Electrolysis 1

These practice questions can be used by students and teachers and is suitable for GCSE AQA Chemistry topic Questions 8462

Level: GCSE AQA Chemistry 8462

Subject: Chemistry

Exam board: GCSE AQA

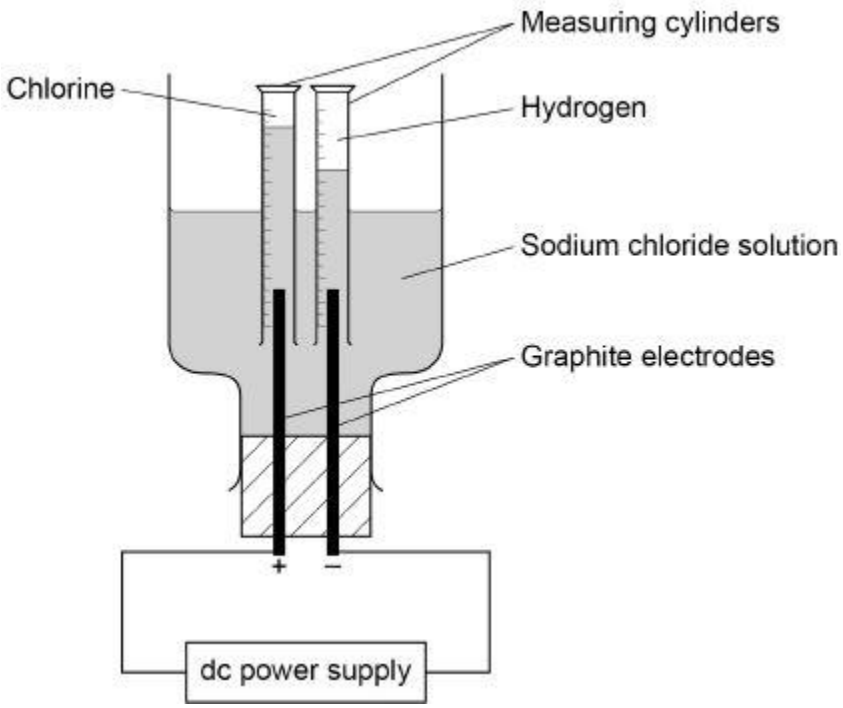
Topic: Electrolysis 1

Q1.

A student investigated the electrolysis of sodium chloride solution.

Figure 1 shows the apparatus.

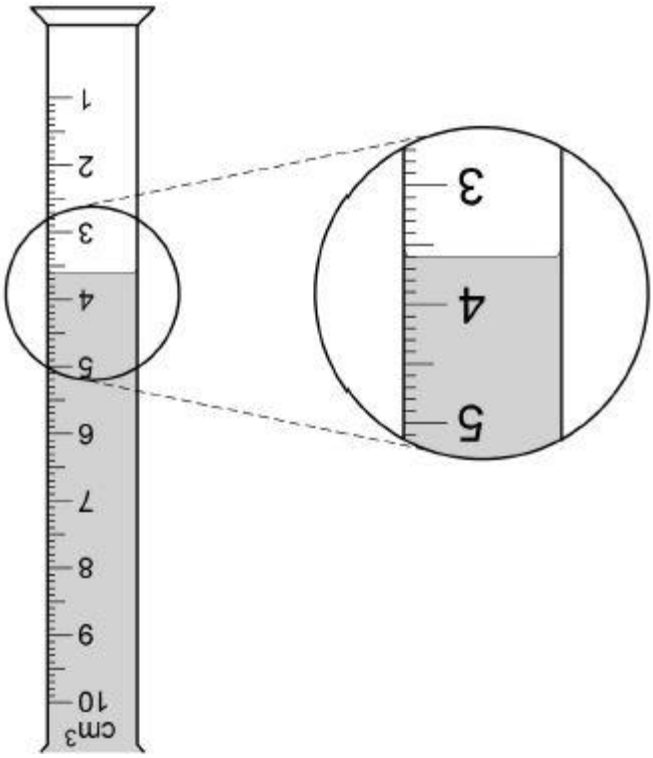
Figure 1



The student measured the volume of gas collected in each measuring cylinder every minute for 20 minutes.

(a) **Figure 2** shows the volume of hydrogen gas collected in the measuring cylinder after 8 minutes.

Figure 2



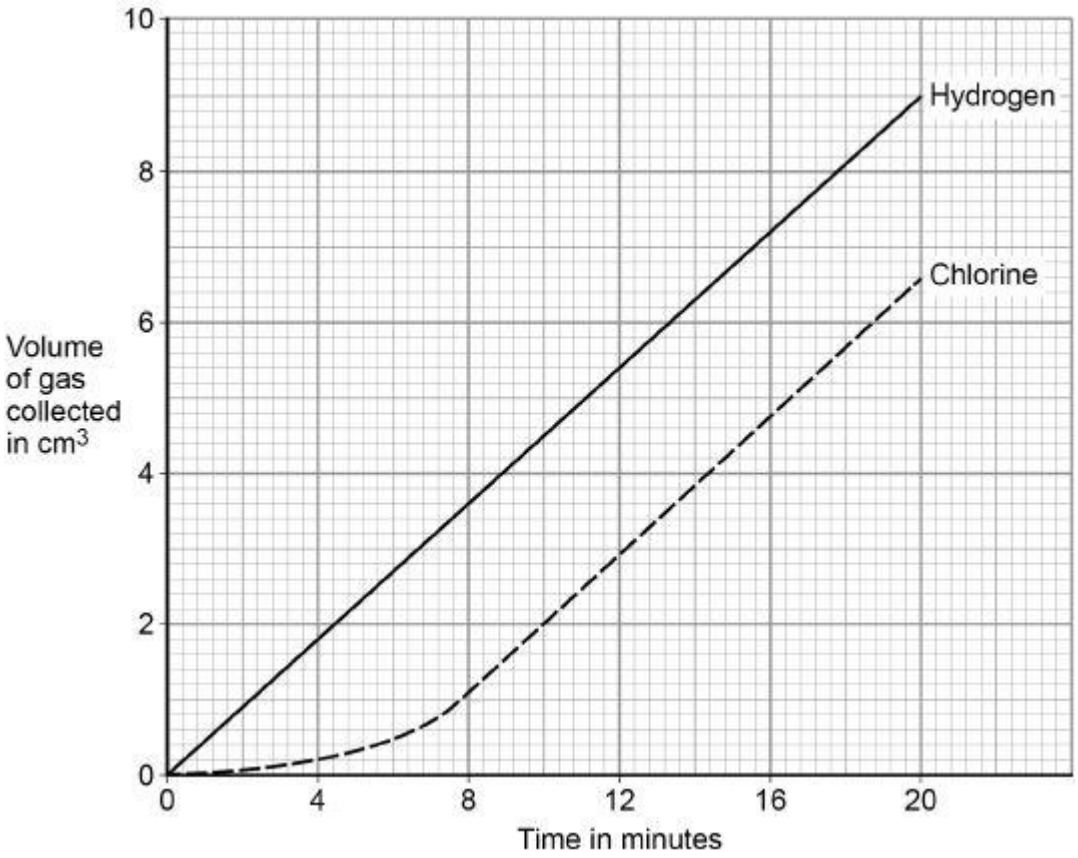
What is the volume of hydrogen gas collected?

Volume = _____ cm^3

(1)

Figure 3 shows the results of the investigation.

Figure 3



(b) Which of the lines on **Figure 3** show that the volume of gas collected is directly proportional to the time?

Tick **one** box.

Both lines ☐

Chlorine line only ☐

Hydrogen line only ☐

Neither line ☐

(1)

(c) Which of the lines on **Figure 3** show a positive correlation between the volume of gas collected and time?

Tick **one** box.

Both lines ☐

Chlorine line only ☐

Hydrogen line only ☐

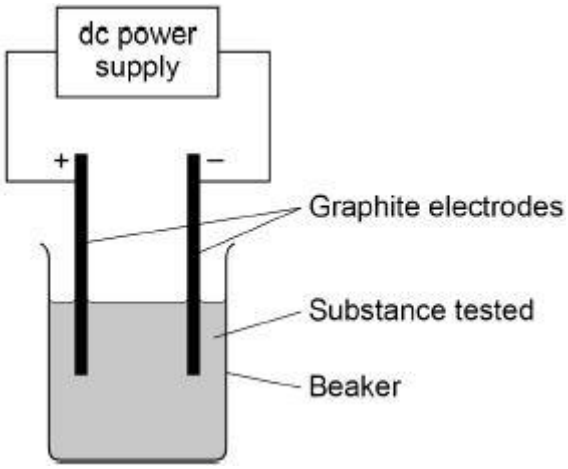
Neither line ☐

(1)

A teacher demonstrates the electrolysis of different substances using graphite electrodes.

Figure 4 shows the apparatus used.

Figure 4



(d) Why can graphite conduct electricity?

Tick **one** box.

Graphite exists in layers of atoms. ☐

Graphite has a giant structure. ☐

Graphite has a high melting point. ☐

Graphite has delocalised electrons. ☐

(1)

(e) The teacher demonstrates the electrolysis of:

- molten zinc chloride
- potassium bromide solution.

Complete the table below to predict the products.

Choose answers from the box.

chlorine	**bromine**	**hydrogen**	**oxygen**	**potassium**	**zinc**

Substance electrolysed	**Product at cathode (negative electrode)**	**Product at anode (positive electrode)**
Molten zinc chloride		
Potassium bromide solution		

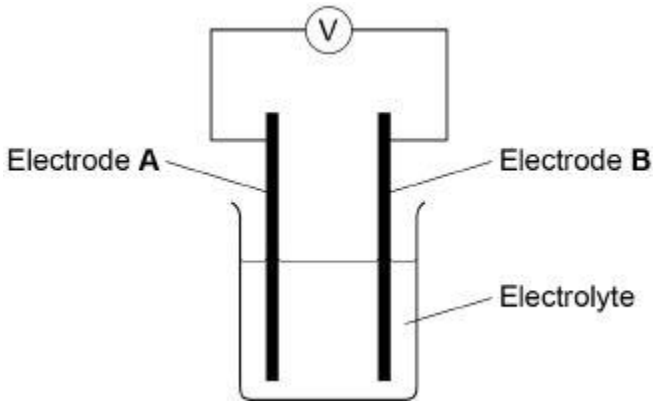
(4)

(Total 8 marks)

Q2.

Chemical reactions can produce electricity.

(a) The diagram below shows a simple cell.



Which of these combinations would not give a zero reading on the voltmeter in the diagram above?

Tick **one** box.

Electrode A	Electrode B	Electrolyte	
Copper	Copper	Sodium chloride solution	☐
Zinc	Zinc	Water	☐
Copper	Zinc	Sodium chloride solution	☐
Copper	Zinc	Water	☐

(1)

Alkaline batteries are non-rechargeable.

(b) Why do alkaline batteries eventually stop working?

_____

_____

(1)

(c) Why can alkaline batteries **not** be recharged?

_____

_____

(1)

Hydrogen fuel cells and rechargeable lithium-ion batteries can be used to power electric cars.

(d) Complete the balanced equation for the overall reaction in a hydrogen fuel cell.

_____ H_2 + _____ $\longrightarrow$ _____ H_2O

(2)

(e) The table below shows data about different ways to power electric cars.

	Hydrogen fuel cell	Rechargeable lithium-ion battery
Time taken to refuel or recharge in minutes	5	30
Distance travelled before refuelling or recharging in miles	Up to 415	Up to 240
Distance travelled per unit of energy in km	22	66
Cost of refuelling or recharging in £	50	3
Minimum cost of car in £	60 000	18 000

Evaluate the use of hydrogen fuel cells compared with rechargeable lithium-ion batteries to power electric cars.

Use the table above and your own knowledge.

(6)

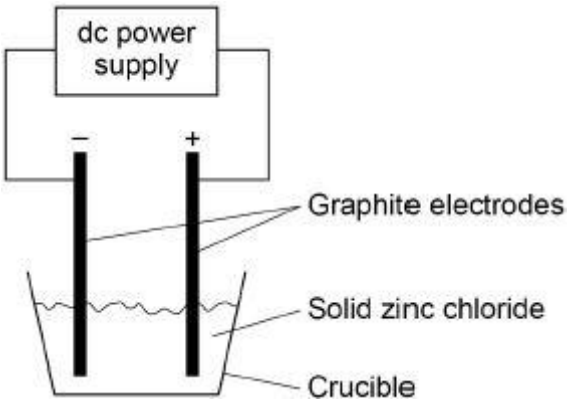
(Total 11 marks)

Q3.

A student investigated the electrolysis of different substances.

Figure 1 shows the apparatus.

Figure 1



(a) Explain why electrolysis would not take place in the apparatus shown in **Figure 1**.

(2)

(b) Explain why graphite conducts electricity.

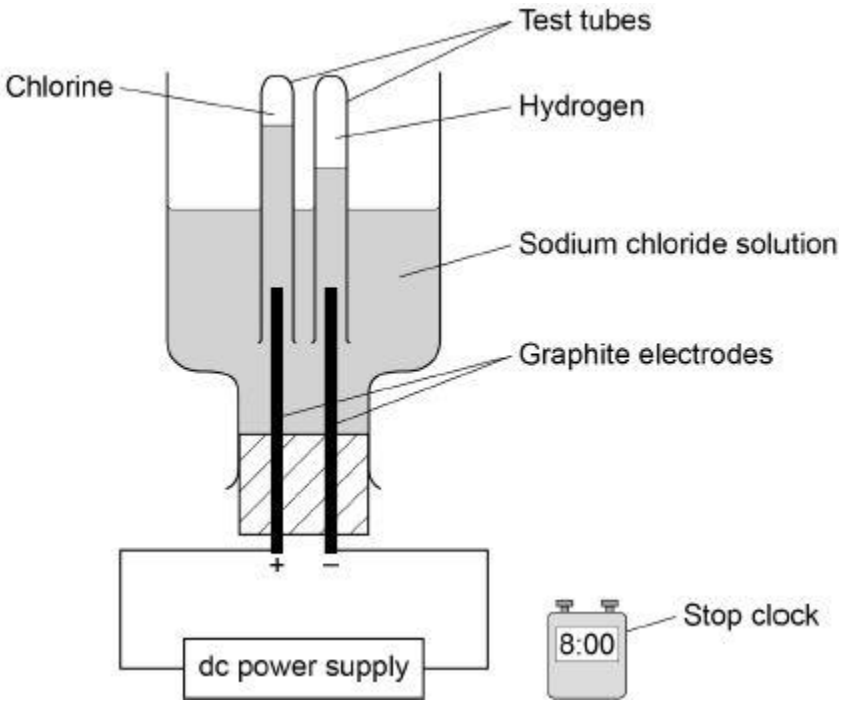
Answer in terms of the structure and bonding in graphite.

(3)

The student investigated how the volume of gases produced changes with time in the electrolysis of sodium chloride solution.

Figure 2 shows the apparatus.

Figure 2



(c) The student made an error in selecting the apparatus for this investigation.

How should the apparatus be changed?

Give **one** reason for your answer.

_____

_____

_____

_____

_____

_____

_____

_____

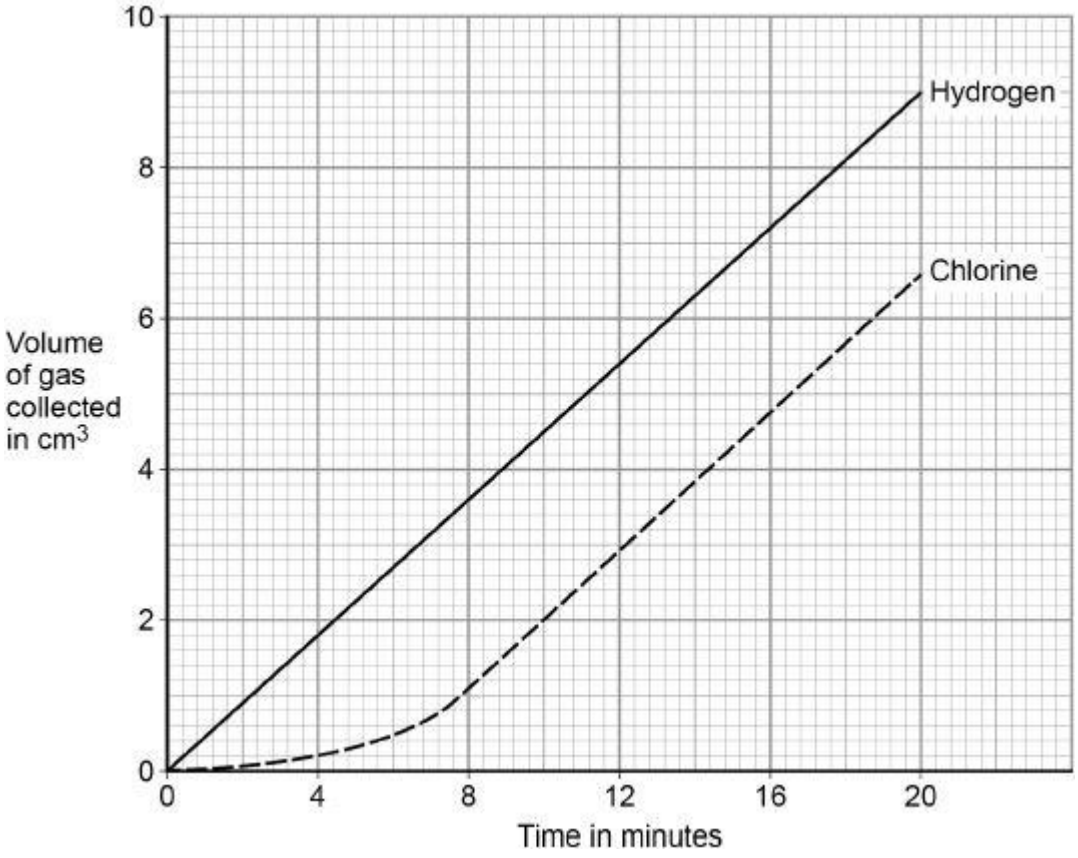
(2)

Another student used the correct apparatus.

This student measured the volumes of gases collected every minute for 20 minutes.

Figure 3 shows the student's results.

Figure 3



(d) Describe the trends shown in the results.

Use values from **Figure 3**.

(3)

(e) The number of moles of each gas produced at the electrodes is the same.

No gas escapes from the apparatus.

Suggest **one** reason for the difference in volume of each gas collected.

_____

_____

_____

_____

(1)

(f) Calculate the amount in moles of chlorine collected after 20 minutes.

Use **Figure 3**.

The volume of one mole of any gas at room temperature and pressure is 24.0 dm^3

Give your answer in standard form.

_____

_____

_____

_____

_____

_____

_____

_____

Moles of chlorine = _____ mol

(3)

(Total 14 marks)

Q4.

A student makes a hypothesis:

'When different salt solutions are electrolysed with inert electrodes, the product at the negative electrode is always a metal'.

(a) Describe how you would test this hypothesis in the laboratory.

You should:

- draw a labelled diagram of the apparatus
- give the independent variable
- describe what you would see at the negative electrode if the hypothesis is true.

Diagram

Independent variable

_____

_____

_____

Observation

_____

_____

_____

(5)

(b) The student's hypothesis is only partially correct.

Explain why the product at the negative electrode is not always a metal.

_____

_____

_____

_____

_____

_____

_____

_____

(2)

(c) Predict the product at the positive electrode in the electrolysis of:

- sodium chloride solution

- copper sulfate solution.

Sodium chloride solution

_____

Copper sulfate solution

_____

(2)

(Total 9 marks)

Q5.

This question is about halogens and their compounds.

The table below shows the boiling points and properties of some of the elements in Group 7 of the periodic table.

Element	**Boiling point in °C**	**Colour in aqueous solution**
Fluorine	−188	colourless
Chlorine	−35	pale green
Bromine	X	orange
Iodine	184	brown

(a) Why does iodine have a higher boiling point than chlorine?

Tick **one** box.

Iodine is ionic and chlorine is covalent ☐

Iodine is less reactive than chlorine ☐

The covalent bonds between iodine atoms are stronger ☐

The forces between iodine molecules are stronger ☐

(1)

(b) Predict the boiling point of bromine.

_____

(1)

(c) A redox reaction takes place when aqueous chlorine is added to potassium iodide solution.

The equation for this reaction is:

$$Cl_2(aq) + 2KI(aq) \rightarrow I_2(aq) + 2KCl(aq)$$

Look at table above.

What is the colour of the final solution in this reaction?

Tick **one** box.

Brown ☐

Orange ☐

Pale green ☐

Colourless ☐

(1)

(d) What is the ionic equation for the reaction of chlorine with potassium iodide?

Tick **one** box.

$Cl_2 + 2K \rightarrow 2KCl$ ☐

$2I^- + Cl_2 \rightarrow I_2 + 2Cl^-$ ☐

$I^- + Cl \rightarrow I + Cl^-$ ☐

$I^- + K^+ \rightarrow KI$ ☐

(1)

(e) Why does potassium iodide solution conduct electricity?

Tick **one** box.

It contains a metal ☐

It contains electrons which can move ☐

It contains ions which can move ☐

It contains water ☐

(1)

(f) What are the products of electrolysing potassium iodide solution?

Tick **one** box.

Product at cathode	**Product at anode**	
hydrogen	iodine	☐
hydrogen	oxygen	☐
potassium	iodine	☐
potassium	oxygen	☐

(1)

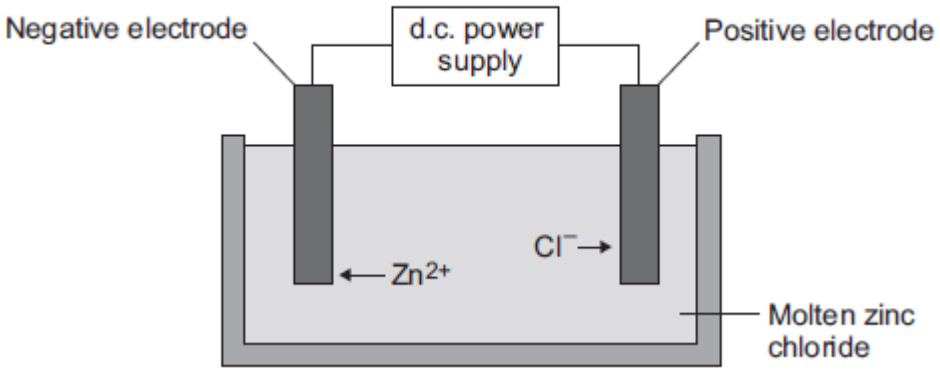
(Total 6 marks)

Q6.

This question is about zinc.

Figure 1 shows the electrolysis of molten zinc chloride.

Figure 1



(a) Zinc chloride is an ionic substance.
Complete the sentence.

When zinc chloride is molten, it will conduct _____ .

(1)

(b) Zinc ions move towards the negative electrode where they gain electrons to produce zinc.

(i) Name the product formed at the positive electrode.

_____

(1)

(ii) Explain why zinc ions move towards the negative electrode.

_____

_____

_____

_____

(2)

(iii) What type of reaction occurs when the zinc ions gain electrons?

Tick (✓) **one** box.

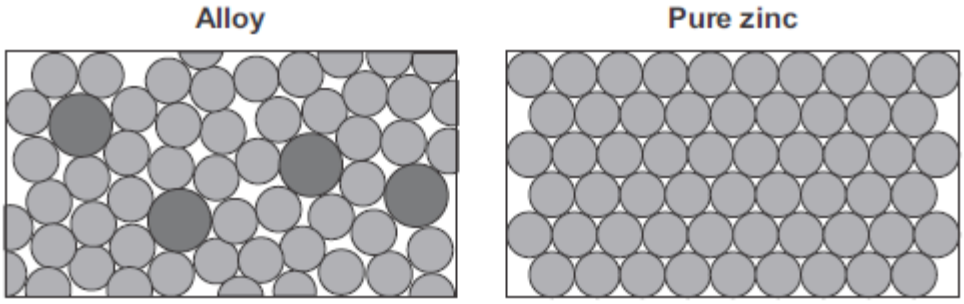
Neutralisation	☐
Oxidation	☐
Reduction	☐

(1)

(c) Zinc is mixed with copper to make an alloy.

(i) **Figure 2** shows the particles in the alloy and in pure zinc.

Figure 2



Use **Figure 2** to explain why the alloy is harder than pure zinc.

_____

_____

_____

_____

_____

_____

_____

_____

(2)

(ii) Alloys can be bent. Some alloys return to their original shape when heated.

What name is used for these alloys?

_____

_____

(1)

(Total 8 marks)

Q7.

This question is about magnesium and magnesium chloride.

(a) Magnesium chloride contains magnesium ions (Mg^{2+}) and chloride ions (Cl^{-}).

Describe, in terms of electrons, what happens when a magnesium atom reacts with chlorine atoms to produce magnesium chloride.

