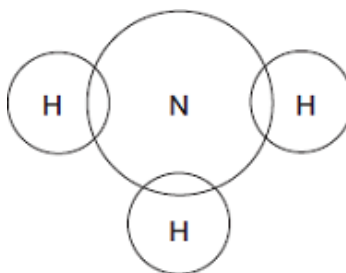
(1)

(b) Hydrogen is used to make ammonia (NH_3).

Complete the diagram to show the bonding in ammonia.

Use dots (•) and crosses (x) to show electrons.

Show only outer shell electrons.



(2)

- (c) The table shows the ions in sodium chloride solution.

Positive ions	Negative ions
hydrogen	chloride
sodium	hydroxide

In industry, some of the waste from the electrolysis of sodium chloride solution is alkaline and has to be neutralised.

- (i) Which ion makes the waste alkaline?

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(1)

- (ii) This waste must be neutralised.

Write the ionic equation for the neutralisation reaction.

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(1)

- (d) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

The electrolysis of sodium chloride solution also produces chlorine and sodium hydroxide.

In industry, the electrolysis of sodium chloride solution can be done in several types of electrolysis cell.

Some information about two different types of electrolysis cell is given below.

	Mercury cell	Membrane cell
Cost of construction	Expensive	Relatively cheap
Additional substances used	Mercury, which is recycled. Mercury is toxic so any traces of mercury must be removed from the waste	Membrane, which is made of a polymer. The membrane must be replaced every 3 years.
Amount of electricity used for each tonne of chlorine produced in kWh	3400	2950
Quality of chlorine produced	Pure	Needs to be liquefied and distilled to make it pure.
Quality of sodium hydroxide solution produced	50% concentration. Steam is used to concentrate the sodium hydroxide solution produced.	30% concentration. Steam is used to concentrate the sodium hydroxide solution produced.

Use the information and your knowledge and understanding to compare the environmental and economic advantages and disadvantages of these **two** types of electrolysis cell.

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(6)
(Total 12 marks)