_____

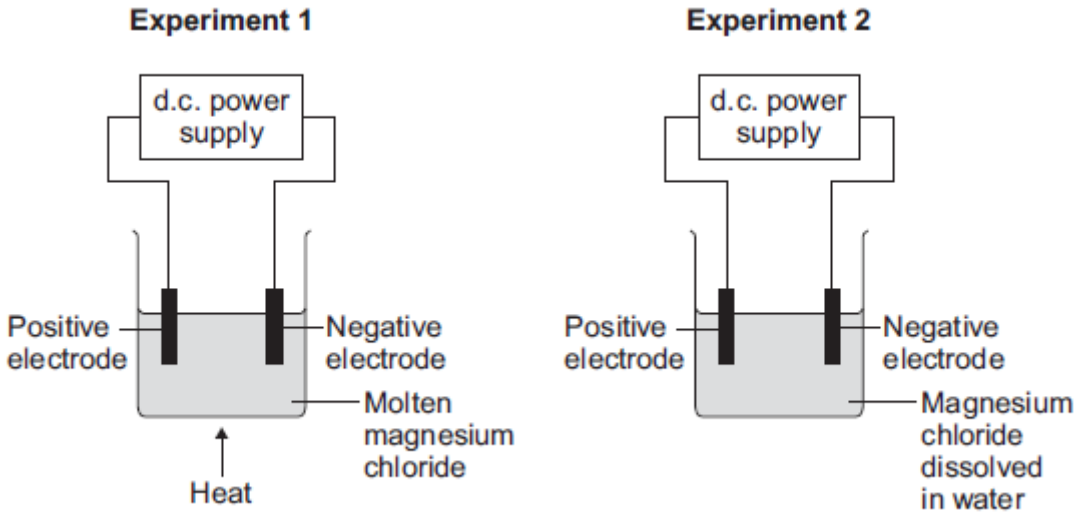
_____

_____

(4)

(b) Magnesium chloride can be electrolysed.

The diagram below shows two experiments for electrolysing magnesium chloride.



(i) Explain why magnesium chloride must be molten or dissolved in water to be electrolysed.

(2)

(ii) Explain how magnesium is produced at the negative electrode in **Experiment 1**.

(3)

(iii) In **Experiment 2** a gas is produced at the negative electrode.
Name the gas produced at the negative electrode.

(1)

(iv) Suggest why magnesium is **not** produced at the negative electrode in **Experiment 2**.

(1)

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

_____ Cl^- $\longrightarrow$ Cl_2 + _____

(1)

(c) Magnesium is a metal.

Explain why metals can be bent and shaped.

_____

_____

_____

_____

_____

_____

_____

_____

(2)

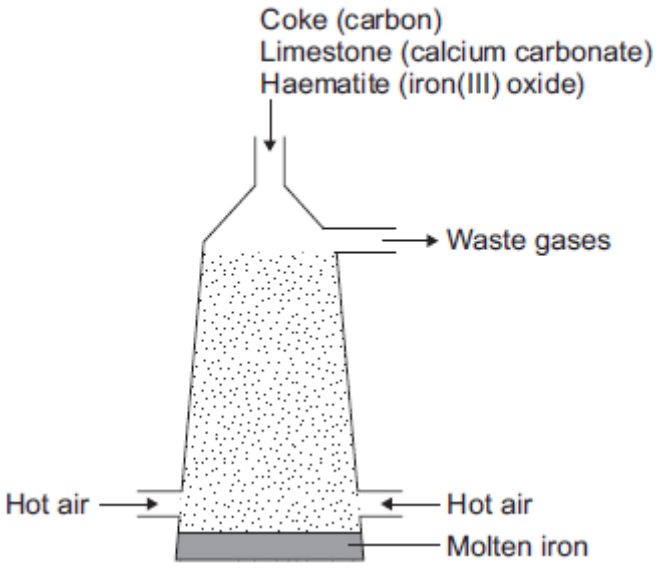
(Total 14 marks)

Q8.

This question is about iron and aluminium.

(a) Iron is extracted in a blast furnace. **Figure 1** is a diagram of a blast furnace.

Figure 1



(i) Calcium carbonate decomposes at high temperatures.

Complete the word equation for the decomposition of calcium carbonate.

calcium carbonate ⟶ _____ +

_____

(2)

(ii) Carbon burns to produce carbon dioxide.

The carbon dioxide produced reacts with more carbon to produce carbon monoxide.

Balance the equation.

$$C(s) + CO_2(g) \longrightarrow \_\_\_\_\_ CO(g)$$

(1)

(iii) Carbon monoxide reduces iron(III) oxide:

$$Fe_2O_3(s) + 3\ CO(g) \longrightarrow 2\ Fe(s) + 3\ CO_2(g)$$

Calculate the maximum mass of iron that can be produced from 300 tonnes of iron(III) oxide.

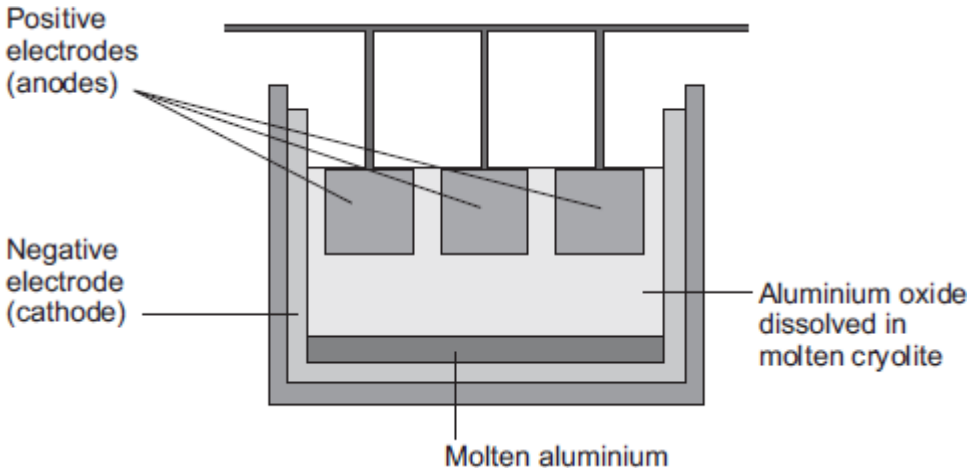
Relative atomic masses (A_r): O = 16; Fe = 56

Maximum mass = _____ tonnes

(3)

(b) Aluminium is extracted by electrolysis, as shown in **Figure 2**.

Figure 2



(i) Why can aluminium **not** be extracted by heating aluminium oxide with carbon?

_____

_____

_____

_____

(1)

(ii) Explain why aluminium forms at the negative electrode during electrolysis.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(3)

(iii) Explain how carbon dioxide forms at the positive electrodes during

electrolysis.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(3)

(Total 13 marks)

Q9.

This question is about electrolysis.

(a) Metal spoons can be coated with silver.
This is called electroplating.

Suggest **one** reason why spoons are electroplated.

_____

_____

_____

_____

(1)

(b) When sodium chloride solution is electrolysed the products are hydrogen and chlorine.

(i) What is made from chlorine?

Tick (✓) **one** box.

Bleach ☐

Fertiliser ☐

Soap ☐

(1)

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

Why is hydrogen produced at the negative electrode and **not** sodium?

Tick (✓) **one** box.

Hydrogen is a gas. ☐

Hydrogen is less reactive than sodium. ☐

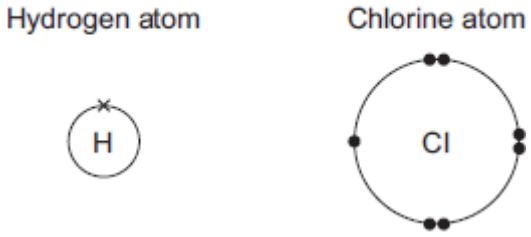
Hydrogen ions move faster than sodium ions. ☐

(1)

(iii) Hydrogen and chlorine can be used to produce hydrogen chloride.

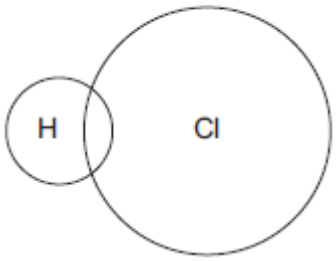
The diagrams in **Figure 1** show how the outer electrons are arranged in an atom of hydrogen and an atom of chlorine.

Figure 1



Complete **Figure 2** to show how the outer electrons are arranged in a molecule of hydrogen chloride (HCl).

Figure 2



(1)

(iv) What is the type of bond in a molecule of hydrogen chloride?

Tick (✓) **one** box.

Covalent ☐

Ionic ☐

Metallic ☐

(1)

(v) Why is hydrogen chloride a gas at room temperature (20 °C)?

Tick (✓) **two** boxes.

Hydrogen chloride has a low boiling point. ☐

Hydrogen chloride has a high melting point. ☐

Hydrogen chloride is made of simple molecules. ☐

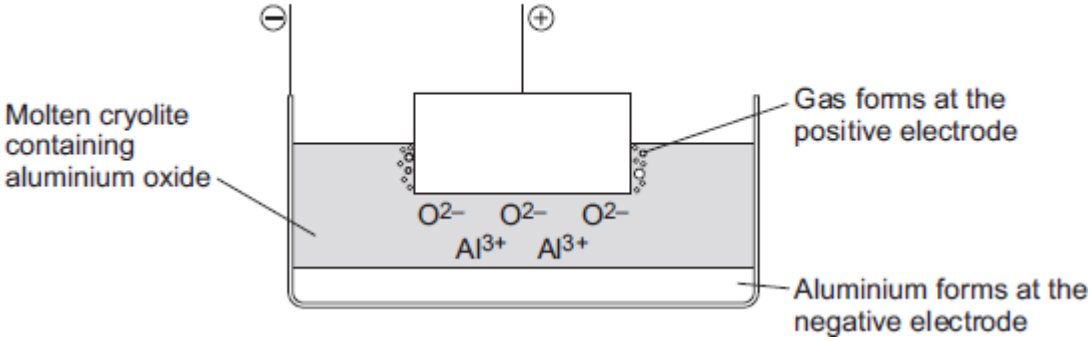
Hydrogen chloride does not conduct electricity. ☐

Hydrogen chloride has a giant structure. ☐

(2)

(c) Aluminium is produced by electrolysis of a molten mixture of aluminium oxide and cryolite.
This is shown in **Figure 3**.

Figure 3



(i) Name a gas produced at the positive electrode.

_____

(1)

(ii) Aluminium ions move to the negative electrode.

Explain why.

_____

_____

_____

_____

(2)

(iii) At the negative electrode, the aluminium ions gain electrons to produce aluminium.

What is this type of reaction called?

Tick (✓) **one** box.

Combustion ☐

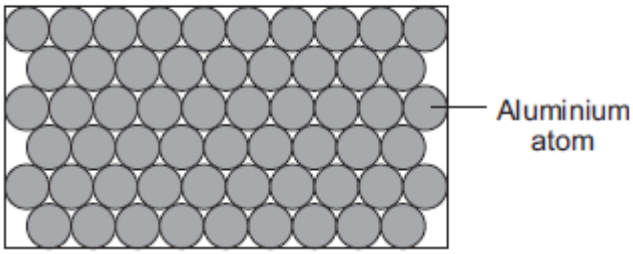
Oxidation ☐

Reduction ☐

(1)

(iv) Aluminium has layers of atoms, as shown in **Figure 4**.

Figure 4



Complete the sentence.

Metals can be bent and shaped because the layers of atoms can _____

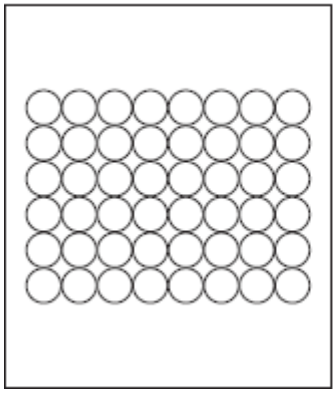
_____

(1)

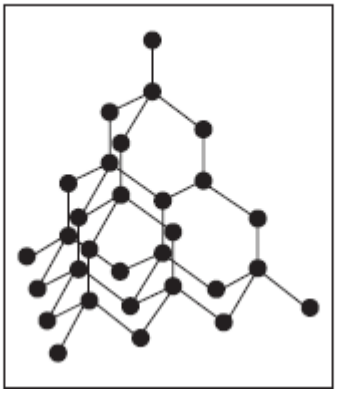
(d) Electrodes used in the production of aluminium are made from graphite.

(i) Which diagram, **A, B** or **C**, shows the structure of graphite?

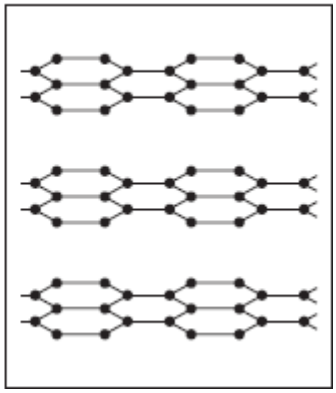
A



B



C



The structure of graphite is shown in diagram ☐

(1)

(ii) The temperature for the electrolysis is 950 °C.

Use the correct answer from the box to complete the sentence.

cross links	**a giant ionic lattice**	**strong covalent bonds**

The graphite does not melt at 950 °C because

graphite has _____ .

(1)

(Total 14 marks)

Q10.

This question is about metals and alloys.

(a) Explain how electricity is conducted in a metal.

To gain full marks you must include a description of the structure and bonding of a metal.

_____

_____

_____

_____

_____

_____

(4)

(b) Describe how the structure of an alloy is different from the structure of a pure metal.

(2)

(c) Alloys are used to make dental braces and coins.

(i) Nitinol is an alloy used in dental braces.

Why is Nitinol used in dental braces?

(1)

(ii) Suggest **one** reason why coins are not made of pure copper.

Do **not** give cost as a reason.

_____

(1)

(iii) Some coins are made from an alloy of aluminium.

Complete the sentence.

Aluminium is manufactured by the electrolysis of a molten mixture of cryolite

and _____ .

(1)

(iv) Banks keep coins in poly(ethene) bags. These bags are made from low density poly(ethene).

High density poly(ethene) can also be made from the same monomer.

How can the same reaction produce two different products?

_____

_____

_____

_____

(1)

(d) Give **two** reasons why instrumental methods of analysis are used to detect impurities in metals.

_____

_____

_____

_____

_____

_____

(1)

(Total 11 marks)

Q11.

This question is about sodium chloride and iodine.

(a) Describe the structure and bonding in sodium chloride.

_____

_____

(4)

(b) When sodium chloride solution is electrolysed, one product is chlorine.

Name the **two** other products from the electrolysis of sodium chloride solution.

(2)

(c) Many people do not have enough iodine in their diet.

Sodium chloride is added to many types of food. Some scientists recommend that sodium chloride should have a compound of iodine added.

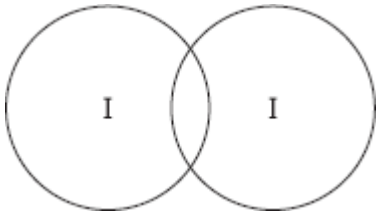
Give **one** ethical reason why a compound of iodine should **not** be added to sodium chloride used in food.

(1)

(d) The bonding in iodine is similar to the bonding in chlorine.

(i) Complete the diagram below to show the bonding in iodine.

Show the outer electrons only.



(2)

(ii) Explain why iodine has a low melting point.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(3)

(iii) Explain, in terms of particles, why liquid iodine does not conduct electricity.

_____

_____

_____

_____

_____

_____

_____

_____

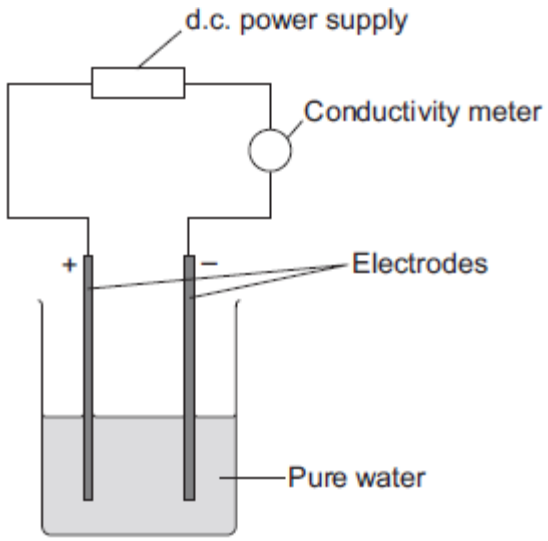
(2)

(Total 14 marks)

Q12.

A student investigated the conductivity of different concentrations of sodium chloride solution.
The student set the apparatus up as shown in **Figure 1**.

Figure 1



The student measured the conductivity of the pure water with a conductivity meter.

The reading on the conductivity meter was zero.

(a) The student:

- added sodium chloride solution one drop at a time
- stirred the solution
- recorded the reading on the conductivity meter.

The student's results are shown in the table below.

Number of drops of sodium chloride solution added	Relative conductivity of solution
0	0
1	100
2	120
3	310
4	400

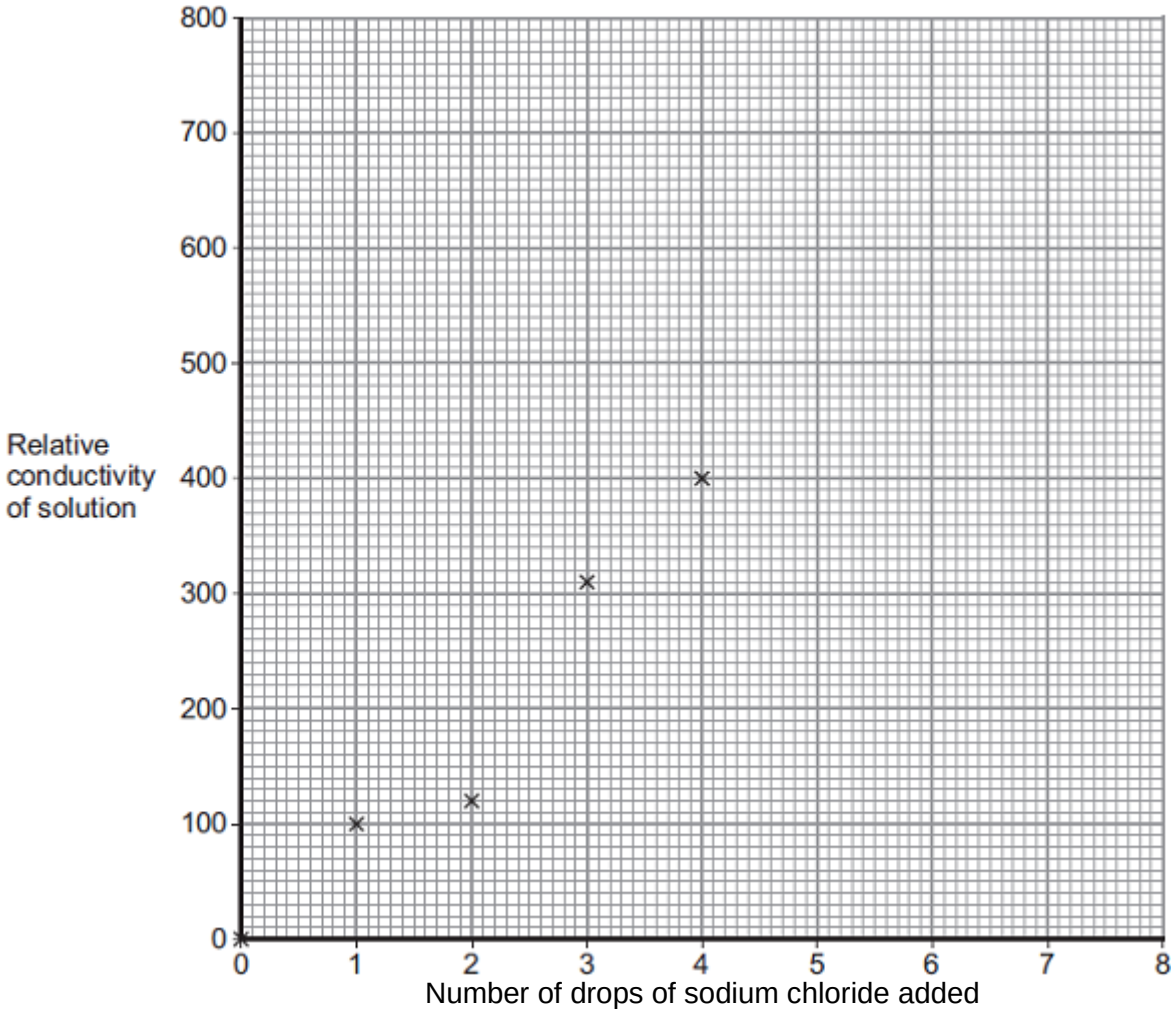
5	510
6	590
7	710
8	800

(i) The student plotted the results on the grid shown in **Figure 2**.

Plot the four remaining results.

Draw a line of best fit, ignoring the anomalous result.

Figure 2



(3)

(ii) One of the points is anomalous.

Suggest **one** error that the student may have made to cause the anomalous result.

_____

_____

(1)

(iii) The student wanted to compare the conductivity of sodium chloride solution with the conductivity of potassium chloride solution.

State **one** variable he should keep constant when measuring the conductivity of the two solutions.

_____

(1)

(b) (i) Explain, in terms of bonding, why pure water does **not** conduct electricity.

_____

_____

_____

_____

(2)

(ii) Explain why sodium chloride solution conducts electricity.

_____

_____

_____

_____

(2)

(iii) After he had added sodium chloride solution, the student noticed bubbles of gas at the negative electrode.

Complete the sentence.

The gas produced at the negative electrode is _____

(1)

(Total 10 marks)

Q13.

Use the periodic table and the information in the table below to help you to answer the questions.

The table shows part of an early version of the periodic table.

Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7
H						
Li	Be	B	C	N	O	F
Na	Mg	Al	Si	P	S	Cl

(a) Hydrogen was placed at the top of Group 1 in the early version of the periodic table.

The modern periodic table does **not** show hydrogen in Group 1.

(i) State one **similarity** between hydrogen and the elements in Group 1.

_____

_____

_____

_____

(1)

(ii) State one **difference** between hydrogen and the elements in Group 1.

_____

_____

_____

_____

(1)

(b) Fluorine, chlorine, bromine and iodine are in Group 7, the halogens.

The reactivity of the halogens decreases down the group.

Bromine reacts with a solution of potassium iodide to produce iodine.

$$Br_2 + 2KI \longrightarrow 2KBr + I_2$$

(i) In the reaction between bromine and potassium iodide, there is a reduction of bromine to bromide ions.

In terms of electrons, what is meant by reduction?

(1)

(ii) Complete the half equation for the oxidation of iodide ions to iodine molecules.

$$2I^- \longrightarrow$$

(2)

(iii) Explain, in terms of electronic structure, why fluorine is the most reactive element in Group 7.

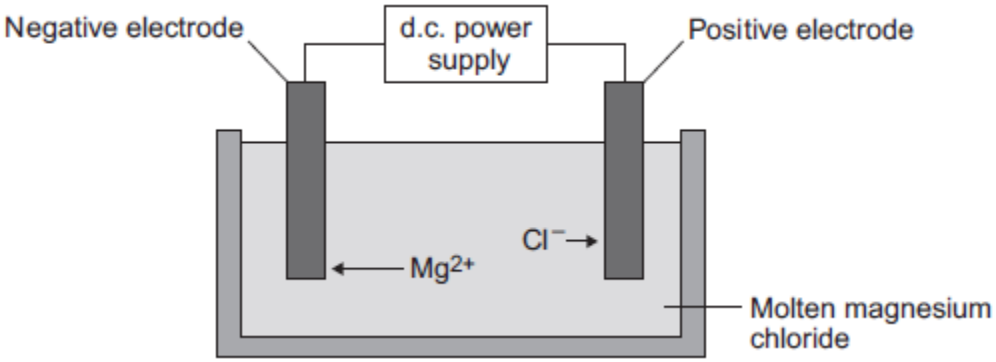
(3)

(Total 8 marks)

Q14.

Some students investigated reactions to produce magnesium.

(a) The students used electrolysis to produce magnesium from magnesium chloride, as shown in the figure below.



(i) Magnesium chloride contains magnesium ions and chloride ions.

Why does solid magnesium chloride **not** conduct electricity?

_____

_____

(1)

(ii) One of the products of the electrolysis of molten magnesium chloride is magnesium.

Name the other product.

_____

(1)

(iii) Why do magnesium ions (Mg^{2+}) move to the negative electrode?

_____

_____

(1)

(iv) At the negative electrode, the magnesium ions (Mg^{2+}) gain electrons to

become magnesium atoms.

How many electrons does each magnesium ion gain?

_____

(1)

(b) The students did the experiment four times and weighed the magnesium produced.

The table below shows their results.

Experiment	Mass of magnesium produced in grams
1	1.13
2	0.63
3	1.11
4	1.09

(i) There is an anomalous result.

Suggest **one** possible reason for the anomalous result.

_____

_____

_____

_____

(1)

(ii) Calculate the mean mass of magnesium produced, taking account of the anomalous result.

_____

_____

_____

_____

_____

_____

Mean mass = _____ g

(2)

(c) The formula of magnesium chloride is $MgCl_2$

The relative formula mass of magnesium chloride is 95.

The relative atomic mass of magnesium is 24.

(i) Use the equation to calculate the percentage mass of magnesium in magnesium chloride.

$$\text{Percentage mass of magnesium} = \frac{\text{mass of magnesium}}{\text{mass of magnesium chloride}} \times 100\%$$

_____

_____

_____

Percentage mass of magnesium in magnesium chloride = _____ %

(2)

(ii) Draw a ring around the relative mass of chlorine in $MgCl_2$

71 **95** **119**

(1)

(d) Magnesium is also produced from the reaction of magnesium oxide with silicon.

(i) The equation for the reaction is:

$$2\,MgO(s) + Si(s) \rightleftharpoons SiO_2(s) + 2\,Mg(s)$$

What is the meaning of this symbol $\rightleftharpoons$?

Draw a ring around the correct answer.

neutralisation reaction **precipitation reaction** **reversible reaction**

(1)

(ii) The forward reaction is endothermic.

Draw a ring around the correct answer to complete the sentence.

In an endothermic reaction the temperature of the surroundings | decreases.

increases.
stays the same.

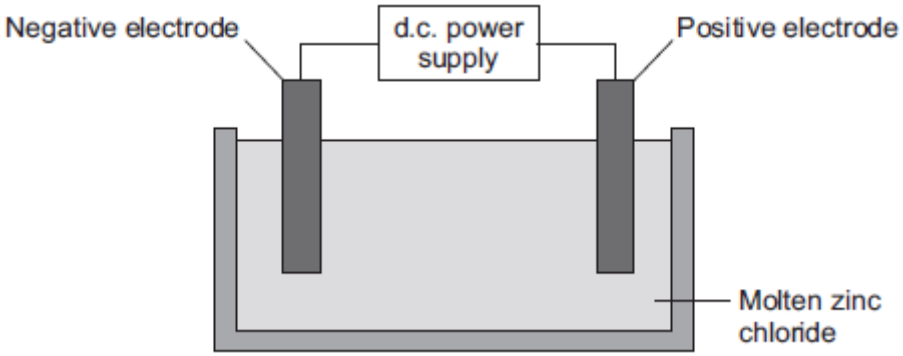
(1)

(Total 12 marks)

Q15.

This question is about zinc and magnesium.

Zinc is produced by electrolysis of molten zinc chloride, as shown in the figure below.



(a) (i) Why must the zinc chloride be molten for electrolysis?

_____

_____

(1)

(ii) Describe what happens at the negative electrode.

_____

_____

_____

_____

_____

_____

_____

(3)

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

_____ ⟶ Cl_2 + _____ e^-

(1)

(b) Magnesium can be produced from magnesium oxide.

The equation for the reaction is:

$$Si(s) + 2\,MgO(s) \longrightarrow SiO_2(s) + 2\,Mg(g)$$

(i) How can you tell from the equation that the reaction is done at a high temperature?

_____

_____

_____

_____

(1)

(ii) This reaction to produce magnesium from magnesium oxide is **endothermic**.

What is meant by an **endothermic** reaction?

_____

_____

_____

_____

(1)

(iii) A company made magnesium using this reaction.

Calculate the mass of magnesium oxide needed to produce 1.2 tonnes of magnesium.

Relative atomic masses (A_r): O = 16; Mg = 24

_____

_____

_____

_____

_____

_____

_____

_____

Mass of magnesium oxide needed = _____ tonnes

(3)

(iv) The company calculated that they would produce 1.2 tonnes of magnesium, but only 0.9 tonnes was produced.

Calculate the percentage yield.

_____

_____

_____

_____

Percentage yield = _____ %

(1)

(v) Give **one** reason why the calculated yield of magnesium might not be obtained.

_____

_____

_____

_____

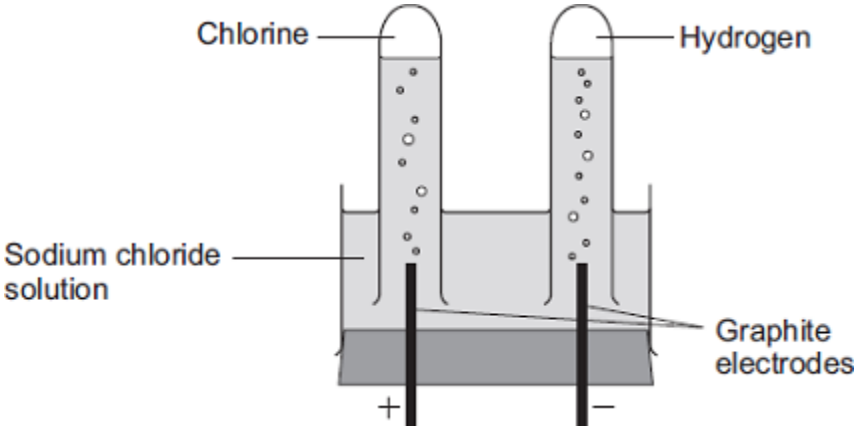
(1)

(Total 12 marks)

Q16.

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?

_____

_____

(1)

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

_____

_____

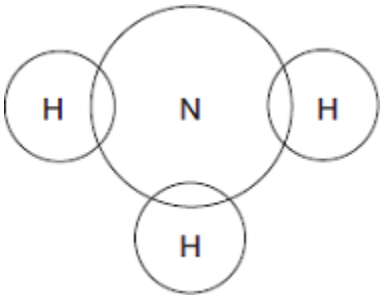
(1)

(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?

_____

(1)

(ii) This waste must be neutralised.

Write the ionic equation for the neutralisation reaction.

_____

(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	3400	2950

for each tonne of chlorine produced in kWh		
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.

_____

_____

_____

_____

_____

_____

_____

(6)

(Total 12 marks)

Q17.

Kelp is a seaweed.

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

(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

_____

_____

_____

_____

_____

_____

_____

_____

_____

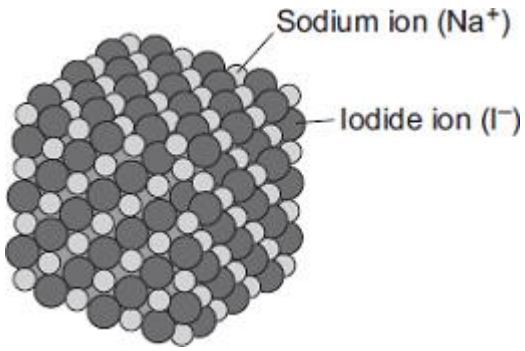
_____

_____

_____

(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.

$$\_\_\_\_\_I^- \rightarrow I_2 + \_\_\_\_\_e^-$$

(1)

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

Explain why.

_____

_____

_____

_____

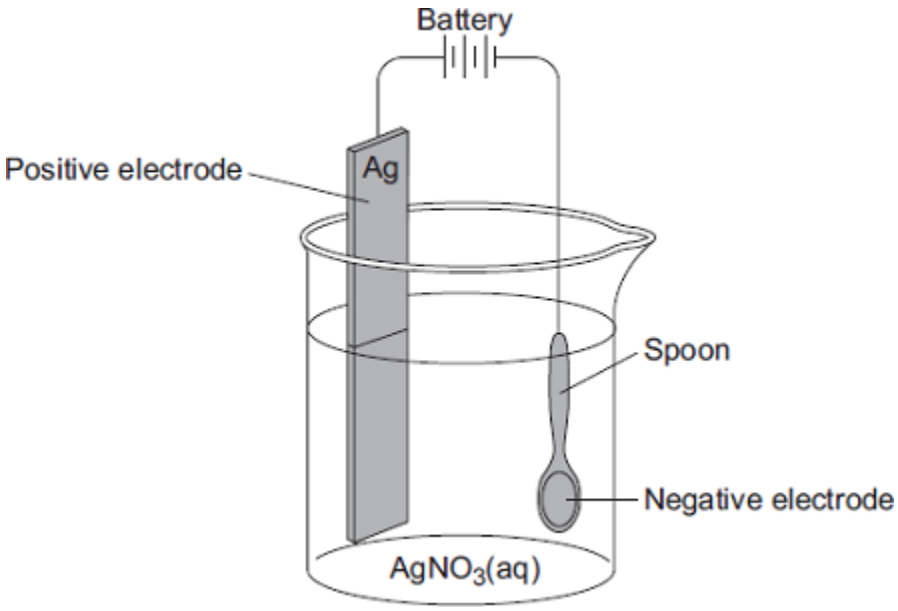
(2)

(Total 11 marks)

Q18.

Electroplating is used to coat a cheap metal with a thin layer of an expensive metal.

In the diagram a teaspoon made of nickel is being coated with silver.



Silver nitrate ($AgNO_3$) contains silver ions (Ag^+) and nitrate ions (NO_3^-).

(a) Solid silver nitrate, $AgNO_3(s)$, does **not** conduct electricity.

Choose the correct answer in the box to complete the sentence.

are too big	**cannot move**	**are too small**

Solid silver nitrate does **not** conduct electricity because the ions

_____

_____

_____

(1)

(b) Draw a ring around the correct answer to complete each sentence.

(i) Silver ions move to the negative electrode because

they have

no charge.
a negative charge.
a positive charge.

(1)

(ii) When silver ions reach the negative electrode they turn into silver

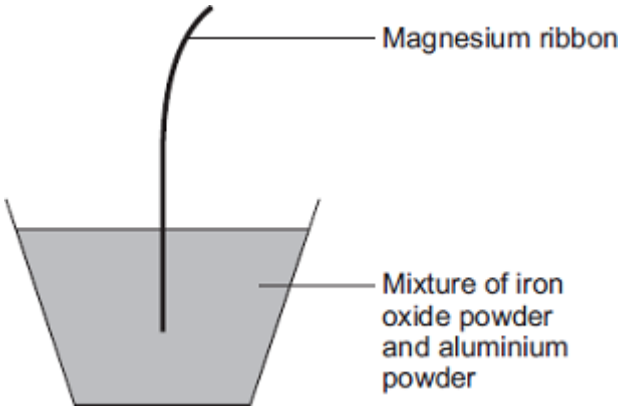
atoms.
compounds.
molecules.

(1)

(Total 3 marks)

Q19.

The diagram shows one way of producing iron.



Iron oxide reacts with aluminium to produce iron.

The symbol equation for the reaction is:

$Fe_2O_3 + 2\ Al \longrightarrow 2\ Fe + Al_2O_3$

(a) (i) Complete the word equation for this reaction.

iron oxide + aluminium ⟶ iron + _____

(1)

(ii) The magnesium ribbon is lit to start the reaction.

Why does the burning magnesium ribbon start the reaction?

_____

_____

_____

_____

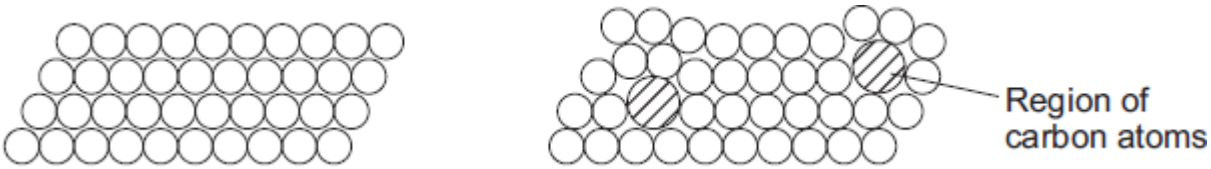
(1)

(b) In industry, iron is produced in the blast furnace when iron oxide is heated with carbon.

The iron from the blast furnace is called cast iron.

Cast iron contains carbon.

The diagrams show the structure of pure iron and cast iron.



Pure iron

Cast iron

Use the diagrams to help you answer the questions.

(i) Draw a ring around the correct answer to complete the sentence.

Pure iron is an element because pure iron

contains only one sort of atom.
is magnetic.
is a metal.

(1)

(ii) Suggest why cast iron is harder than pure iron.

_____

_____

_____

_____

_____

_____

_____

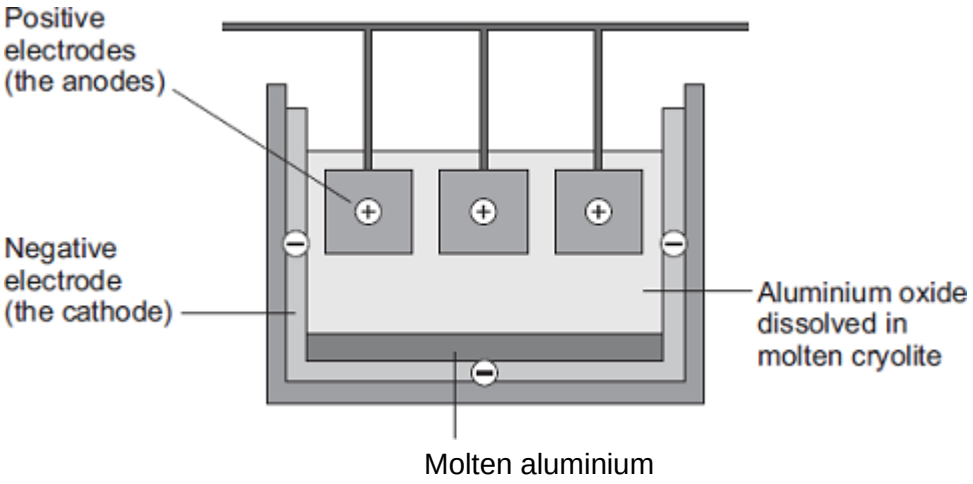
_____

_____

_____

(2)

(c) Aluminium is extracted by electrolysis using the ionic compound aluminium oxide.



(i) Aluminium **cannot** be extracted by heating aluminium oxide with carbon.

Suggest why.

_____

_____

_____

_____

(1)

(ii) Why is aluminium oxide dissolved in molten cryolite?

_____

_____

_____

_____

(1)

(iii) Aluminium metal is produced at the negative electrode (cathode).

Complete the half equation for the process.

Al^{3+} + _____ e^- ⟶ Al

(1)

(iv) Use the half equation to state why Al^{3+} ions are reduced.

_____

_____

(1)

(v) Explain why the positive electrodes (anodes) burn away.

Use your knowledge of the products of electrolysis to help you.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 13 marks)

Q20.

Metals are extracted from their ores.

Many copper ores contain only 2% of copper compounds.

(a) Copper is now extracted from ores containing a low percentage of copper compounds.

Suggest **two** reasons why.

_____

_____

_____

_____

_____

_____

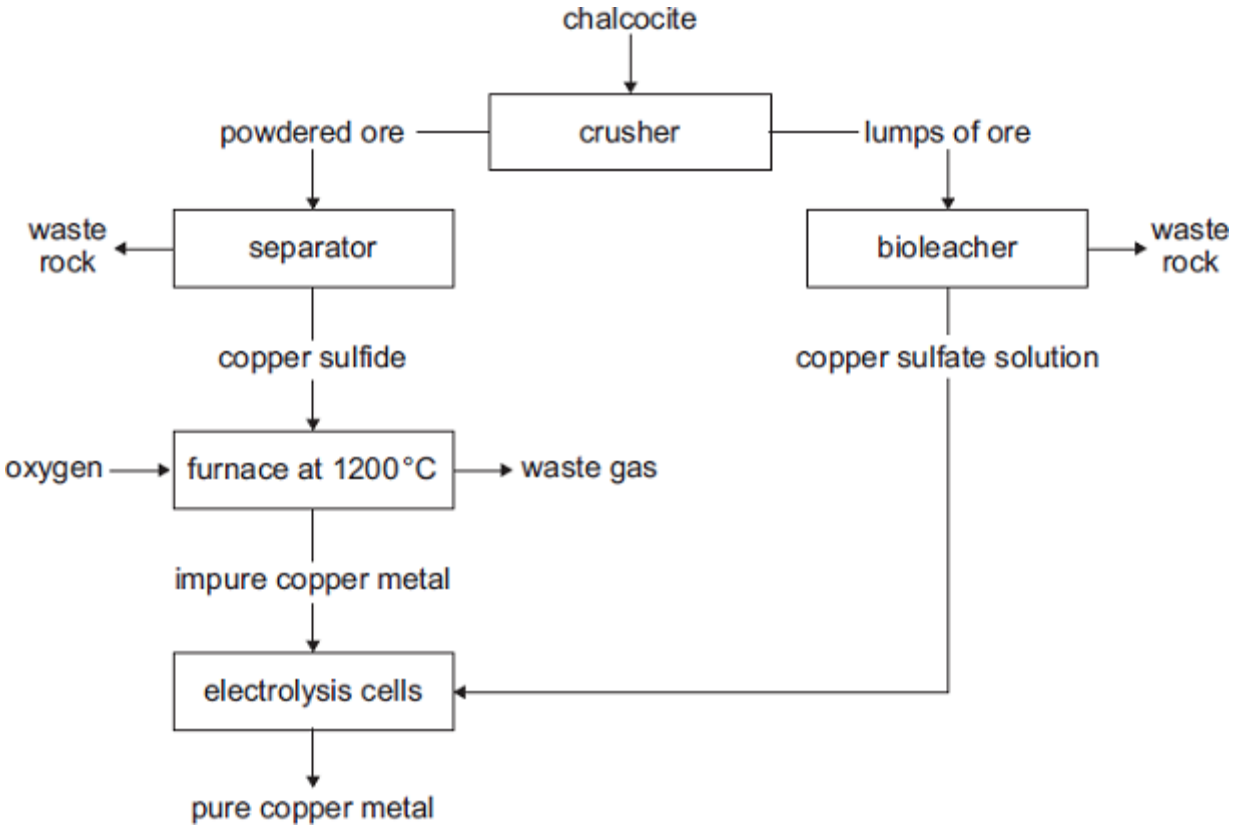
_____

_____

(2)

(b) Chalcocite, an ore of copper, contains copper sulfide.

The flow diagram shows how copper metal is extracted from chalcocite.



(i) Suggest **one** reason why it is difficult to dispose of the waste rock.

(1)

(ii) The reaction in the furnace could cause environmental pollution.
Explain how.

(2)

(iii) The extraction of pure copper is expensive.
Give **one** reason why.

(1)

(iv) Pure copper is produced by electrolysis of copper sulfate solution.

Which electrode do the copper ions move towards?
Give a reason for your answer.

(2)

(v) Large areas of land are contaminated with copper compounds. Phytomining can be used to remove these copper compounds from the land.

What is used in phytomining to remove copper compounds from the land?

_____

_____

(1)

(Total 9 marks)

Q21.

Humphrey Davy was a professor of chemistry.

In 1807 Humphrey Davy did an electrolysis experiment to produce potassium.

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

Draw a ring around the correct answer to complete each sentence.

Humphrey Davy's experiment to produce this new element was quickly

accepted by other scientists because he

had a lot of money.
had a lot of staff to help.
was well qualified.

(1)

(ii) Other scientists were able to repeat Davy's experiment.

Draw a ring around the correct answer to complete each sentence.

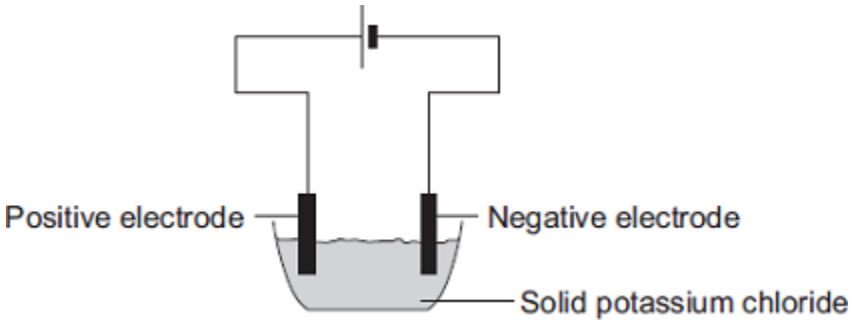
Being able to repeat Davy's experiment is important because

other scientists can

check the results of the experiment.
see if the experiment is safe.
take the credit for the discovery.

(1)

(b) A student tried to electrolyse potassium chloride.



Potassium chloride contains potassium ions (K^+) and chloride ions (Cl^-).

(i) The student found that solid potassium chloride does not conduct electricity.

Use the correct answer from the box to complete the sentence.

are too big	cannot move	have no charge

Solid potassium chloride does not conduct electricity because

the ions _____ .

(1)

(ii) What could the student do to the potassium chloride to make it conduct electricity?

_____

_____

(1)

(iii) During electrolysis why do potassium ions move to the negative electrode?

_____

_____

(1)

(iv) Draw a ring around the correct answer to complete the sentence.

When the potassium ions reach the negative electrode

they turn into potassium

atoms.
electrodes.
molecules.

(1)

(Total 6 marks)

Q22.

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.

_____

_____

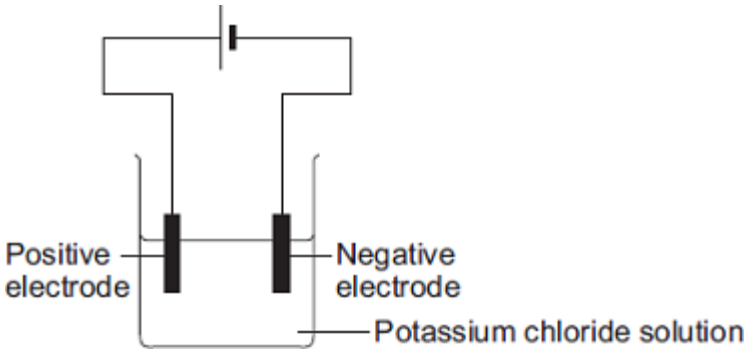
_____

_____

(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.

_____
_____

_____

_____

_____

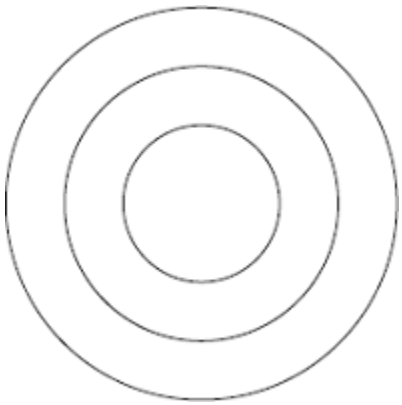
(2)

(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)

Q23.

Cans for food and drinks are made from steel or aluminium.
The main metal in steel is iron.

(a) Reacting iron oxide with carbon produces iron.

Draw a ring around the correct answer to complete the sentence.

The reaction to produce iron from iron oxide is

decomposition.
oxidation.
reduction.

(1)

(b) Aluminium cannot be produced by reacting aluminium oxide with carbon.

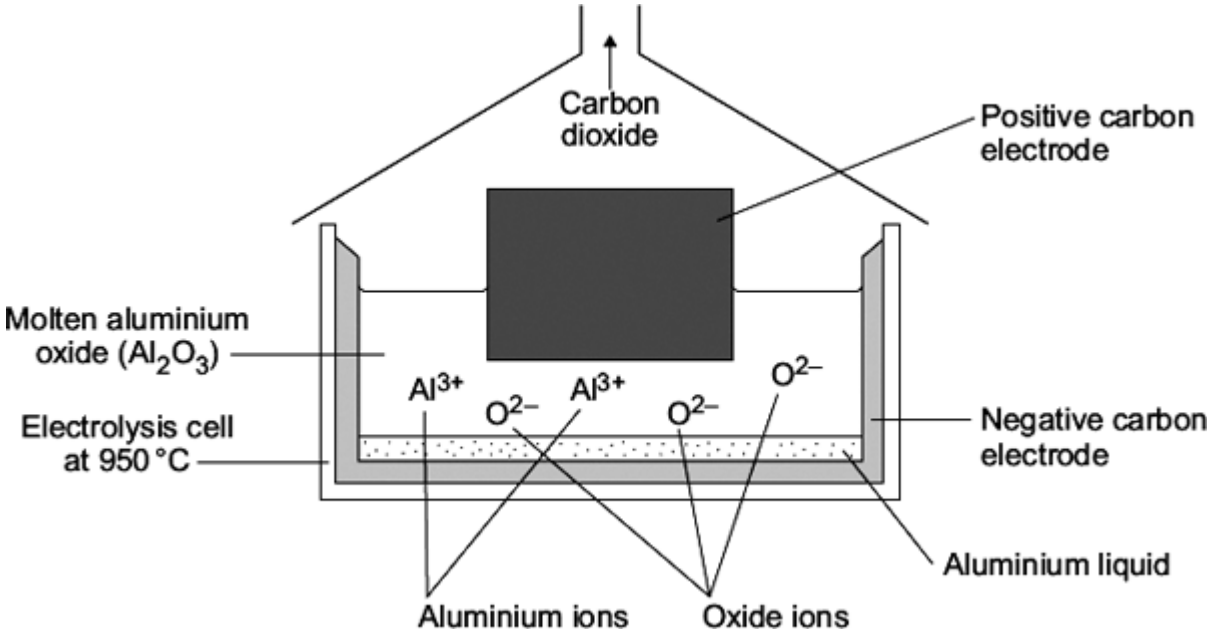
Why does aluminium oxide **not** react with carbon?

Tick (✓) the correct answer.

Answer	Tick (✓)
aluminium is less reactive than carbon	
carbon is less reactive than aluminium	
oxygen is more reactive than carbon	

(1)

(c) Aluminium can be produced by electrolysis.



Why do the aluminium ions collect at the negative electrode?

_____

_____

_____

_____

_____

_____

(2)

(d) Some statements about aluminium are given below.

Tick (✓) **two** statements that are correct reasons why aluminium is used to make cans.

Statement	Tick (✓)
aluminium conducts electricity	
aluminium is not a transition metal	
aluminium has a low density	
aluminium is resistant to corrosion	

(2)

(e) Recycling aluminium cans uses less fossil fuels than producing aluminium from its ore.

Tick (✓) **one** advantage and tick (✓) **one** disadvantage of recycling aluminium to make aluminium cans.

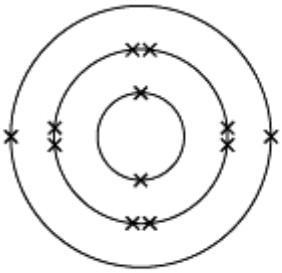
Statement	Advantage Tick (✓)	Disadvantage Tick (✓)
aluminium is the most common metal in the Earth's crust		
less carbon dioxide is produced		
more aluminium ore needs to be mined		
used aluminium cans have to be collected and transported		

(2)

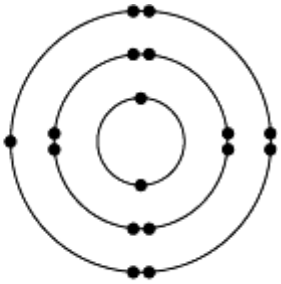
(Total 8 marks)

Q24.

The diagrams represent the electronic structure of a magnesium atom and a chlorine atom.



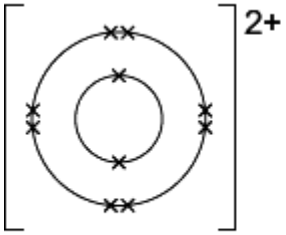
Magnesium atom



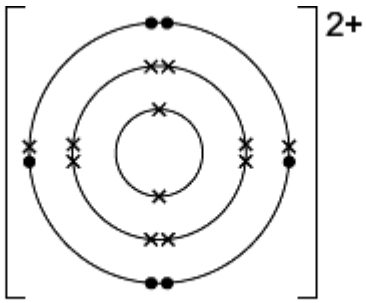
Chlorine atom

Magnesium reacts with chlorine to make the ionic compound called magnesium chloride. This contains magnesium ions, Mg^{2+}, and chloride ions, Cl^-

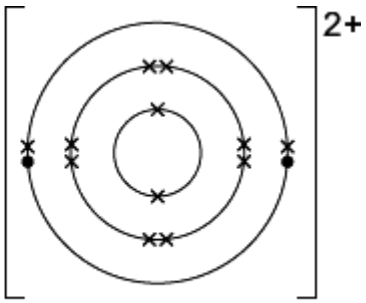
(a) (i) Which structure, **A**, **B** or **C**, represents a magnesium ion?



Structure **A**



Structure **B**

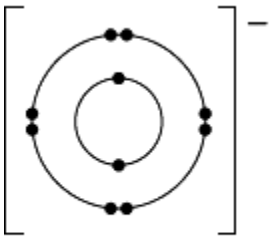


Structure **C**

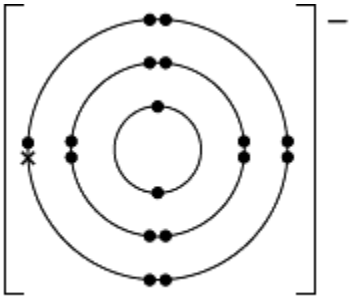
The magnesium ion is Structure ☐

(1)

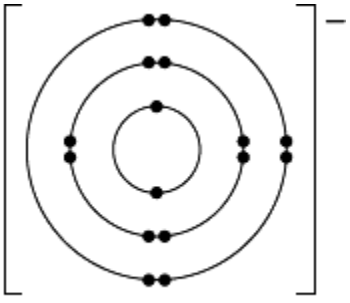
(ii) Which structure, **D**, **E** or **F**, represents a chloride ion?



Structure **D**



Structure **E**



Structure **F**

The chloride ion is Structure ☐

(1)

(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 as a solid.

This is the equation for the reaction:

$$MgCl_2(aq) + Ca(OH)_2(aq) \rightarrow Mg(OH)_2(s) + CaCl_2(aq)$$

Draw a ring around the correct answer to complete each sentence.

Magnesium hydroxide forms as a solid because it is [soluble / insoluble / dissolved] in water.

This type of reaction is called [precipitation. / neutralisation. / thermal decomposition.]

(2)

(ii) How is the solid magnesium hydroxide separated from the solution?

_____

(1)

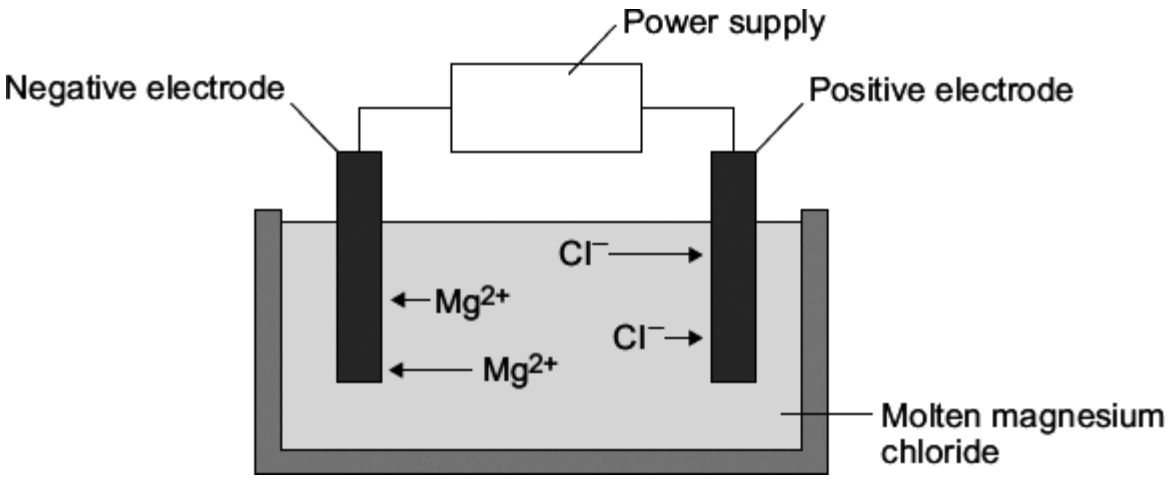
(iii) An acid is then added to the solid magnesium hydroxide to make magnesium chloride.

Draw a ring around the name of this acid.

nitric acid **hydrochloric acid** **sulfuric acid**

(1)

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



(i) What must be done to solid magnesium chloride to allow it to conduct electricity?

_____

_____

(1)

(ii) Why do the magnesium ions move to the negative electrode?

_____

_____

_____

_____

(1)

(iii) Name the product formed at the positive electrode.

_____

_____

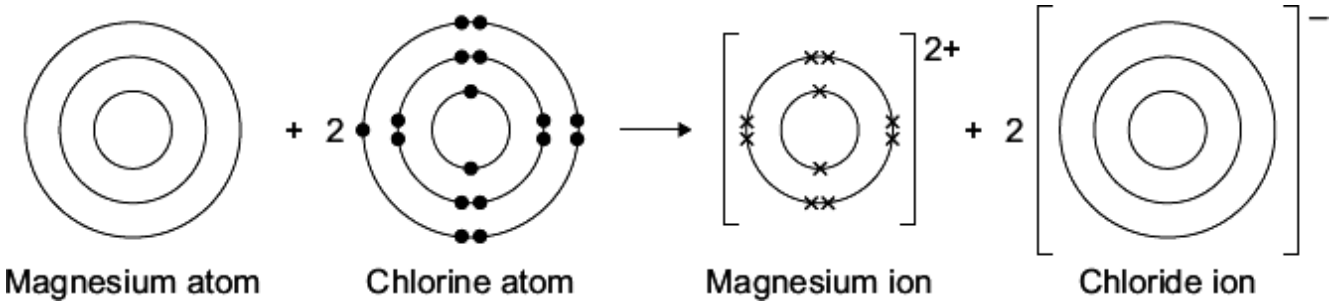
(1)

(Total 9 marks)

Q25.

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.

$$MgCl_2(aq) + Ca(OH)_2(aq) \rightarrow Mg(OH)_2(s) + CaCl_2(aq)$$

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

_____

(1)

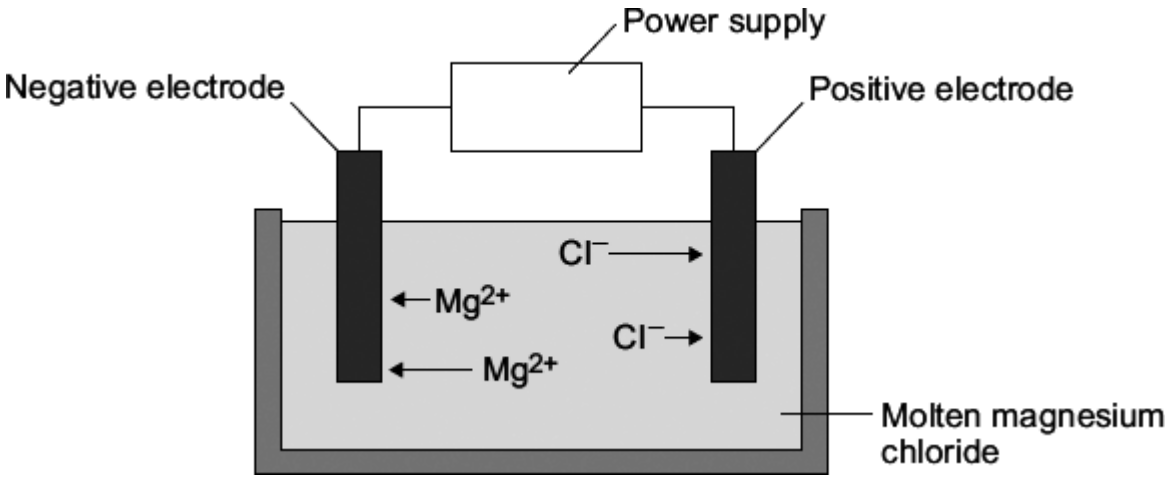
(ii) An acid is then added to the magnesium hydroxide to make magnesium chloride.

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.

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

Why is this reaction an oxidation reaction?

_____

_____

(1)

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

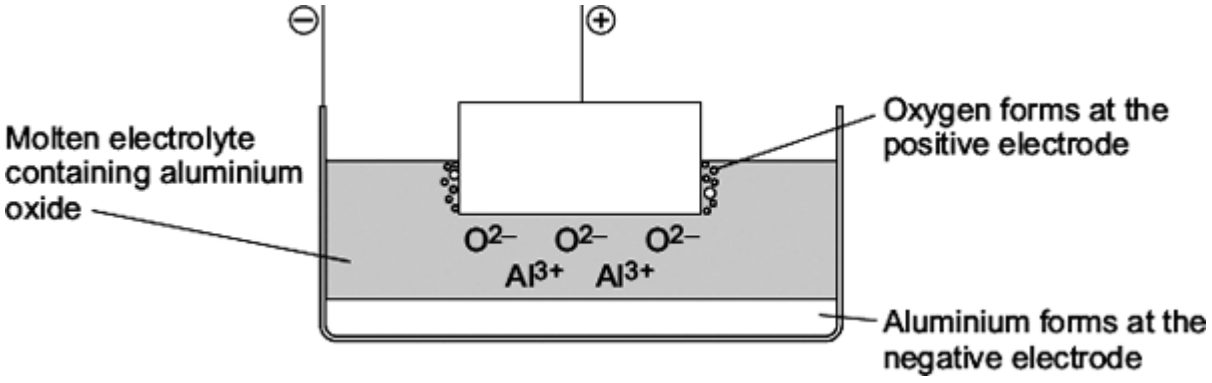
$$Mg^{2+} \rightarrow Mg$$

(1)

(Total 7 marks)

Q26.

The diagram represents an electrolysis cell for extracting aluminium.
The current will only flow when the electrolyte is molten.



(a) The electrolyte is aluminium oxide mixed with another substance.

(i) What is the name of the other substance in the electrolyte?

Draw a ring around the correct answer.

cryolite **rock salt** **limestone**

(1)

(ii) Draw a ring around the correct answer to complete the sentence.

This other substance is added to

condense the aluminium oxide.
lower the melting point of the aluminium oxide.
raise the boiling point of the aluminium oxide.

(1)

(b) (i) Oxide ions (O^{2-}) move to the positive electrode.

Explain why.

_____

_____

_____

_____

(2)

(ii) Oxygen is formed at the positive electrode. The oxygen then forms carbon dioxide.

The equation for the reaction is shown below.

$$C + O_2 \rightarrow CO_2$$

Complete the sentence.

The name of the element which reacts with oxygen is

_____

(1)

(iii) The positive electrode gets smaller.

Suggest why.

_____

_____

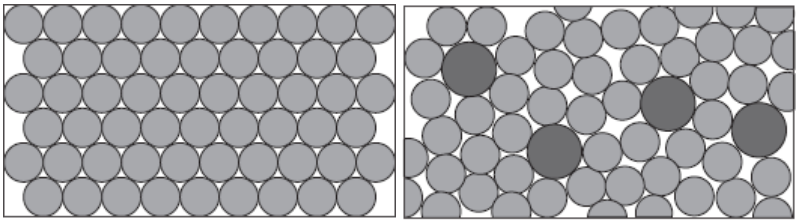
_____

_____

(1)

(c) Aluminium is used in an alloy with magnesium to make drinks cans.

The diagrams show the arrangement of atoms in pure aluminium and in the alloy.



Pure aluminium Alloy

The alloy is harder than pure aluminium.

Explain why. Use the diagrams to help you.

_____

_____

_____

_____

_____

_____

_____

_____

(2)

(Total 8 marks)

Q27.

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.

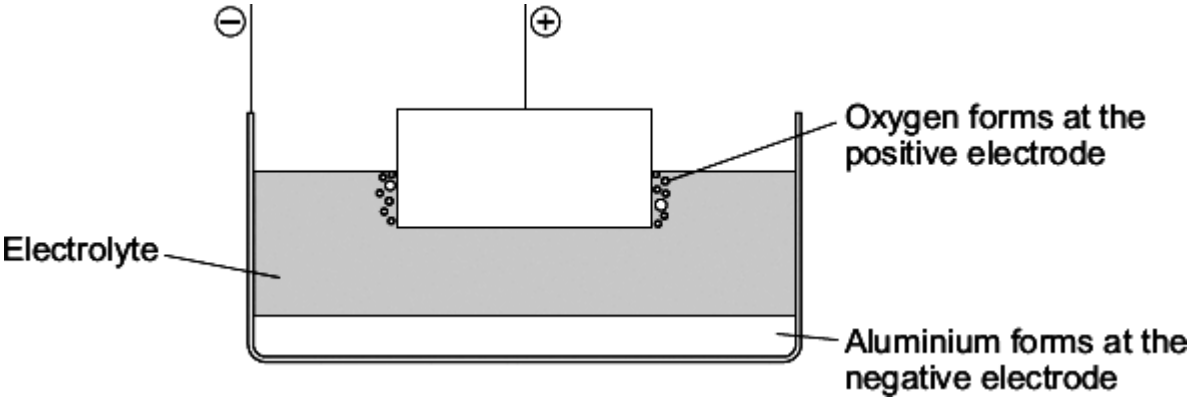
Relative atomic masses (A_r): O = 16; Al = 27.

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.

_____

_____

_____

_____

_____

_____

_____

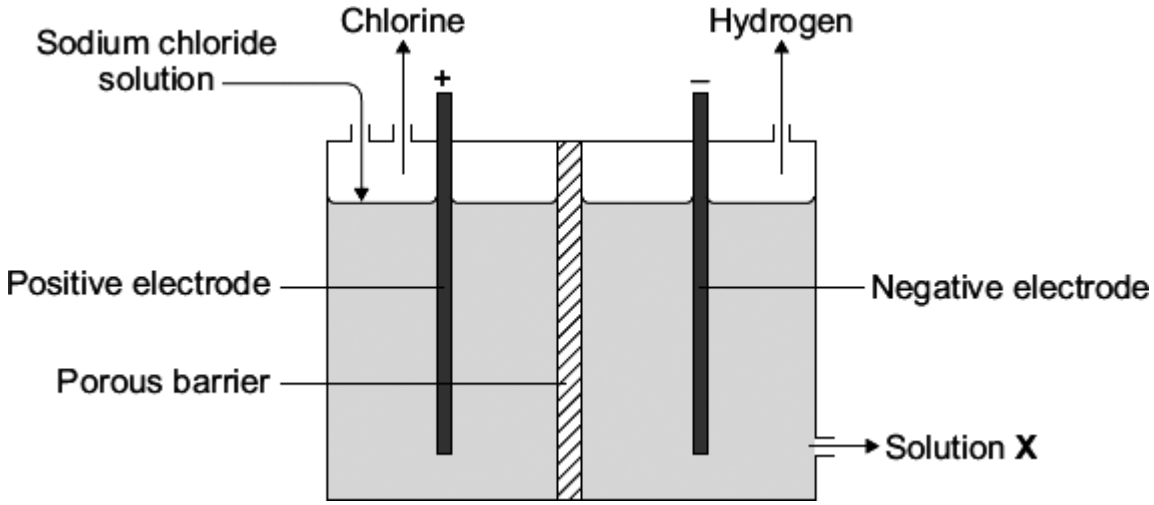
_____

(2)

(Total 8 marks)

Q28.

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?

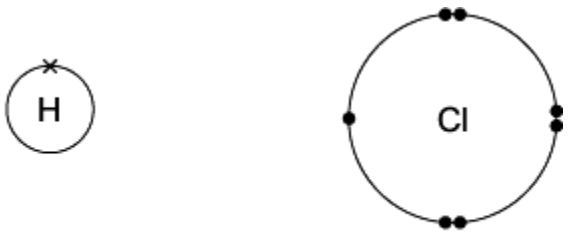
_____

_____

(1)

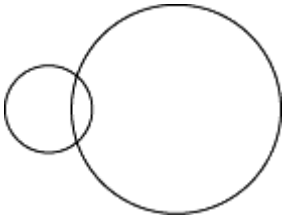
(d) Electrolysis of sodium chloride solution produces hydrogen and chlorine. The hydrogen and chlorine can be used to make hydrogen chloride.

(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)

Q29.

The flow diagram shows the main stages used to extract a metal from its ore.

mining the ore → purifying the ore → extracting the metal

The table shows some information about three metals.

Metal	Metal ore	Purified ore	% of metal in the ore	% of metal in the Earth's crust
aluminium	bauxite	aluminium oxide, Al_2O_3	28.0	8.0
copper	chalcocite	copper sulfide, Cu_2S	0.5	0.001
iron	haematite	iron oxide, Fe_2O_3	29.0	5.0

(a) Use the information in the table and your knowledge and understanding to help you to answer the questions.

(i) Suggest why purifying the copper ore produces large quantities of waste.

_____

_____

_____

_____

_____

_____

(1)

(ii) Suggest why the annual world production of iron is forty times greater than that of aluminium.

_____

_____

_____

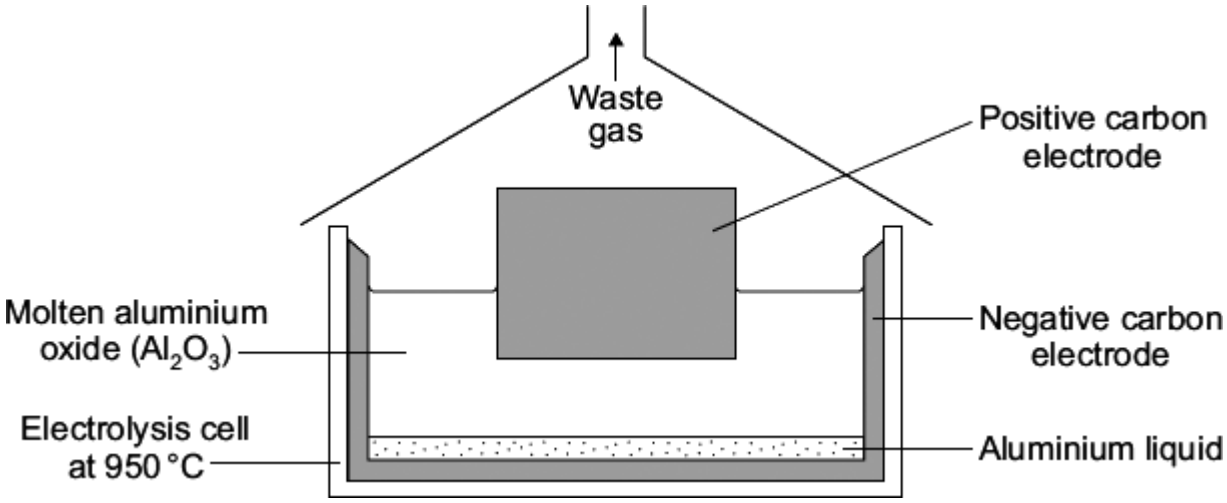
_____

_____

_____

(1)

(b) Aluminium is used for drinks cans.
Aluminium is extracted from its purified ore by electrolysis.



(i) Suggest why the aluminium produced in the electrolysis cell is a liquid.

_____

_____

_____

_____

(1)

(ii) In this electrolysis, aluminium and oxygen gas are produced from the aluminium oxide.

Use the information in the diagram to suggest why most of the waste gas is carbon dioxide and not oxygen.

_____

_____

_____

_____

_____

_____

_____

_____

(2)

(iii) Aluminium is the most abundant metal in the Earth's crust.

Suggest **two** reasons why we should recycle aluminium drinks cans.

1.

_____

_____

_____

_____

2.

_____

_____

_____

_____

(2)

(Total 7 marks)

Q30.

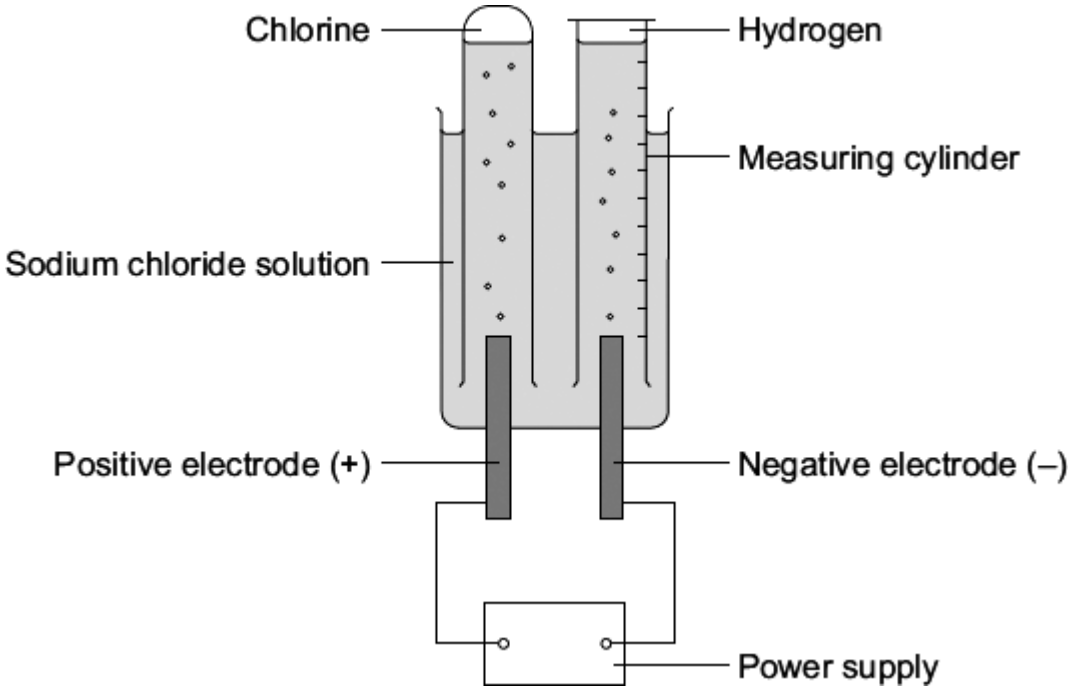
A student investigated the electrolysis of sodium chloride solution.

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)

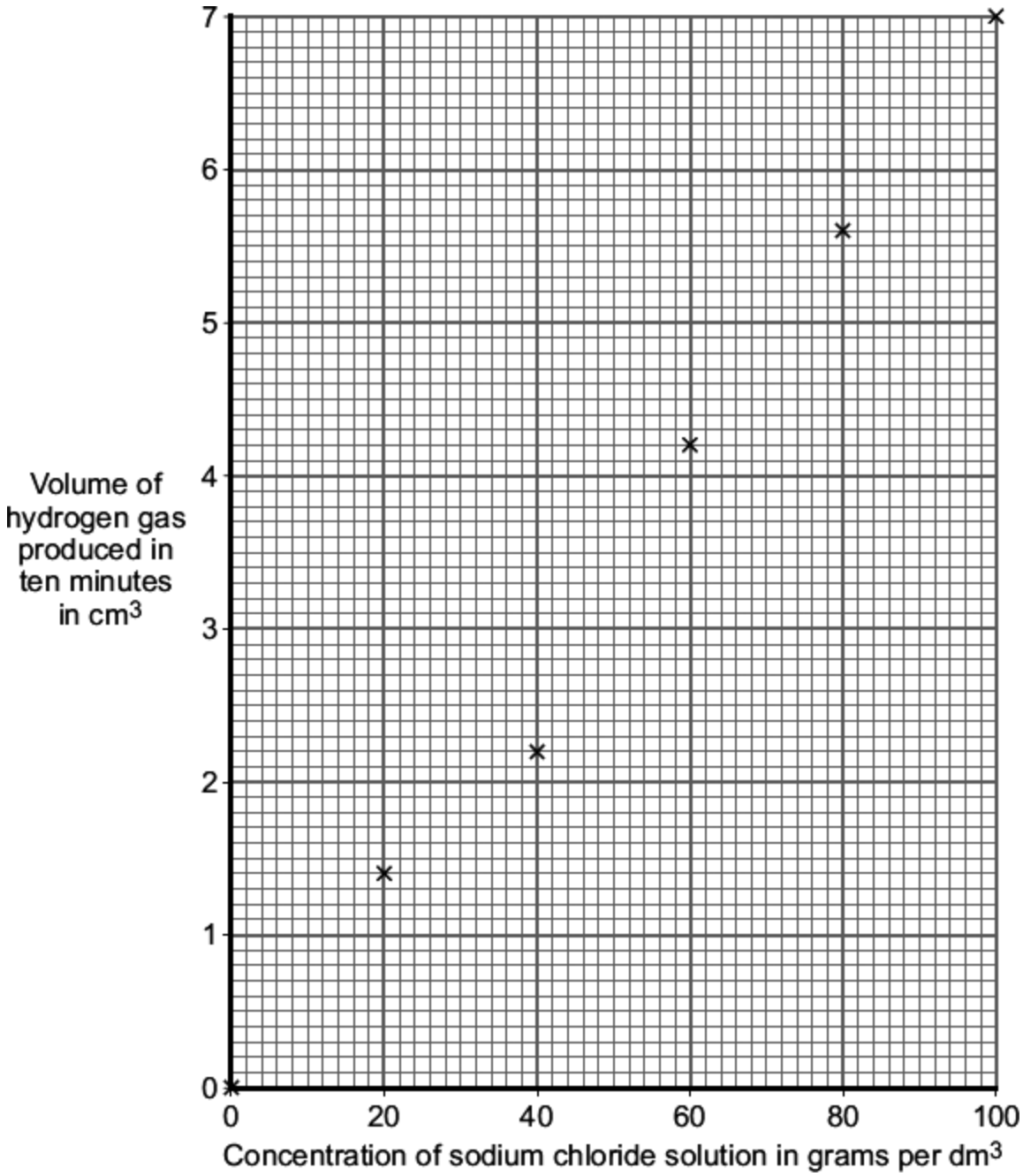
(c) The solution left at the end of each experiment contains sodium hydroxide.

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 dm^3

(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?

_____

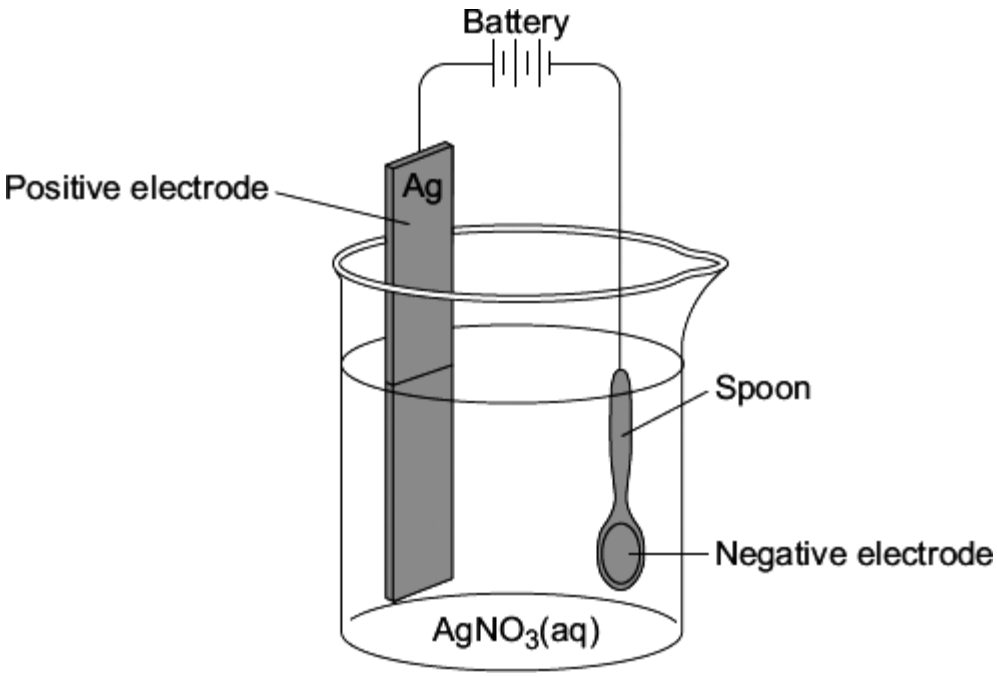
(1)

(Total 9 marks)

Q31.

Electroplating is used to coat a cheap metal with a thin layer of an expensive metal.

In the diagram a teaspoon made of nickel is being coated with silver.



Silver nitrate, $AgNO_3$, contains silver ions (Ag^+) and nitrate ions (NO_3^-).

(a) Solid silver nitrate, $AgNO_3(s)$, does **not** conduct electricity.

Choose the correct answer in the box to complete the sentence.

are too big	**cannot move**	**are too small**

Solid silver nitrate does **not** conduct electricity because the ions

_____

_____

(1)

(b) What substance is added to $AgNO_3(s)$ to turn it into $AgNO_3(aq)$?

Draw a ring around the correct answer.

petrol **alcohol** **water**

(1)

(c) Draw a ring around the correct answer to complete each sentence.

(i) Silver ions move to the negative electrode because

no charge.

they have

a negative charge.
a positive charge.

(1)

(ii) When silver ions reach the negative electrode they turn into

silver

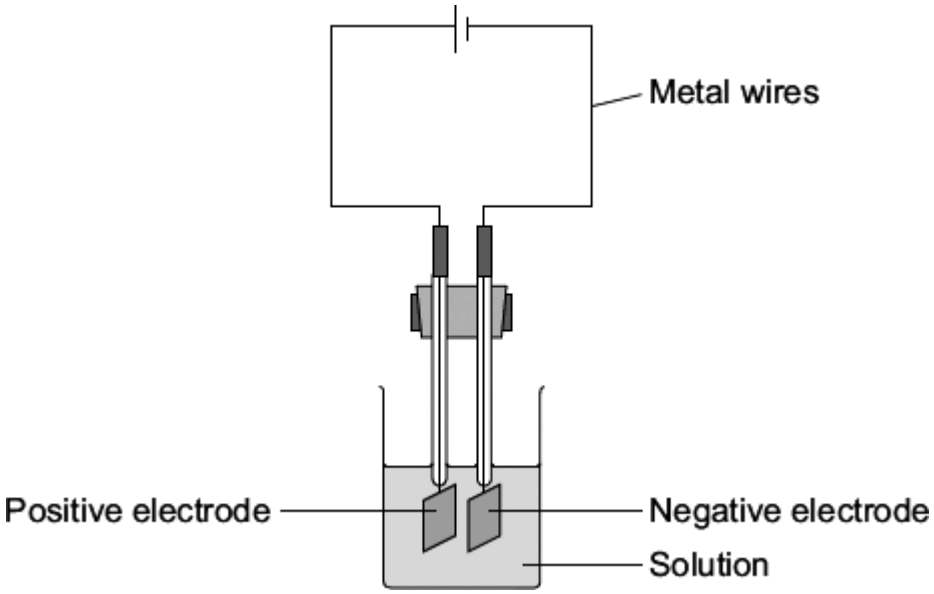
atoms
compounds.
molecules.

(1)

(Total 4 marks)

Q32.

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^+ → H_2

(1)

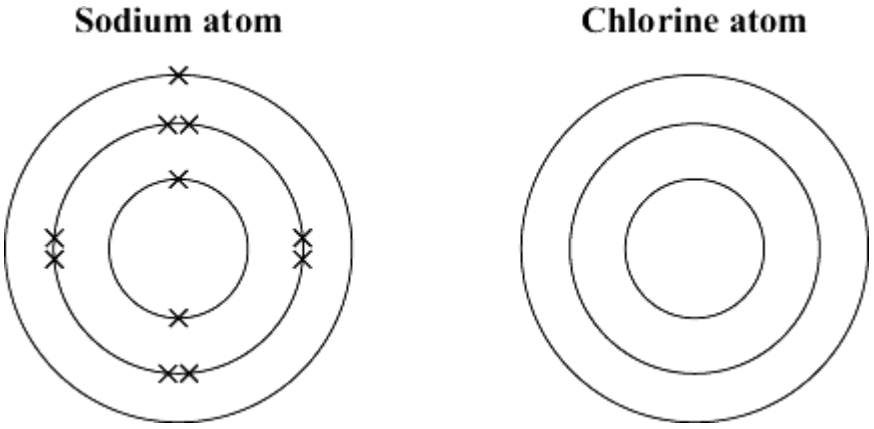
(Total 7 marks)

Q33.

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?

_____

_____

_____

_____

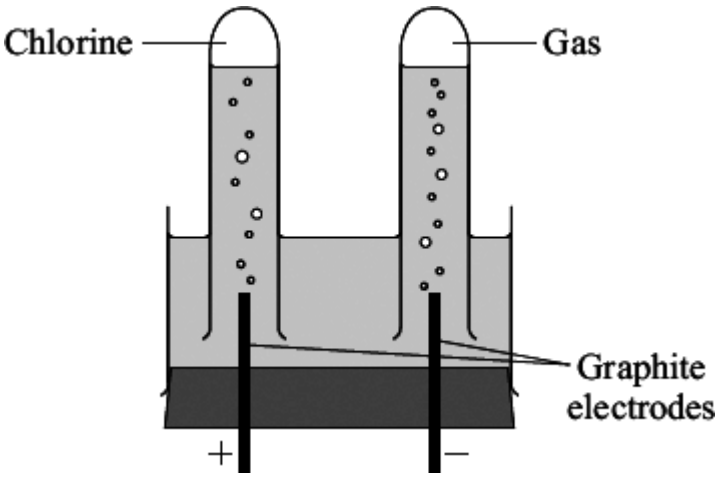
_____

_____

_____

(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)

Q34.

(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.

_____

_____

_____

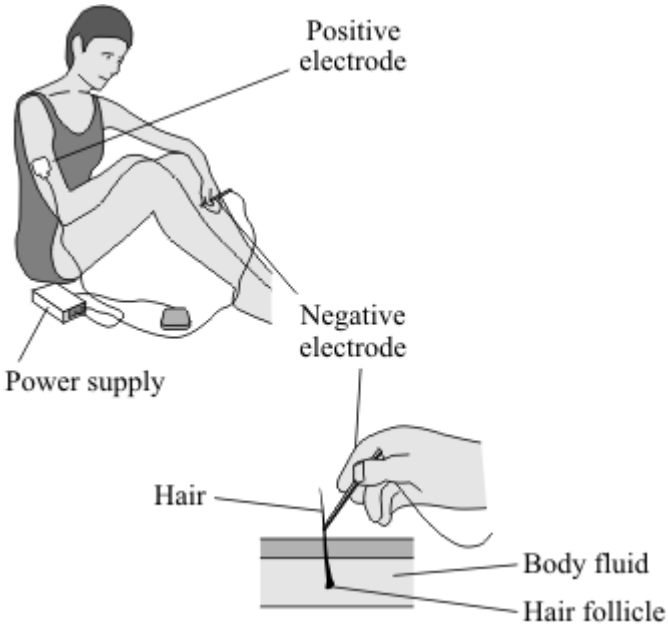
_____

(1)

(Total 7 marks)

Q35.

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.

chloride **hydroxide** **nitrate**

The name of this strong alkali is sodium _____ .

(1)

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

_____

_____

(1)

(Total 4 marks)

Mark schemes

Q1.

(a) 3.6 (cm^3)

1

(b) hydrogen line only

1

(c) both lines

1

(d) graphite has delocalised electrons

1

(e) **cathode** **anode**

zinc (1) chlorine (1)

*do **not** accept chloride*

*allow **1** mark if chlorine and zinc the wrong way around*

1+1

hydrogen (1) bromine (1)

*do **not** accept bromide*

*allow **1** mark if bromine and hydrogen the wrong way around*

1+1

[8]

Q2.

(a) copper, zinc, sodium chloride solution

1

(b) a reactant is used up

allow the reaction stops

allow electrolyte / electrode / ions / metal / metal hydroxide / alkali for reactant

1

(c) the reaction is not reversible

1

(d) $2H_2 + O_2 \longrightarrow 2H_2O$

allow fractions / multiples

*allow **1** mark for O_2*

2

(e) **Level 3:** A judgement, strongly linked and logically supported by a sufficient range of correct reasons, is given.

5–6

Level 2: Some logically linked reasons are given. There may also be a simple

judgement.

3–4

Level 1: Relevant points are made. This is not logically linked.

1–2

No relevant content

0

Indicative content

reasons why fuel cells could be judged as better

from the table	from other knowledge
• time for refuelling a fuel cell is faster than recharging **or** a fuel cell does not need to be recharged • a fuel cell has a greater range	• hydrogen can be renewable if made by electrolysis using renewable energy • lithium-ion batteries can catch fire • produces only water **or** no pollutants produced • lithium-ion batteries may release toxic chemicals on disposal • lithium-ion batteries (eventually cannot be recharged so) have a finite life

reasons why the lithium-ion battery could be judged as better

from the table	from other knowledge
• lithium-ion uses energy more efficiently • cost of lithium-ion car much less • cost of recharging much less than refuelling with hydrogen	• hydrogen is often made from fossil fuels so is not renewable • charging points are more widely available than hydrogen filling stations • hydrogen takes up a lot of space **or** is difficult to store • hydrogen can be highly flammable / explosive • no emissions produced • (catalyst in the hydrogen fuel-cell eventually becomes poisoned so) have a finite life

[11]

Q3.

(a) solid (zinc chloride) does not conduct (electricity)
or
zinc chloride needs to be in solution **or** molten
allow liquid / aqueous

1

(because) ions cannot move in the solid
or
(as) ions can (only) move in liquid / solution
*do **not** accept references to movement of electrons in zinc chloride*

1

(b) each carbon / atom forms 3 (covalent) bonds

1

one electron per carbon / atom is delocalised

1

(so) these electrons carry charge through the graphite
or
(so) these electrons move through the structure
ignore carry current / electricity

1

*if no other mark scored, allow **1** mark for delocalised / free electrons*
allow free electrons for delocalised electrons

(c) use measuring cylinders (instead of test tubes)
allow use burettes
allow use (gas) syringes
allow Hoffmann voltameter

1

(because) test tubes cannot measure volume
or
(because) test tubes have no graduations / scale
allow (so that) volume can be measured

1

(d) any **three** from:

- the volume of hydrogen collected is directly proportional to the time
  allow the (volume of) hydrogen is collected at a constant / steady rate
- the rate of collection of hydrogen is 0.45 (cm^3/min)
- up to 8 minutes chlorine is collected at an increasing rate
  allow any value from 6 to 8 minutes
  allow initially chlorine is collected at an increasing rate
- after 8 minutes the rate of collection of chlorine is the same as that of

hydrogen

allow any value from 6 to 8 minutes

or

after 8 minutes the rate of collection of chlorine is 0.45 (cm^3/min)

allow after 8 minutes the (volume of) chlorine is collected at a constant / steady rate

*if neither bullet point 3 nor bullet point 4 is awarded allow **1** mark for chlorine is collected slowly up to 8 minutes and then more quickly*

allow any value from 6 to 8 minutes

3

(e) chlorine reacts with water

or

chlorine dissolves (in the solution).

1

(f) $(\text{volume} =) \frac{6.6}{1000}\ (dm^3)$

or 0.0066 (dm^3)

allow 6.5 (cm^3) for 6.6 (cm^3)

1

$(\text{moles} =) \frac{0.0066}{24}$

allow use of incorrect volume from step 1

1

$= 2.75 \times 10^{-4}$ (mol)

allow 2.8×10^{-4} (mol)

allow answer from incorrect calculation given in standard form

alternative approach for marking points 1 and 2

24 dm^3 = 24 000 cm^3 (1)

$(\text{moles} =) \frac{6.6}{24\,000}$ (1)

1

*an answer of 2.75×10^{-4} (mol) or 2.8×10^{-4} (mol) scores **3** marks*

*an answer of 0.000275 / 0.00028 / 2.75×10^{-1} / 2.8×10^{-1} (mol) / scores **2** marks*

*an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps*

[10]

Q4.

(a) **(diagram)**

complete circuit with power supply

1

test solution in beaker or other appropriate apparatus

1

electrodes

allow carbon, platinum or inert electrodes

1

(independent variable)
salt solutions (with different metal ions)

1

(observation)
solid / metal deposit on the negative electrode

1

(b) (sometimes) hydrogen is produced

1

(because) the metal is more reactive than hydrogen

1

(c) chlorine

1

oxygen

1

[9]

Q5.

(a) The forces between iodine molecules are stronger

1

(b) anything in range +30 to +120

1

(c) Brown

1

(d) $2\ I^- + Cl_2 \rightarrow I_2 + 2\ Cl^-$

1

(e) It contains ions which can move

1

(f) hydrogen iodine

1

[6]

Q6.

(a) electricity

allow an electric current

1

(b) (i) chlorine/Cl_2

*do **not** accept chloride*

1

(ii) (zinc ions are) positive

ignore to gain electrons

1

and (opposite charges) attract

1

(iii) reduction

1

(c) (i) in alloy:

accept converse

different sized atoms/particles

or

no layers/rows

accept layers distorted

1

so cannot slide

1

(ii) shape memory (alloys)

accept smart

1

[8]

Q7.

(a) magnesium loses two electrons **and** chlorine gains one electron

*accept magnesium loses electrons **and** chlorine gains electrons for 1 mark*

ignore oxidation and reduction

2

one magnesium and two chlorines

accept $MgCl_2$

1

noble gas structure

or

eight electrons in the outer shell

accept full outer shell (of electrons)

or

(electrostatic) attraction between ions

or

forms ionic bonds

*do **not** accept covalent bonds*

1

*reference to incorrect particles **or** incorrect bonding **or** incorrect structure = **max 3***

(b) (i) because ions can move

ignore ions attracted

*do **not** accept molecules / atoms moving*

*do **not** accept incorrect reference to electrons moving*

1

(and ions move) to the electrodes

or

(and ions) carry charge

1

accept converse for solid

(ii) magnesium (ions) attracted (to the electrode)

1

so magnesium ions gain electrons

accept magnesium ions are reduced

ignore oxidised

1

2 electrons

*accept a correct half equation for 2nd **and** 3rd marking points*

1

(iii) hydrogen

allow H_2

1

(iv) magnesium is more reactive than hydrogen

accept converse

*allow magnesium is high in the reactivity series **or** magnesium is very/too reactive.*

*do **not** accept magnesium ions are more reactive than hydrogen ions*

1

(v) **2** $Cl^- \rightarrow Cl_2 + \mathbf{2e^-}$

must be completely correct

1

(c) layers (of particles/atoms/ions)

1

(particles/atoms/ions/layers) can slide

1

*any mention of intermolecular / weak bonds/forces = **max 1***

[14]

Q8.

(a) (i) calcium oxide

in either order

1

carbon dioxide

accept correct formulae

1

(ii) $C(s) + CO_2(g) \rightarrow \mathbf{2}CO(g)$

allow multiples

1

(iii) 210 (tonnes)

*award **3** marks for the correct answer with or without working*

allow ecf for arithmetical errors

*if answer incorrect allow up to **2** marks for any of the steps below:*

160 → 112

300 → 112 / 160 × 300

or

moles Fe_2O_3 = 1.875 (× 10^6) or 300 / 160

moles of Fe = 3.75 (× 10^6) or 2 × moles Fe_2O_3

mass Fe = moles Fe × 56

105 (tonnes) scores 2 (missing 1:2 ratio)

420 (tonnes) scores 2 − taken M_r of iron as 112

3

(b) (i) aluminium is more reactive than carbon **or** carbon is less reactive than aluminium

must have a comparison of reactivity of carbon and aluminium

accept comparison of position in reactivity series.

1

(ii) (because) aluminium ions are positive

ignore aluminium is positive

1

and are attracted / move / go to the negative electrode / cathode

1

where they gain electrons / are reduced / $Al^{3+} + 3e^- \rightarrow Al$

accept equation or statements involving the wrong number of electrons.

1

(iii) (because) the anodes **or** (positive) electrodes are made of carbon / graphite

1

oxygen is produced (at anode)

1

which reacts with the electrodes / anodes

*do **not** accept any reference to the anodes reacting with oxygen from the air*

equation $C + O_2 \rightarrow CO_2$ *gains **1** mark (M3)*

1

[13]

Q9.

(a) any **one** from:
- protection / improve lifespan
- improve appearance.

1

(b) (i) Bleach

1

(ii) Hydrogen is less reactive than sodium

1

(iii) 1 bonding pair of electrons 6 unbonded electrons on Cl

accept dot, cross or e or − or any combination

1

(iv) Covalent

1

(v) Hydrogen chloride has a low boiling point.

1

Hydrogen chloride is made of simple molecules.

1

(c) (i) oxygen

accept carbon dioxide

1

(ii) aluminium ions are positive

1

so are attracted (to the negative electrode)

allow opposites attract

1

(iii) Reduction

1

(iv) slide

allow move

1

(d) (i) C

1

(ii) strong covalent bonds

1

[14]

Q10.

(a) giant structure / lattice / layers / close packed

first 3 marks can be obtained from a suitably labelled diagram

incorrect structure or bonding or particle = max 3

1

made up of atoms / <u>positive</u> ions

1

with delocalized / free electrons

1

so electrons can move / flow through the metal

accept so electrons can carry charge through the metal

accept so electrons can form a current

1

(b) an alloy (is a metal which) has different types / sizes of atoms

accept converse for pure metal throughout

both marks can be obtained from suitable diagrams

allow made of different metals

allow mixture of metals / atoms / elements

ignore particles

ignore properties

*do **not** accept compound*

1

alloy has distorted layers

allow layers are unable to slide

1

(c) (i) can return to its original shape

accept shape memory alloy

accept smart alloy

ignore other properties

1

(ii) (pure copper is too) soft

accept converse

accept malleable or bends

accept copper is running out

ignore references to strength and weakness

1

(iii) aluminium oxide

accept alumina

accept Al_2O_3

ignore bauxite / aluminium ore

1

(iv) any **one** from:

- different conditions
- different catalyst
- different pressure

  allow different concentration
- different temperature.

  *do **not** accept different monomers*

1

(d) any **two** from:
- accurate
- sensitive
- rapid
- small sample.

  both needed for 1 mark

1

[11]

Q11.

(a) lattice / giant structure

*max **3** if incorrect structure or bonding or particles*

1

ionic **or** (contains) ions

1

Na^+ **and** Cl^-

accept in words or dot and cross diagram: must include type and magnitude of charge for each ion

1

electrostatic attraction

allow attraction between opposite charges

1

(b) hydrogen

allow H_2

1

sodium hydroxide

allow NaOH

1

(c) any **one** from, eg:
- people should have the right to choose
- insufficient evidence of effect on individuals
- individuals may need different amounts.

allow too much could be harmful

ignore religious reasons

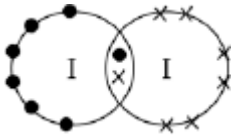
ignore cost

ignore reference to allergies

1

(d) (i) one bonding pair of electrons

accept dot, cross or e or − or any combination, eg



1

6 unbonded electrons on each atom

1

(ii) simple molecules

*max **2** if incorrect structure or bonding or particles*

accept small molecules

accept simple / small molecular structure

1

with intermolecular forces

accept forces between molecules

must be no contradictory particles

1

which are weak **or** which require little energy to overcome − must be linked to second marking point

reference to weak covalent bonds negates second and third marking points

1

(iii) iodine has no delocalised / free / mobile electrons or ions

1

so cannot carry charge

*if no mark awarded iodine molecules have no charge gains **1** mark*

1

[14]

Q12.

(a) (i) points correctly plotted (± ½ small square)

*four points = **2** marks*

*three points = **1** mark*

Max 2

straight line of best fit using full range of points from 0,0

1

(ii) any **one** from:

must explain why the point is below the line

- the solution may not have been properly stirred
- the electrodes may have been a larger distance apart
- the drop of sodium chloride may have been a smaller volume / smaller

allow not enough sodium chloride added

allow smaller amount of sodium chloride

*do **not** allow too few drops added*

ignore the student may have misread the conductivity meter

1

(iii) any **one** from:

- the volume of pure water
  allow amount
- the concentration (of the solutions added)
- the volume (of the drops) of solution added
  ignore number of drops
- the distance between the electrodes
- the same electrodes **or** electrodes made of the same material
- same depth **or** surface area of electrodes in the water
- constant power supply
  ignore current
- stirred

1

(b) (i) because (pure) water is covalent / molecular (simple) **or** contains molecules

1

therefore (pure) water has no free / mobile electrons **or** ions
*molecules do not have a charge **or** molecules do not contain ions gains **2** marks*

1

(ii) because there are ions in sodium chloride
*allow Na^+ and / or Cl^-(ions) **or** ionic bonding.*
Ignore particles other than ions for MP1.

1

which can move **or** carry the current / charge
MP2 must be linked to ions only.

1

(iii) Hydrogen
allow H_2 / H

1

[10]

Q13.

(a) (i) any **one** from:

- one electron in the outer shell / energy level
- form ions with a 1+ charge

1

(ii) any **one** from:

- hydrogen is a non-metal
- (at RTP) hydrogen is a gas
- hydrogen does not react with water
- hydrogen has only one electron shell / energy level
- hydrogen can gain an electron **or** hydrogen can form a negative /

hydride / H^-ion

- hydrogen forms covalent bonds **or** shares electrons

accept answers in terms of the Group 1 elements

1

(b) (i) (bromine) gains electrons

it = bromine

*do **not** accept bromide ion gains electrons*

ignore loss of oxygen

1

(ii) I_2

must both be on the right hand side of the equation

1

$+ 2e^-$

*$2I^- - 2e^- \rightarrow I_2$ for **2** marks*

1

(iii) fluorine is the smallest atom in Group 7 **or** has the fewest energy levels in Group 7 **or** has the smallest distance between outer shell and nucleus

*the outer shell **must** be mentioned to score 3 marks*

1

fluorine has the least shielding **or** the greatest attraction between the nucleus and the outer shell

1

therefore fluorine can gain an electron (into the outer shell) more easily

1

[8]

Q14.

(a) (i) ions cannot move

allow only conducts as a liquid

1

(ii) chlorine

1

(iii) they are positively / oppositely charged

or

they are attracted

1

(iv) 2

1

(b) (i) any **one** from:

- not all the magnesium was collected

allow some magnesium was lost

- *used less time **or** lower current **or** different battery / power pack **or***

*different balance **or** lower voltage*

- error in reading balance
- error in recording result

1

(ii) 1.11

*correct answer with or without working gains **2** marks.*
*if answer incorrect, allow **1** mark for 0.99*
***or** for 1.13 + 1.11 + 1.09*

2

(c) (i) *25 – 25.3*

*correct answer with or without working gains **2** marks.*
*If answer incorrect, allow **1** mark for 24 / 95*

2

(ii) 71

1

(d) (i) reversible reaction

1

(ii) decreases

1

[12]

Q15.

(a) (i) so ions can move (and carry charge)

accept so current can flow
allow so it can conduct (electricity)
allow so charged particles can move
*do **not** accept so electrons can move*

1

(ii) because zinc ions gain electrons

accept because zinc ions are reduced

1

2 (electrons)

1

zinc is formed

*accept correct half equation for **3** marks*
if no mark gained allow
*positive ions go to negative electrode **or***
*opposites attract **or***
*reduction (of zinc) **or***
*(zinc) gains electrons for **1** mark*

1

(iii) **2** Cl^- $\longrightarrow$ Cl_2 + **2** e^-

must be completely correct

1

(b) (i) because the magnesium is *a gas*

allow magnesium goes from solid to gas

1

(ii) (a reaction which) takes in energy (from the surroundings)

accept more energy needed to break bonds than released by forming bonds

accept correct reference to energy level diagram

allow (a reaction which) takes in heat (from the surroundings)

1

(iii) (M_r MgO =) 40

accept (2 M_r MgO =) 80

1

1.2 / 24 (x40) **or** 0.05 (x40)

or

40 / 24 (x1.2) **or** 1.67 (x1.2)

allow ecf from step 1

1

2(.0)

allow ecf carried through from step 1

*correct answer with or without working gains **3** marks*

1

(iv) 75(%)

1

(v) any **one** from:

- the reaction is reversible

  accept incomplete reaction

  ignore equilibrium not reached
- *some lost / escaped / released (when* separated)
- some of the reactant may react in different ways from the expected reaction
- *impure reactant(s)*

ignore measurement and calculation errors

1

[12]

Q16.

(a) (i) because they are positively charged

accept they are positive / H^+

*accept oppositely charged **or** opposites attract*

ignore they are attracted

1

(ii) gains one / an electron

accept $H^+ + e^- \rightarrow H$ or multiples
allow gains electrons

1

(b) 3 bonding pairs

1

1 lone pair
accept 2 non-bonding electrons on outer shell of nitrogen

1

(c) (i) hydroxide / OH^-
*do **not** accept sodium hydroxide*

1

(ii) $H^+ + OH^- \rightarrow H_2O$
ignore state symbols
ignore word equation

1

(d) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information in the Reference material.

0 marks
No relevant content.

Level 1 (1-2 marks)
There are basic descriptions of advantages or disadvantages of the electrolysis cells.

Level 2 (3-4 marks)
There are clear descriptions of environmental or economic advantages or disadvantages of the electrolysis cells. Comparisons may be implied.

Level 3 (5-6 marks)
There are detailed descriptions of environmental and economic advantages and disadvantages, comparing the electrolysis cells.

Examples of chemistry points made in the response:

Accept converse where appropriate.

- mercury cell is more expensive to construct
- mercury is recycled but membranes must be replaced
- mercury is toxic but membrane / polymer is not
- removing traces of mercury from waste is expensive
- mercury cell uses more electricity
- mercury cell produces chlorine that is purer
- mercury cell produces higher concentration / better quality of sodium

hydroxide (solution)

6

[12]

Q17.

(a) Will kelp last longer than coal as an energy source?

1

(b) any **two** from:

- cannot be determined by experiment
  allow can't predict how long kelp / coal will last
  allow more testing needed
- based on opinion
- ethical **or** environmental **or** economic reason
  allow could damage ecosystem allow reference to cost

2

(c) (i) 7

1

(ii) sodium (atom) loses (electron) **and** iodine (atom) gains (an electron)
*reference to incorrect bonding **or** incorrectly named particle = max **2***
any or all marks can be obtained from a labelled diagram
ignore inner shell electrons if shown

1

1 electron

1

(electrostatic) attraction **or** forms ionic bond(s)

1

(iii) ions can move (in the solution)

1

(iv) $2\,I^- \rightarrow \mathbf{I_2} + \mathbf{2}\,e^-$

1

(v) hydrogen is formed

1

because sodium is more reactive (than hydrogen)

1

[11]

Q18.

(a) cannot move

1

(b) (i) a positive charge

1

(ii) atoms

1

[3]

Q19.

(a) (i) aluminium oxide

ignore (III) after aluminium

1

(ii) (because it provides) heat / energy (to overcome activation energy)

1

(b) (i) contains only one sort of atom

1

(ii) the atoms (in cast iron) are different sizes

*any mention of molecules, maximum **1** mark*

*accept layers are distorted **or** structure is disrupted*

1

which prevents the layers / rows sliding

accept an answer in terms of pure iron being softer than cast iron for both marks

1

(c) (i) because aluminium is more reactive than carbon

'it' = aluminium must be a comparison between the elements

or

because aluminium is above carbon in the reactivity series

*do **not** accept any comparison of the reactivity of aluminium and iron*

1

(ii) reduces / lowers the temperature for the process **or** lowers the operating temperature **or** allows ions to move

ignore any temperature values

allow reduces the (effective) melting point (of Al_2O_3)

1

(iii) 3

accept multiples

1

(iv) electrons are gained (by Al^{3+})

ignore any numbers

ignore any reference to oxygen

1

(v) electrodes are made of carbon

allow graphite / coke

1

oxygen is produced (at the positive electrode / anode)

accept $2O^{2-} \rightarrow O_2 + 4e^-$

1

so the electrodes react with the oxygen / are oxidised

1

producing carbon dioxide (gas)

accept $C + O_2 \rightarrow CO_2$ *for marking points 3 and 4.*

1

[13]

Q20.

(a) any **two** from:

- copper / ores are running out / harder to find
- there are no / very small amounts of high-grade copper ores left
- copper metal is in demand
- copper is expensive
- now economical to extract copper from low-grade ores

it = copper

allow new methods of extraction e.g. bioleaching and phytomining

*allow high-grade ores are running out for **2** marks*

2

(b) (i) large amounts / 98% of rock to dispose of as waste

accept contains toxic (metal) compounds / bioleacher

or

waste rock takes up a lot of space

1

(ii) (copper sulfide reacts with oxygen to) produce sulfur dioxide / SO_2

allow (sulfur reacts with oxygen to) produce sulfur dioxide / SO_2

1

that causes acid rain

*allow description of effects of acid rain **or** sulfur dioxide*

*if no other mark awarded allow CO_2 produced which causes global warming **or** CO_2 produced by burning fuel or heating the furnace for **1** mark*

1

(iii) any **one** from:

- large amounts of fuels / energy used (for the furnace and electrolysis)

allow large amounts of electricity needed

ignore high temperature / electrolysis unqualified

- (the extraction has) <u>many</u> steps / stages / processes
  allow (extraction) is a long process / takes a lot of time
- <u>large</u> amounts of ore / material have to be mined
  allow ores contain a low percentage of copper

1

(iv) (copper ions move towards) the negative electrode / *cathode*

1

because copper ions / Cu^{2+} are positively charged **or** are oppositely charged **or** copper ions need to gain electrons
*allow because metal ions are positive **or** opposites attract*

1

(v) (growing) plants

1

[9]

Q21.

(a) (i) was well qualified

1

(ii) check the results of the experiment

1

(b) (i) cannot move

1

(ii) melt it / make it a liquid
allow heat it
allow dissolve (in water) / make a solution

1

(iii) they are positive
*allow opposites attract **or** opposite charges*

1

(iv) atoms

1

[6]

Q22.

(a) (i) current / charge couldn't flow
allow could not conduct (electricity)

1

because the ions / particles couldn't move
*do **not** accept electrons/ molecules / atoms*

or

(salt) needs to be molten / (1) dissolved (to conduct electricity)

so that the ions / particles can move (1)

*do **not** accept electrons / molecules / atoms*

1

(ii) he had status

*accept he had authority **or** experience*

or

he had evidence / proof

accept the experiment could be repeated

1

(b) hydrogen / H_2

*do **not** allow hydrogen ions*

1

the ions are positive

accept because opposite (charges) attract

1

potassium is more reactive (than hydrogen)

accept potassium ions are less easily discharged (than hydrogen)

***or** potassium ions are less easily reduced (than hydrogen)*

1

(c) (i) gain electron(s)

*accept fully balanced correct equation for **2** marks*

1

one electron

*if no other marks awarded allow (potassium ions) reduced for **1** mark*

1

(ii) $2\ Cl^- \rightarrow Cl_2 + \mathbf{2e^-}$

must be completely correct, including charge on electron

accept correct multiples

1

(iii) 2, 8, 8

accept any combination of dots, crosses, "e" or any other relevant symbol

ignore any charges if given

1

[10]

Q23.

(a) reduction

1

(b) carbon is less reactive than aluminium

1

(c) aluminium (ions) / they are positively charged

they = aluminium ions
ignore particle names
accept aluminium (ions) / they are cations
allow aluminium (ions they have an opposite charge

1

so they are attracted **or** they move towards the negative electrode

OR

aluminium (ions) / they need to gain electrons (1)

which come from the negative electrode (1)

*if no other marks awarded allow 'opposites attract' for **1** mark*

1

(d) aluminium has a low density

1

aluminium is resistant to corrosion

1

(e) **advantage** less carbon dioxide is produced

1

disadvantage used aluminium cans have to be collected and transported

1

[8]

Q24.

(a) (i) A

1

(ii) E

1

(b) (i) insoluble

precipitation

2

(ii) filtration

*accept decant **or** centrifuge*

1

(iii) hydrochloric acid

1

(c) (i) melt

allow add to / dissolve in water

allow heat until liquid
allow turn it to liquid / make it molten
ignore heat

1

(ii) they are positive

or

opposite charges **or** opposites attract
*do **not** accept electrodes attracting*
*do **not** accept positive electrons*

1

(iii) chlorine
accept Cl_2
*do **not** accept chloride*

1

[9]

Q25.

(a) *ignore any attempts to change the charge on chloride ion*

2.8.2 (drawn as dots or crosses on the circles)
accept e instead of dots or crosses

1

2.8.8 (drawn as dots or crosses on the circles)

1

(b) (i) filtration
accept decanting or centrifugation
*do **not** accept evaporation*

1

(ii) hydrochloric
accept HCl

1

(c) (i) so that ions / particles can <u>move</u> (in electrolyte)
allow so it can conduct electricity / carry charge / carry current
ignore reference to electrons moving in the external circuit
*any unqualified reference to electrons moving / carrying charge / carrying current = **0** marks*

1

(ii) electrons are lost
ignore numbers

1

(iii) + $2e^-$ on left hand side of equation

must be correct with no other additions
accept correct multiples

1

[7]

Q26.

(a) (i) cryolite

1

(ii) lower the melting point of the aluminium oxide

1

(b) (i) opposite charges **or** oxide ions are negative

1

attract

1

(ii) carbon

1

(iii) reacts with oxygen **or** forms carbon dioxide
accept burns

1

(c) **Structure mark:**

either Al (atoms) in layers / rows
accept Al (atoms) all the same size
allow Al (atoms) in lines

or alloy (atoms) not in layers / rows
accept different sizes of atoms in alloy
allow alloy (atoms) not in lines

1

Sliding mark:

either so (Al layers) can slide

or so (alloy) layers cannot slide

1

[8]

Q27.

(a) 52.9(411765) / 53
*correct answer with or without working = **2** marks*
*if answer incorrect allow 2 x 27= 54 **or** 27/102 x 100 **or** 26.5 for **1** mark*

2

(b) (i) because it lowers the melting point (of the aluminium oxide)

allow lowers the temperature <u>needed</u>
*do **not** accept lowers boiling point*

1

so less energy is needed (to melt it)
accept so that the cell / equipment does not melt

1

(ii) **2** O^{2-} on left hand side
accept correct multiples or fractions

1

$4e^-$ on right hand side
*accept **$-4e^-$** on left hand side*

1

(iii) because the electrode reacts with oxygen **or**

because the electrode burns

1

to form carbon dioxide **or**

electrode made from carbon / graphite

1

[8]

Q28.

(a) any **one** from:

- they are negative / anions
  allow Cl^-
  ignore atoms / chlorine
  *do **not** accept chloride ions are negative electrodes*
- they are attracted
- they are oppositely charged

1

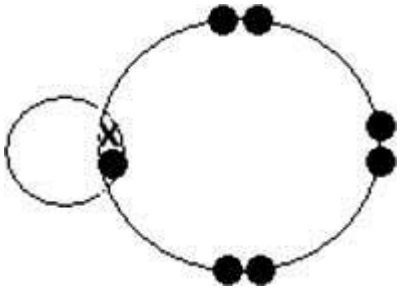
(b) hydrogen is less reactive than sodium

1

(c) hydroxide (ions) / OH^-
ignore OH
*do **not** accept NaOH / sodium hydroxide*

1

(d) (i)



allow any combination of dots or crosses

ignore chemical symbols

1

(ii) covalent

allow close spelling errors

apply list principle

1

(iii) hydrogen (ion) / H^+

ignore (aq) / H

do not accept hydrochloric acid / HCl

apply list principle

1

[6]

Q29.

(a) (i) low percentage / very little of metal (in the ore)

*accept <u>only</u> 0.5% metal in the ore **or** over 99% waste in the ore **or** nearly 100% waste in the ore*

*ignore reference to percentage of metal in the Earth's crust **or** energy used or pollution*

1

(ii) any **one** from

(it = iron)

- iron uses less energy / fuel for extraction

  ignore electrolysis / uses electricity / reactivity

- iron has more uses

- more demand for iron

  ignore high abundance in the Earth's crust / high percentage of metal in ore

- iron is stronger

  ignore harder

- cheaper / costs less

- easier to extract

1

(b) (i) has melting point lower than 950°C

(it = aluminium)

allow has a low melting point

ignore boiling point

1

(ii) electrode(s) made of carbon

1

oxygen reacts with electrode(s) / carbon

accept $C + O_2 (\rightarrow CO_2)$

*NB oxygen reacts with the carbon electrode(s) = **2** marks*

1

(iii) any **two** from:

- saves resources / non-renewable
  *accept aluminium / ore will run out **or** conserves aluminium*
- landfill problem
  accept aluminium does not corrode
- saves energy / fuel / electricity
  ignore global warming
- less carbon dioxide / carbon emissions **or** reduces carbon footprint
  ignore consequences of quarrying / mining
- less quarrying / mining
  ignore pollution / harms environment / costs / easy to recycle

2

[7]

Q30.

(a) the ions can move / travel / flow /are free

accept particles / they for ions

allow delocalised ions

or

ignore delocalised / free electrons

ignore references to collisions

accept converse with reference to solid

the ions carry the charge / current

ignore ions carry electricity

1

(b) any **one** from:

- because they are negative / anion
  allow Cl^-
  ignore chlorine

- opposite charges / attract

1

(c) 13

1

(d) (i) reasonable attempt at straight line which misses the anomalous point

must touch all five crosses

*do **not** allow multiple lines*

1

(ii) 40

ignore 2.2

1

(iii) any **two** sensible errors from:

ignore systematic / human / apparatus / zero /experimental / random / measurement / reading errors unless qualified

- gas escapes
- weighing error

  allow NaCl not measured correctly
- error in measuring (volume / amount) of hydrogen
- error in measuring (volume / amount) of water

  *allow error in measuring volume / scale for **1** mark if neither hydrogen or water mentioned*
- incorrect concentration

  *allow NaCl not fully dissolved **or** spilled **or** impure*
- timing error
- change in voltage / current

  allow faulty power supply
- change in temperature
- recording / plotting error

2

(iv) any **one** from:

ignore 'do more tests'

- repeat the experiment
- results compared with results from /other students / other groups / other laboratories / internet / literature.
- results compared with another method

1

(v) increases owtte

allow directly proportional or positive correlation

allow rate / it is faster / quicker

1

[9]

Q31.

(a) cannot move

1

(b) water

1

(c) (i) a positive charge

1

(ii) atoms

1

[4]

Q32.

(a) (i) electron(s)

allow free / delocalised / negative electrons

*do **not** accept additional particles*

1

(ii) <u>ion</u>(s)

allow named ions from table

ignore positive or negative

*do **not** accept additional particles*

1

(b) (i) copper

accept Cu

*do **not** accept Cu^{2+}*

1

(ii) it is / they are positive (ions)

accept formula of positive ion

1

and it is the least reactive

1

(c) (i) loss of electron(s)

ignore numbers

1

(ii) $\mathbf{2H^+} + \mathbf{2e^-} \rightarrow H_2$

accept correct multiples / fractions

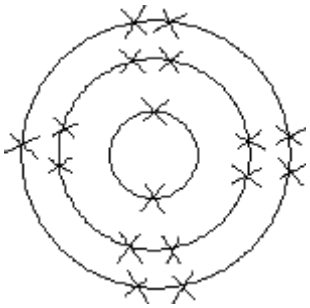
accept e / e^-

allow $\mathbf{2H^+} \rightarrow H_2 - \mathbf{2e^-}$

1

[7]

Q33.

(a) 

accept dots / crosses / e
must be drawn on diagram
electrons do not need to be paired
ignore brackets or + or -charges
ignore 2,8,7

1

(b) (one) electron

recognition that electrons are involved

1

lost / given away / transferred from sodium / transferred to chlorine owtte

must be linked to electrons
*accept loses electron(s) for **2** marks*
*NB loses 2 or more electrons gains **1** mark*
*reference to sharing / covalent max **1** mark*
ignore charges on ions formed

1

(c) (i) any **one** from:

- ions / atoms / they are / it is negatively charged / anions
  accept they are negative
- opposite (charges) attract
  accept they are <u>attracted</u> or it is oppositely charged
  ignore opposite forces attract

1

(ii) hydrogen

accept H_2
ignore H or H^+

1

(d) (i) poisons released into environment (owtte)

accept any sensible idea of harm / harmful / poisons / poisonous / pollution / damaging
*do **not** accept answers such as global warming / ozone layer etc.*
ignore safety unless qualified

1

(ii) any **one** sensible idea eg

- loss of work / unemployment
  eg shops / house prices etc.

  or
  company goes out of business
- any adverse effect on local economy (owtte)
- any adverse effect on paper production / cost of paper / cost of water (treatment)
  allow less expensive to use chlorine or converse
- chlorine (compounds) have been used (for many years) without causing harm owtte
- only a tiny amount of chlorine is released so it would not cause harm
  ignore uses of chlorine to treat drinking water unless qualified

1

(iii) ideas related to bias
accept more reliable or valid or fair
ignore more accurate / fair test

1

[8]

Q34.

(a) (i) (different) properties
allow ideas of different property / behaviour / element

1

(ii) any **one** from:
they = Crawford + Cruikshank

- they had high status

  or

  they were lecturers / doctors / professors / famous scientists
- other scientists repeated experiments
  allow experiment could be repeated
  allow other scientists showed they had different properties
- they had proof

  or

  lots of / strong / conclusive / enough / clear evidence
  ignore evidence unqualified

1

(iii) other scientists obtained similar results / proved it

or

experiments were repeated

1

(b) (i) any **one** from:

- mass of solid / strontium (chloride) / barium (chloride)
  allow amount / volume
- volume of water
  allow amount / mass
- type of container
  allow initial / starting temperature (of water)
  ignore room temperature / time / concentration
  ignore reference to hydrochloric acid

1

(ii) 2 **and** takes in heat / energy

or

2 **and** temperature goes down (owtte)

1

(iii) temperature increased for one experiment and decreased for the other (owtte)

or

one was exothermic and one was endothermic (owtte)
accept experiment 1 was exothermic

1

(c) any **one** from

- positive / + (charge)
  *do **not** accept incorrect further qualification eg electrons / atoms / electrodes*
- opposite (charges) attract

1

[7]

Q35.

(a) positive
*accept + **or** +ve **or** plus*

1

(b) chlorine

1

(c) (i) hydroxide

Any indication of hydro…

1

(ii) destroys / damages / dissolves (owtte) the hair / follicle / root

allow burns / reacts with the hair

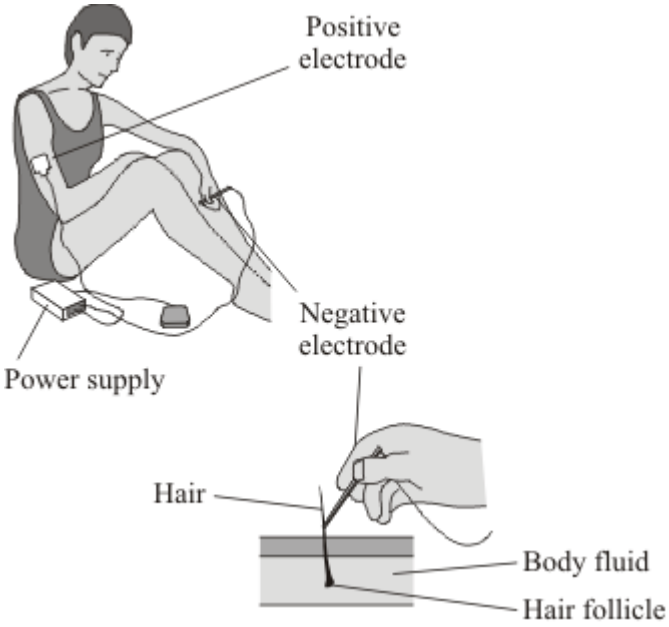
ignore incorrect name of compound

1

[4]

Q1.

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.

$Cl^- \rightarrow Cl_2$

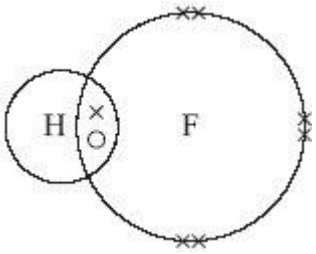
(1)

(Total 6 marks)

Q2.

This question is about fluorine and some of its compounds.

(a) The diagram represents a molecule of hydrogen fluoride.



Draw a ring around the type of bonding that holds the hydrogen and fluorine atoms together in this molecule.

covalent **ionic** **metallic**

(1)

(b) Fluorine is made in industry by the electrolysis of a mixture of potassium fluoride and hydrogen fluoride.

(i) Use **one** word from the box to complete the sentence.

gas	**liquid**	**solid**

To allow electrolysis to take place the mixture of potassium fluoride and hydrogen fluoride must be _____ .

(1)

(ii) The mixture of potassium fluoride and hydrogen fluoride contains fluoride ions (F^-), hydrogen ions (H^+) and potassium ions (K^+).

Use **one** word from the box to complete the sentence.

fluorine	**hydrogen**	**potassium**

During electrolysis the element formed at the **positive** electrode is

_____ .

(1)

(c) Fluoride ions are sometimes added to drinking water. It is thought that these ions help to reduce tooth decay.

(i) Tick (✓) **one** question that **cannot** be answered by scientific investigation alone.

Question	Tick (✓)
Do fluoride ions in drinking water reduce tooth decay?	
Are fluoride ions in drinking water harmful to health?	
Should fluoride ions be added to drinking water?	

(1)

(ii) Explain why you have chosen this question.

_____

_____

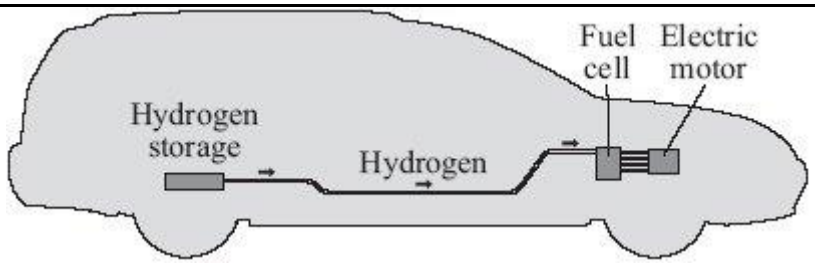
(1)

(Total 5 marks)

Q3.

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 → _____ 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.

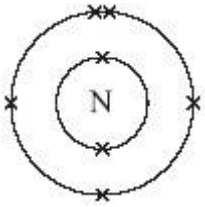
Explain why.

_____

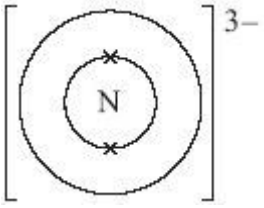
_____

(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)

Q4.

The electrolysis of sodium chloride solution produces useful substances.

(a) (i) Choose a word from the box to complete the sentence.

covalent	**ionic**	**non-metallic**

Electrolysis takes place when electricity passes through _____

compounds when they are molten or in solution.

(1)

(ii) Choose a word from the box to complete the sentence.

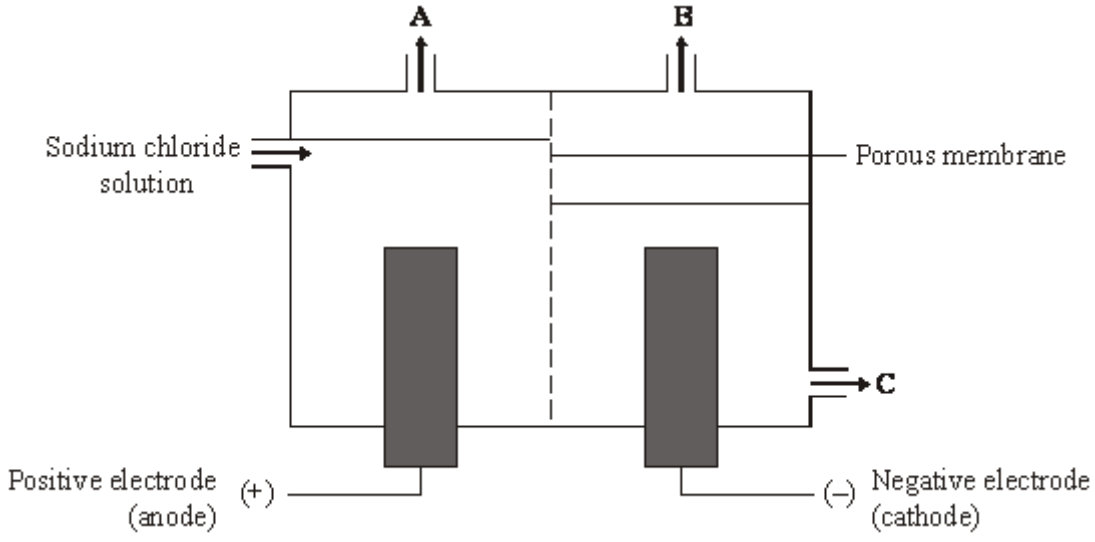
alkenes	**elements**	**salts**

During electrolysis the compound is broken down to form_____

(1)

(b) The table of ions on the Data Sheet may help you to answer this question.

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



Identify the products **A**, **B** and **C** on the diagram using substances from the box.

chlorine gas	**hydrogen gas**	**oxygen gas**
sodium hydroxide solution		**sodium metal**

(i) **A** is _____

(1)

(ii) **B** is _____

(1)

(iii) **C** is _____

(1)

(Total 5 marks)

Q5.

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

(a) Explain the meaning of *electrolysis*.

_____

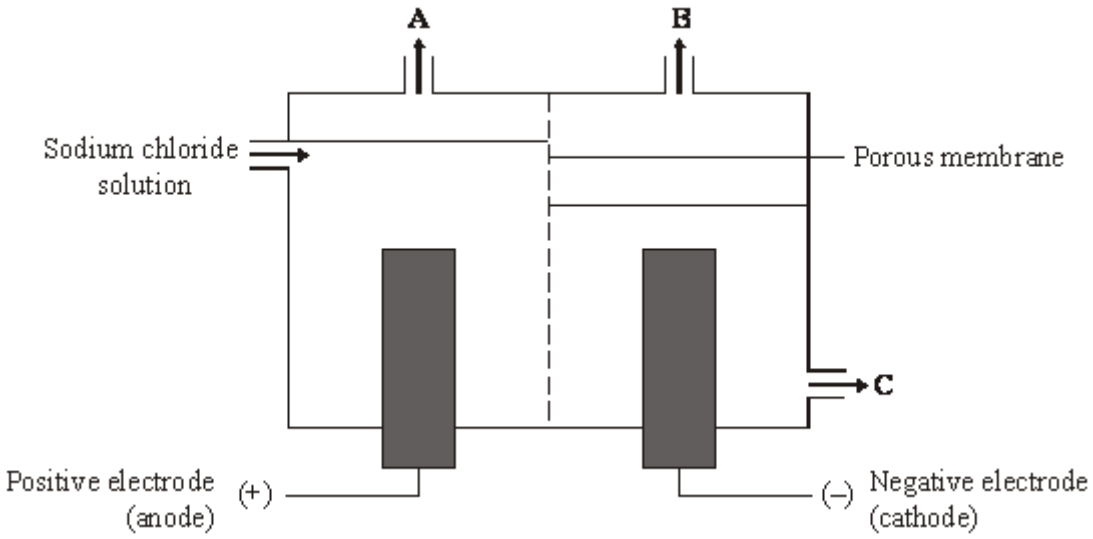
_____

_____

_____

(2)

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



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.

_____

_____

_____

_____

(2)

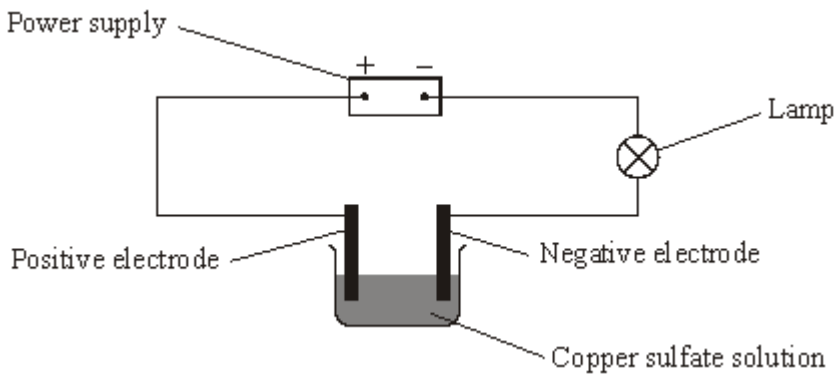
(Total 5 marks)

Q6.

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.

_____

_____

_____

_____

_____

_____

_____

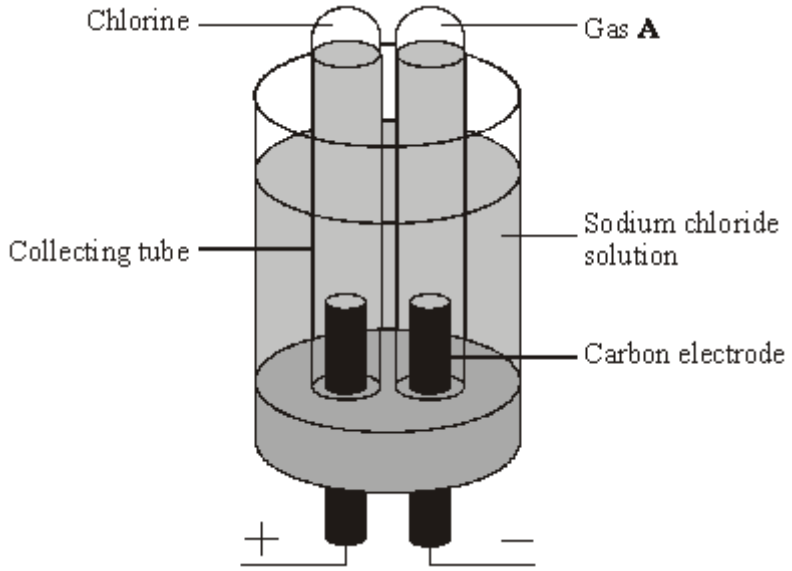
_____

(4)

(Total 8 marks)

Q7.

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.

_____

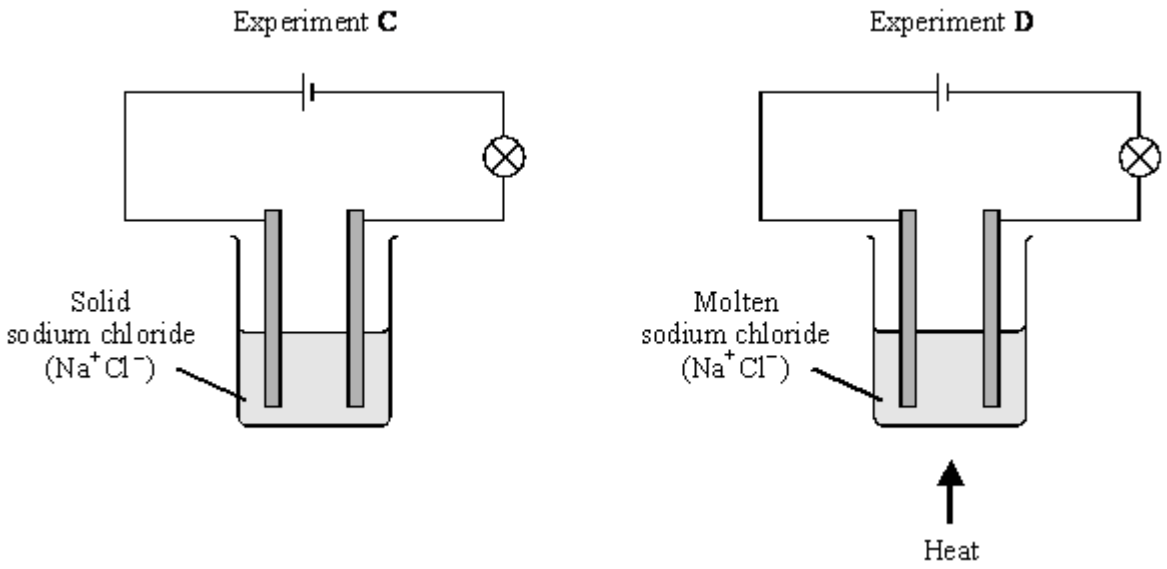
_____

(1)

(Total 6 marks)

Q8.

(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.

_____

_____

_____

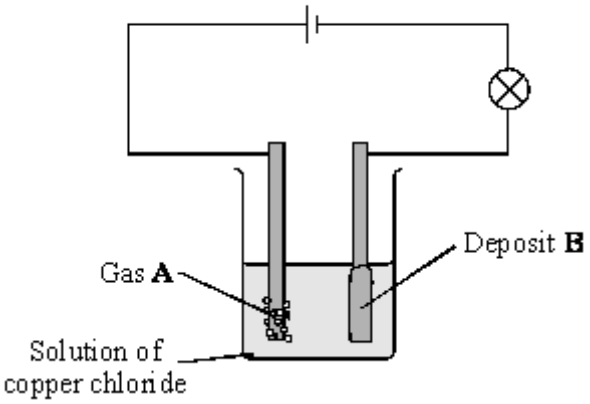
_____

_____

(2)

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

Experiment **E**



(i) What does *electrolysis* mean?

_____

_____

_____

(2)

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

_____

_____

(2)

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

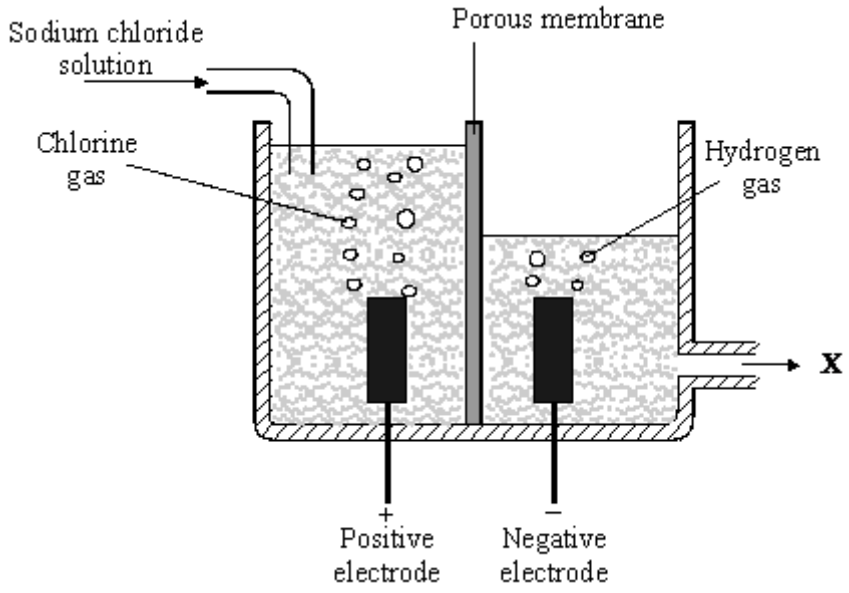
_____

(1)

(Total 9 marks)

Q9.

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.

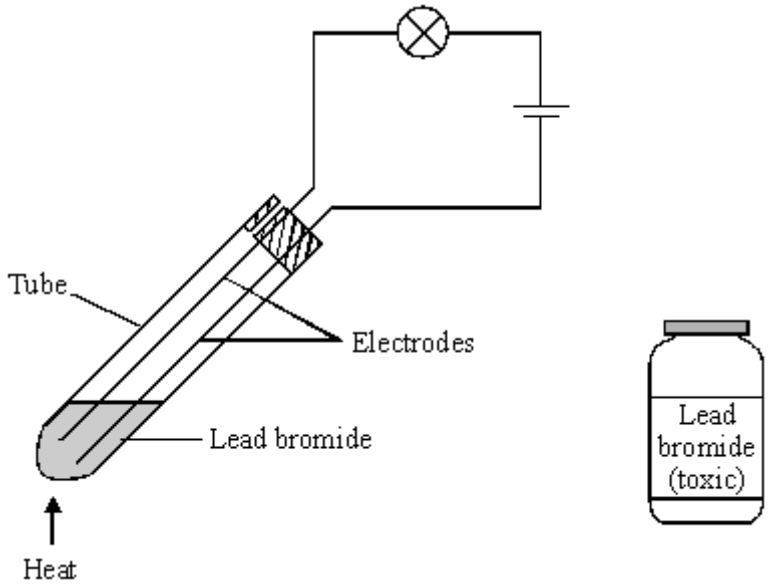
_____

(3)

(Total 7 marks)

Q10.

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.

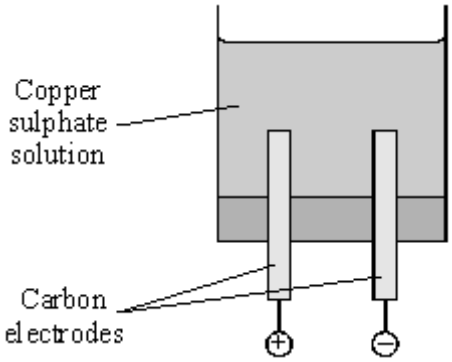
_____

(1)

(Total 6 marks)

Q11.

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)

Q12.

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?

_____

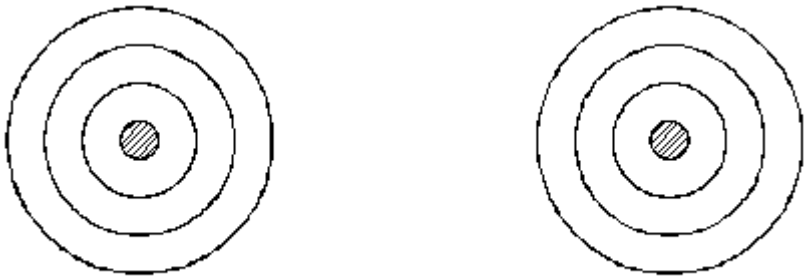
(1)

(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.



(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)

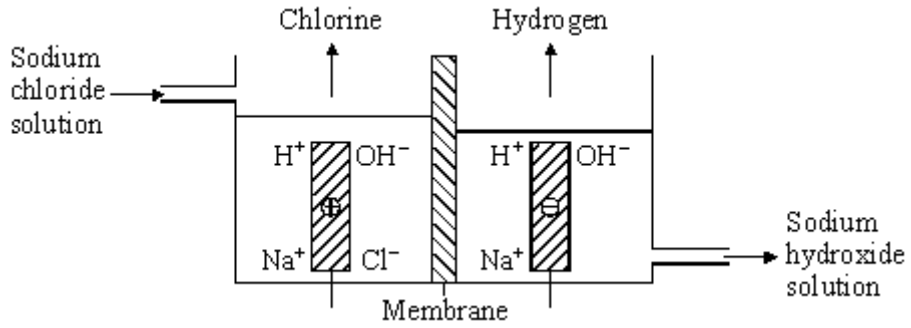
(iii) Why do these sodium and chloride particles bond?

_____

_____

(1)

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



Describe how each of these products are formed.

_____

_____

_____

_____

_____

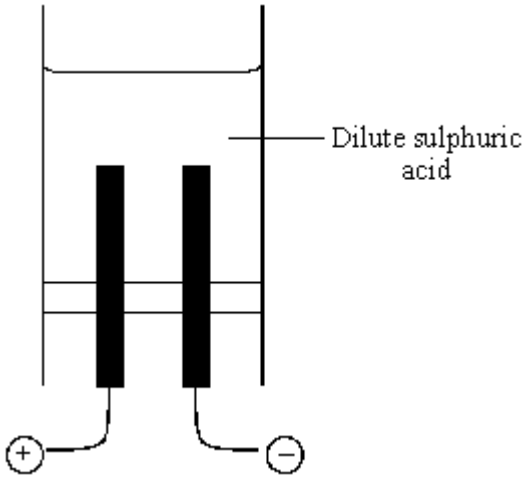
_____

(3)

(Total 15 marks)

Q13.

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)

Q14.

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

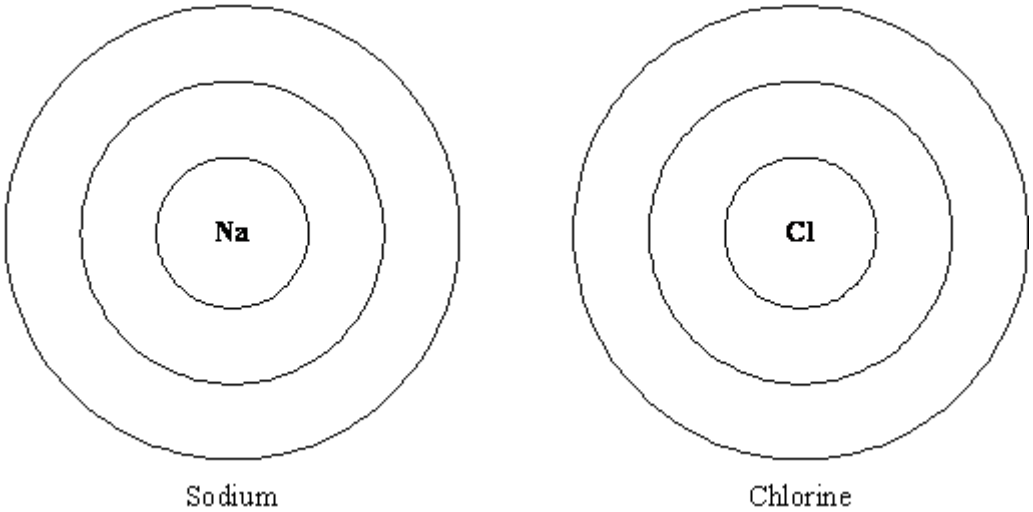
Sodium chloride can be made by burning sodium in chlorine gas.

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

$$Na_{(s)} \quad + \quad Cl_{2(g)} \quad \rightarrow \quad NaCl_{(s)}$$

(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:

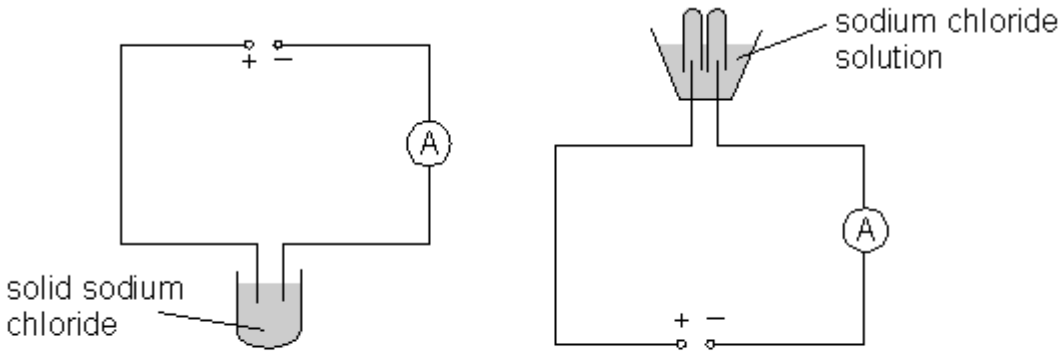
(ii) Why the reaction of potassium with chlorine is similar to the reaction of sodium with chlorine.

_____

_____

(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.



Experiment 1 Experiment 2

(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.

$H_2O_{(1)} \rightarrow H^+_{(aq)} + OH^-_{(aq)}$

$2H^+_{(aq)} + 2e^- \rightarrow H_{2(g)}$

$2Cl^-_{(aq)} - 2e^- \rightarrow Cl_{2(g)}$

(i) Which substance provides hydrogen ions?

_____

(1)

(ii) Name the product formed at:

(A) the positive electrode;

_____

(B) the negative electrode.

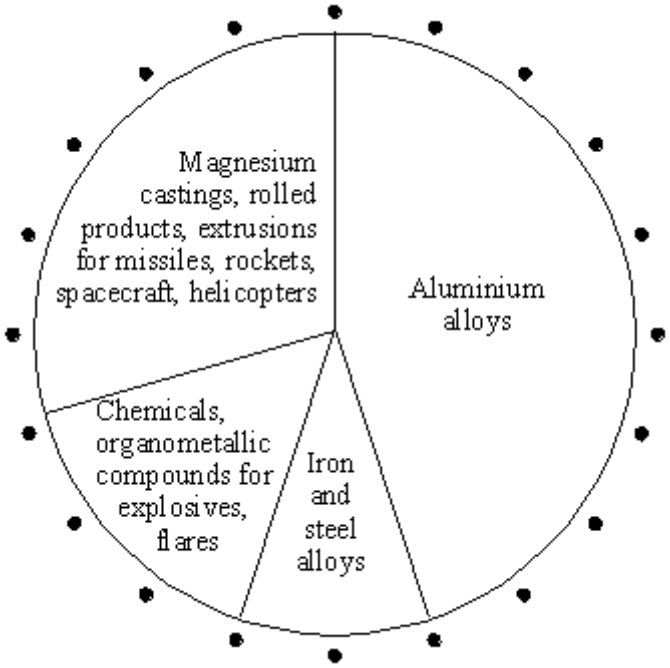
_____

(1)

(Total 15 marks)

Q15.

280 000 tonnes of magnesium are produced in the world each year. The pie chart below shows the ways in which magnesium is used.



(a) (i) Use the pie chart to calculate the percentage of magnesium used to make aluminium alloys.

_____ %

(1)

(ii) How many tonnes of magnesium are used to make aluminium alloys each year?

_____ tonnes

(1)

(b) Magnesium is produced by the electrolysis of molten magnesium chloride. The reactions which take place at the electrodes are represented by the equations below.

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

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

(i) Calculate the mass of chlorine produced when one kilogram of magnesium is made.
(Relative atomic masses: Mg = 24, Cl = 35.5)

_____

_____

_____

_____

(3)

(ii) Give a use for chlorine.

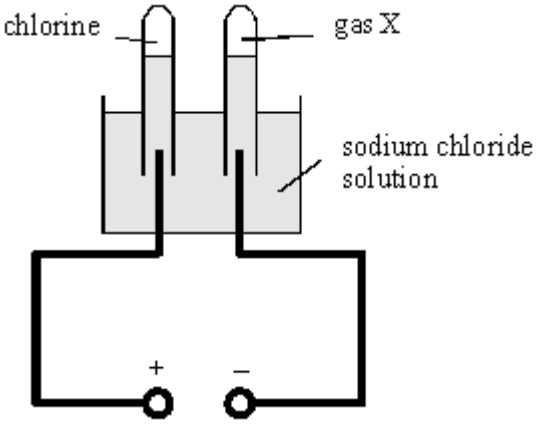
_____

(1)

(Total 6 marks)

Q16.

(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?

_____

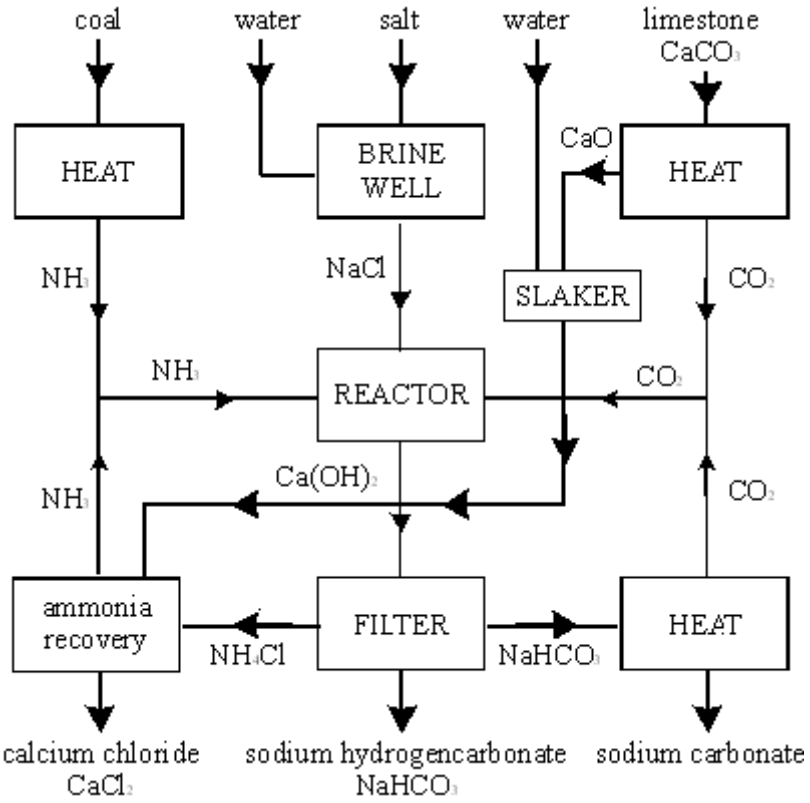
(1)

(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)

Q17.

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.

_____

_____

_____

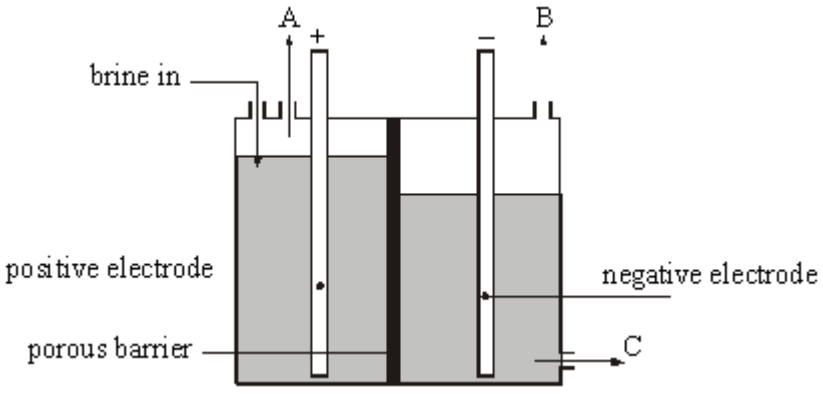
_____

(3)

(Total 13 marks)

Q18.

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)

Q19.

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)

Q20.

Use the Reactivity Series of Metals on the Data Sheet to help you to answer this question.

The table gives information about the extraction of some metals.

Metal	Date of discovery	Main source	Main extraction method
Gold	Known to ancient civilisations	In the Earth as the metal itself	Physically separating it from the rocks it is mixed with
Zinc	1500	Zinc carbonate	Reduction by carbon
Sodium	1807	Sodium chloride	Electrolysis

(a) Explain why gold is found mainly as the metal itself in the Earth.

_____

_____

(1)

(b) One of the reactions involved in producing zinc is represented by this equation.

$ZnO + C \rightarrow Zn + CO$

Explain why carbon can be used to extract zinc.

_____

_____

(1)

(c) Sodium is one of the most abundant metals on Earth.

Explain, as fully as you can, why sodium was not extracted until 1807.

_____

_____

_____

_____

(2)

(Total 4 marks)

Q21.

Read the passage carefully and then answer the questions.

The electrolysis of acidified water

After a few drops of dilute sulphuric acid have been added to some distilled water, there will be three types of ion in solution:

from the water, $H_2O(l) \rightarrow H^+(aq) + OH^-(aq)$

from the acid, $H_2SO_4(aq) \rightarrow 2H^+(aq) + SO_4^{2-}(aq)$

When the electrodes (anode and cathode) in a circuit are put into the acidified water, the hydroxide ions and the sulphate ions are both attracted to the electrode called the anode. However, it is harder for the sulphate ions to give up their electrons than for the hydroxide ions to do this. So the hydroxide ions are the ones which react and bubbles of oxygen are formed at the anode.

There are only hydrogen ions to be attracted towards the cathode and, when they get there, they take up electrons to form hydrogen molecules.

From Chemistry Matters by Richard Hart, reproduced by permission of Oxford University Press

Even in a small volume of water acidified with dilute sulphuric acid there will be billions of ions. Some will be anions and some will be cations.

(i) Name the ions in water acidified with dilute sulphuric acid.

_____

(1)

(ii) Explain why only some of the ions are attracted to the anode.

_____

_____

_____

(2)

(iii) Balance the equation for the reaction of hydroxide ions at the anode.

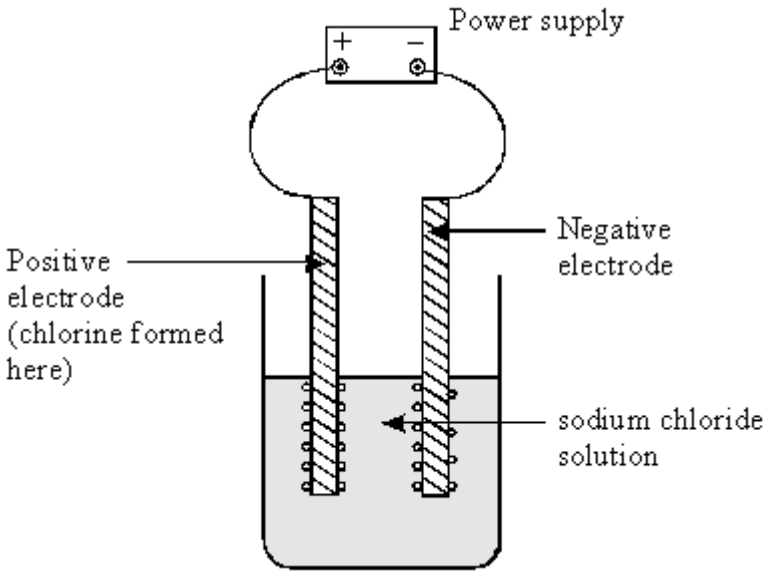
$4OH^- \rightarrow H_2O + O_2 + e^-$

(1)

(Total 4 marks)

Q22.

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.

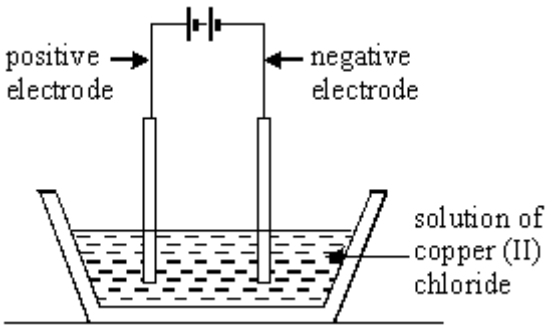
_____

(1)

(Total 4 marks)

Q23.

Copper metal can be extracted from a solution of copper(II) chloride.



Copper chloride is an ionic compound.

State where the copper would collect and explain your answer fully.

_____

_____

_____

(Total 2 marks)

Q24.

Cassiterite is an ore of the metal tin.

(a) What is an ore?

_____

_____

(2)

(b) Some metals are obtained by removing oxygen from the metal oxide.

What name do we give to this chemical reaction?

_____

(1)

(c) Name **one** metal which must be extracted from its melted ore by electrolysis rather than by using carbon.

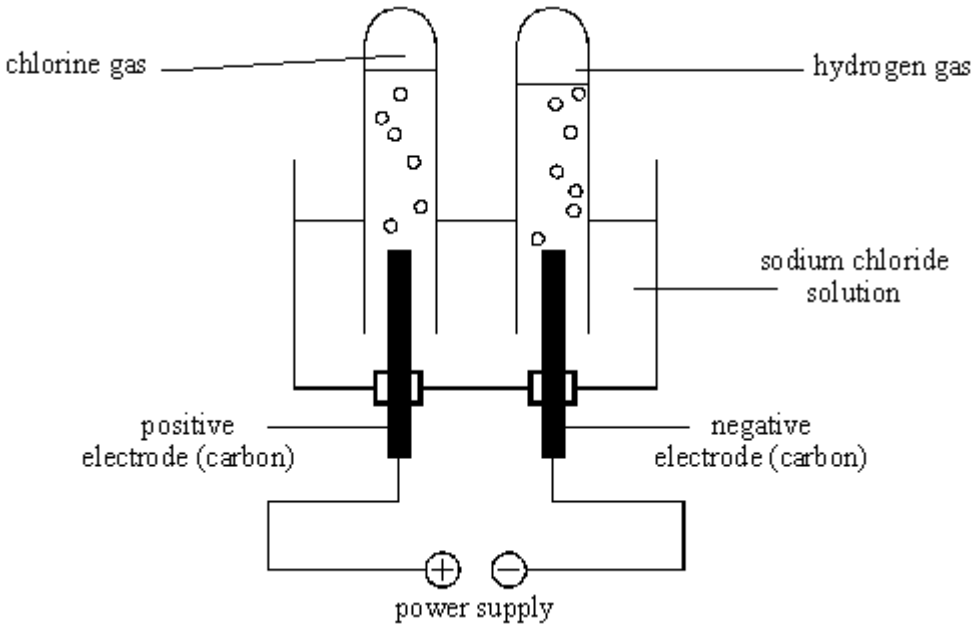
_____

(1)

(Total 4 marks)

Q25.

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)

Mark schemes

Q1.

(a) any **two** from:

- outer shell electrons / electrons in highest energy level (in metals)
- electrons are delocalised / sea of electrons
- electrons are free **or** electrons move around **or** electrons are free to flow **or** electrons attracted to positive terminal
- electrons carry charge / current **or** electrons form the current / electrons transfer charge / electrons pass charge

ignore electrons carry electricity

ignore reference to positively charged atoms / ions

*if they state electrons have +ve charge = max **1** mark*

*if they state covalent bonding then max **1** mark*

2

(b) ions can move / are attracted to electrode

accept ions are free

allow 'they' for ions

or

attracted to named electrode

or

ions are charged **or** ions form / carry the current **or** ions form the charge

1

(c) (i) electron gain

ignore hydrogen reduces charge

1

(ii) sodium hydroxide **or** NaOH **or** caustic soda

*do **not** allow hydroxide alone*

1

(iii) $2Cl^- - 2\ e^- \rightarrow Cl_2$

or

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

*allow fractions **or** multiples*

*allow e **or** e^-*

*do **not** allow e^+*

1

[6]

Q2.

(a) covalent

1

(b) (i) liquid

1

(ii) fluorine

accept F / F_2

*do **not** accept fluoride*

1

(c) (i) should fluoride ions be added to drinking water?

1

(ii) any **one** from:

- not enough reliable/valid evidence
- may be other factors involved
- it is an opinion / choice / belief / ethics issue
- it can't be scientifically investigated

allow can't do an experiment

ignore test

mark independently of (c) (i)

1

[5]

Q3.

(a) (i) any **one** from:

- they are positive / cations
- they are H^+
- opposite charges attract

ignore atom

1

(ii) potassium is more reactive (or reverse)

assume 'it' refers to hydrogen

allow potassium reacts <u>with</u> water

*allow potassium is very reactive **or** most reactive metal / element*

allow hydrogen gains electrons more easily / is reduced more easily

accept potassium is higher up the reactivity series

1

(b) 6 **and** 2

accept correct multiples and fractions

1

(c) (i) the reaction / it is reversible **or** a description of a reversible reaction

allow 'it is an equilibrium'

allow reversible symbol drawn correctly

allow 'the reverse / back reaction'

1

(ii) **lithium nitride**

assume that 'it' or if they do not specify means lithium nitride

assume lithium / lithium nitrate refers to lithium nitride

- hydrogen is bonded / held / absorbed / has formed a compound / reacted with lithium nitride

1

plus **one** of:

- does not explode / cause a fire
- is not free / less hydrogen
- is not under pressure
- does not leak
- is only released slowly

1

- compound of hydrogen with lithium nitride / product is (more) stable / less reactive / less chance of a reaction

accept converse for hydrogen as below

assume that gas / hydrogen means gas in the cylinder

- *hydrogen (in cylinder) / gas is not bonded / held absorbed / in a compound / reacted with lithium nitride*

1

*plus **one** of:*

- *can explode / cause a fire*
- *is free*
- *is under pressure*
- *can leak*
- *releases quickly*

1

(d) (i) loss of an electron **or** loses electrons

do not accept any ref. to oxygen

1

(ii) full outer shell of 8 electrons on circle

need not be paired

can be ×, dot or e

*do **not** accept if extra electrons added to inner shell*

1

[10]

Q4.

(a) (i) ionic

1

(ii) elements

1

(b) (i) chlorine (gas)

allow Cl_2 / Cl / Cl^2

allow chloride

1

(ii) hydrogen (gas)

allow H / H_2 / H^2

1

(iii) sodium hydroxide (solution)

allow NaOH

allow sodium solution

1

[5]

Q5.

(a) electric current / electricity

1

plus **one** from:

- is passed through <u>ionic</u> compound / substance / electrolyte
- passed through molten/aqueous <u>compound</u> / <u>substance</u>

  must be linked to electricity

  allow liquid compound / substance

  *do **not** allow solution / liquid alone*
- causing decomposition

  accept split up / breakdown / breaking up owtte

  ignore separated

  accept elements are formed

  ignore new substances form

1

(b) hydrogen

accept H_2

*do **not** accept H / H^2*

1

(c) one electron from each atom

accept each carbon is bonded to three other carbon atoms leaving one (unbonded) electron owtte

1

is delocalised / free (to move)

must be linked to electrons

*answers of delocalised / free electrons only, gains **1** mark*

*accept each carbon is bonded to three other carbon atoms leaving delocalised / free electrons = **2** marks*

***maximum 1** mark if graphite described as a metal / giant ionic lattice*

1

[5]

Q6.

(a) (propanone) has a low(er) boiling point

***or** water has a high(er) boiling point **or** water evaporates slow(er)*

or (propanone) evaporates fast(er) owtte

allow propane / solution / it

*allow evaporates at lower temperature **or** boils quicker*

ignore density / reactivity / melting point

1

(b) (i) 0.29

*ignore + **or** –*

ignore units

1

(ii) any **two** sensible suggestions eg:

- weighing error
  *accept human error **or** inaccurate measurements*
- (copper) lost during washing owtte
  allow different washing of electrodes
- (copper) lost during electrolysis / reaction owtte
- electrodes not completely dry
- impurities in the electrode
- copper falling off when removing electrode / copper from cell
  ignore timing errors
  ignore 'fair test'
  ignore sludge

ignore gases produced

2

(c) any **four** from:

- impure copper is anode / positive (electrode)
- pure copper is cathode / negative (electrode)
- copper sulfate solution **or** any soluble copper salt in solution
- copper loses electrons **or** copper is oxidised(*)
- copper forms positive ions / particles(*)

  (*)as alternative to these two points $Cu \rightarrow Cu^{2+} + 2e^{-}$ = ***2*** *marks*
- copper gains electrons **or** copper reduced at negative electrode

  or $Cu^{2+} + 2e^{-} \rightarrow Cu$ *at negative electrode*
- copper attracts to / collects at negative electrode
- sludge / impurities collect at the bottom owtte

  *allow sludge left behind **or** sludge left in solution **or** impurities separated from copper*
- impurities not attracted to electrode

  ignore get rid of impurities

4

Q7.

(a) hydrogen

accept H_2
*do **not** accept H*

1

(b) litmus paper / Universal Indicator paper / pH paper

allow any suitable named indicator

1

bleached / turns white **or** loses its colour

*do **not** accept bleached cloth / leaves etc.*
allow second mark unless incorrect indicator given
allow starch iodide paper (1)
goes black / blue black (1)
allow potassium iodide solution (1) goes brown / orange / black precipitate (1)

1

(c) because they have a negative charge **or** opposite charges attract

accept (because) it is Cl^-
*accept chlorine, Cl **or** chlorine ions has a negative charge*
*do **not** accept* Cl^- *on its own*

*do **not** accept Cl_2 o.e. has negative charge*

1

(d) kill bacteria / germs, etc. **or** sterilise / disinfect

accept destroys bacteria etc.
ignore clean / purify water (owtte)
*do **not** accept just gets rid of bacteria*

1

(e) hydroxide (ion)

accept OH^-

1

[6]

Q8.

(a) (i) bulb lights up

1

bubbles / fizz / gas or chlorine given off

1

(ii) in solid, ions

1

are not free to move / (charged) particles cannot move or converse

atoms / electrons cannot move worth 0 marks

1

(b) (i) breakdown / decomposition / splitting up

***not** separation*

1

by using electricity

1

(ii) gas **A** = chlorine / oxygen

1

deposit **B** = copper

1

(c) any one from:

- manufacturer of chlorine / sodium hydroxide / hydrogen / sodium
- electroplating of steel / reference to plating

  ***not** galvanising*
- extraction of aluminium / metal reactivity series specified
- purification of copper

  ***not** making copper*

1

[9]

Q9.

(i) electrolysis

1

(ii) oxidation

1

(iii) hydroxide ions **or** OH^-

*accept sodium hydroxide **or** hydroxide **or** OH for one mark only*

2

(iv) $H^+ + e^-$

1

H_2

ignore any state symbols

1

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

*accept $H^+ + e^- \rightarrow H$ for **one** mark only*

1

[7]

Q10.

(a) breakdown / decomposition / splits into elements /

***not** ions*

separates into elements / produce a chemical reaction

1

using electricity

1

(b) lead bromide melted / free ions

not electrolyte

1

(c) (+) bromine

element must be appropriate to electrode

1

(–) lead

element must be appropriate to electrode

1

(d) fume cupboard / protective clothing

allow safety glasses
***not** safety mat*

1

[6]

Q11.

(a) substance brokendown / separates / splits into elements

by electric current / electricity

ions free to move e.g. when molten / in solution

allow 1 mark for "a substance that conducts electricity"

max 2

(b) (i) copper / Cu

1

(ii) oxygen /O_2

allow CO_2

1

(c) tube over electrode

full of $CuSO_4$(aq) / water

allow sulphuric acid / sensible electrolyte

***not** any other liquid / using a syringe*

2

(d) Cu^{2+} ions removed / less Cu^{2+}

***not** copper sulphate removed*

allow 1 mark for "copper removed / less copper"

2

[8]

Q12.

(a) (i) H_2SO_4 **or** red (acidic) pH < 7

accept names of compounds

accept correct use of acidic

1

NaOH **or** purple (alkaline) pH > 7

*alkaline and neutral without any mention of pH for **1** mark only*

1

NaCl **or** green (neutral) pH 7

*ignore high **or** low pH*

1

(ii) hydrogen (ion)

accept proton

accept hydroxonium ion

1

H^+

accept H_3O^+ for hydroxonium ion

1

(b) (i) neutralisation

1

(ii) NaOH + HCl

ignore state symbols

1

NaCl + H_2O

ignore state symbols

*maximum of **1** mark if incorrectly balanced*

1

(c) (i) sodium – 2 . 8 . 1

accept 2.8.1 written

1

chlorine – 2 . 8 . 7

accept 2.8.7 written

1

(ii) ion(s)

1

(iii) attraction between oppositely charged particles (ions)

accept attraction between + and – particles (ions)

accept electrostatic attraction

1

(d) chloride ions lose electrons to form chlorine

$Cl^- - e^- \rightarrow Cl$

1

hydrogen ions gain electrons to form hydrogen

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

1

sodium hydroxide remains in solution

Na + and OH^- remain in solution to form sodium hydroxide

1

[15]

Q13.

(a) electrolytes

1

(b) oxidation

1

electrons lost

1

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

minus sign on e^- not needed

2

(d) concentration increases

1

OH^- discharged from water / water decomposes

1

H^+ concentration increases / H_2 and O_2 evolved

1

[8]

Q14.

(a) 2 2 multiples of ½ allowed

for 1 mark

1

(b) (i) 2. 8. 1 and 2. 8. 7

gains 3 marks

1 mark for 2 electrons in each inner shell
1 mark for 8 electrons in each second shell
1 mark for 1 electron in sodium outer shell
and 7 in chlorine outer shell

3

(ii) sodium atom loses;
electron;
chlorine atom gains;
electron

for 1 mark each

inversion = 2 marks
lose negative charge = 1 mark

4

(c) (i) KCl (accept 2KCl)

for 1 mark

1

(ii) both have on electron in outer shell/same number of electrons/
lose same number of electrons in compound formation/
both lose one electron

for 1 mark

1

(d) 0 amps;
the ions;
cannot move in the solid
solid Na chloride does not conduct

for 1 mark each

3

(e) (i) water (H_2O)

for 1 mark

1

(ii) (1) chlorine;

(2) hydrogen

for 1 mark

1

[15]

Q15.

(a) (i) 45%

for 1 mark

1

(ii) 126 000 (consequential on (i))

for 1 mark

1

(b) (i) $Cl_2 = 71$
$1 \times 71/24$ or correct mathematical attempt

for 1 mark

(If Cl_2 wrong take figure given)

for 1 mark

= 2.96 kg

gains 3 marks

(or alternative methods)
(if units not given - 3 marks. If units wrong - 2 marks)

3

(ii) any sensible eg. bleach/disinfectant/antiseptics/kill bacteria/ sterilise water/solvents/refrigerents/CFCs/PVC
(not water treatment or warfare)

for 1 mark

1

[6]

Q16.

(a) (i) hydrogen/H_2

for 1 mark

1

(ii) i.e. $2Cl^- - 2e^- \rightarrow Cl_2$

for 1 mark

1

(iii) hydroxide or OH^-

for 1 mark

1

(iv) sodium hydroxide/caustic soda/NaOH/bleach/ chemical name of bleach

for 1 mark

1

(b) (i) Na_2CO_3 or $(Na+)_2\ CO_3^{2-}$

for 1 mark

1

(ii) coal
water/H_2O
limestone/$CaCO_3$/calcium carbonate

any one for 1 mark

1

(iii) calcium chloride/$CaCl_2$/sodium hydrogen carbonate/$NaHCO_3$

for 1 mark

1

(iv) decomposition/heating of limesstone
decomposition/heating of coal
decomposition/heating of sodium hydrogen carbonate

any 1 for 1 mark

1

described change e.g. $NaHCO_3 \rightarrow Na_2\ CO_3$
(Use judgement)
breakdown (owtte.)
by heat

for 1 mark each

2

(v) carbon dioxide/CO_2 or ammonia/NH_3

for 1 mark

1

(c) (i) zinc carbonate/$ZnCO_3$/zinc hydroxide/$Zn(OH)_2$

for 1 mark

1

(ii) It is insoluble
zinc carbonate is insoluble in water

for 1 mark

1

[13]

Q17.

(a) potassium / K

for 1 mark

1

(b) carbon dioxide / CO_2

for 1 mark

1

(c) losing

electrons
gaining
electrons

for 1 mark each

4

(d) (i) power supply, (not mains)
beaker containing solution,
(inert) electrodes and circuit
ammeter or bulb/
(or see bubbling etc. at electrodes written by drawing)

for 1 mark each

4

(ii) reading on ammeter/bulb lights / (solution) conducts (electricity)
bubbling / gas produced
hydrogen produced
chlorine / oxygen produced
ions move
to electrodes (must be linked to ions move)
negative ions move to the positive electrode
and/or positive ions move to the negative electrode
negative ions lose electrons
and/or positive ions gain electrons

any 3 for 1 mark each

3

[13]

Q18.

(a) Gas A = Chlorine / Cl_2 not Cl and Gas B = Hydrogen / H_2 not H

for 1 mark

Solution C = sodium hydroxide/NaOH/spent brine

for 1 mark

2

(b) (i) 2, 2

for 1 mark

(ii) 2, 2

for 1 mark

2

(c) water/H_2O/hydrogen oxide not hydrogen hydroxide

for 1 mark

1

(d) ions/positive ions/negative ions/cations/anions
not charged particles/positive particles/negative particles
not H^+ / Cl^-/Na^+ / OH^-
Allow hydrogen ions etc.
not sulphate ions

for 1 mark

1

[6]

Q19.

(a) sodium hydroxide / caustic soda / NAOH

for 1 mark

1

(b) negative ions move to the positive electrode etc.
/because it is negative
/opposite charges attract

for 1 mark

1

(c) loss of electrons

for 1 mark

1

[3]

Q20.

(a) unreactive / near bottom of reactivity series

1

(b) carbon more reactive / higher up reactivity series

1

(c) very reactive / near top of reactivity series

1

cannot use displacement methods / can only be extracted by electrolysis / had to wait discovery of electricity

1

[4]

Q21.

(i) hydrogen, hydroxide and sulphate

*all **three** and no others*

any order

do not credit any formula(e)

1

(ii) the anode is positive

1

(so) only the negative ions are attracted to it

***or** (so) only the hydroxide ions and the sulphate ions are attracted (to it)*

***or** (so) only the anions are attracted (to it)*

1

(iii) $2H_2O + O_2 + 4e^-$

1

[4]

Q22.

(a) hydrogen

for 1 mark

1

(b) chloride ions are negative;
negative ions move to positive electrode

each for 1 mark

2

(c) any **one** use of chlorine e.g.
sterilisation;
bleaching;
making plastics

any one for 1 mark

1

[4]

Q23.

copper collects at the negative electrode
copper positive ions

each for 1 mark

[2]

Q24.

(a) *ideas that it is a*

- compound of metal/metal oxide/combined (NOT mixed) cpd/ named cpd O^{2-}/S^{2-}/CO_3^{2-} etc
- found naturally/in rocks/in Earth's Crust

for 1 mark each

2

(b) reduction (accept smelting/refining but not electrolysis)

for 1 mark

1

(c) One example. Al or above in Reactivity Series
ie Group I or II metals NOT Pb/Cu or compounds

for 1 mark

1

[4]

Q25.

(a) $2Cl^- - 2e^- \rightarrow Cl_2$ (allow unaltered LHS to produce ½ Cl_2)
$Na^+ + e^- \rightarrow Na$ (allow × 2 for **all** terms)

(*credit* candidates who point out that hydrogen / H_2 is in fact produced)

for 1 mark each

2

(b) for <u>product 1*</u>, *idea of* a solid / precipitate **or** silver bromide

gains 1 mark

but solid / a precipitate of silver bromide

gains 2 marks

<u>for product 2*</u>, *idea of* aqueous / a solution / dissolved (in water) / **or** sodium nitrate

gains 1 mark
(do not allow liquid)

but aqueous / a solution / dissolved (in water) of sodium nitrate

(*do not credit formulae)

gains 2 marks

4

[6]