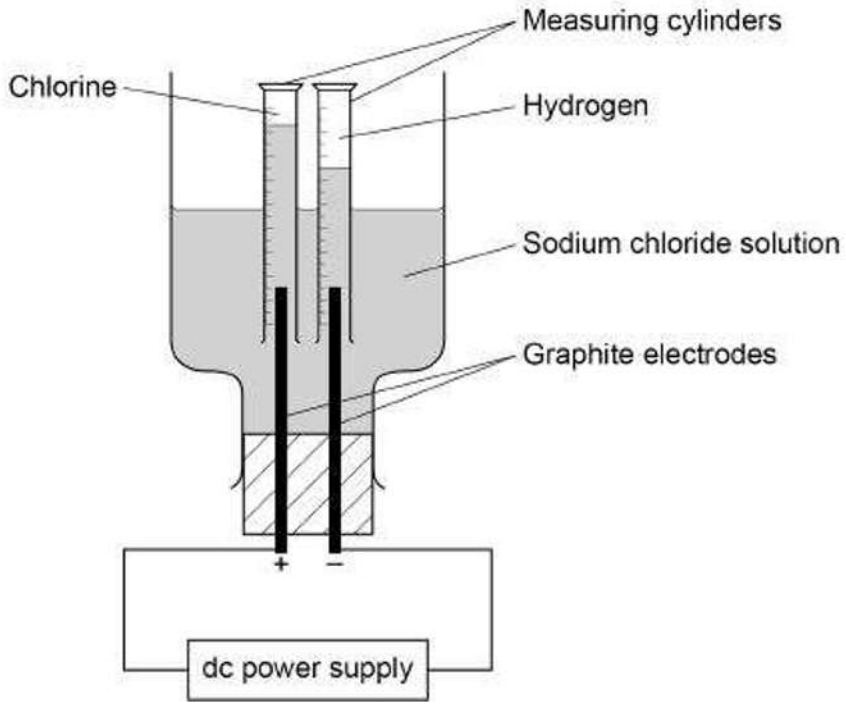
1. A student investigated the electrolysis of sodium chloride solution.

Figure 1 shows the apparatus.

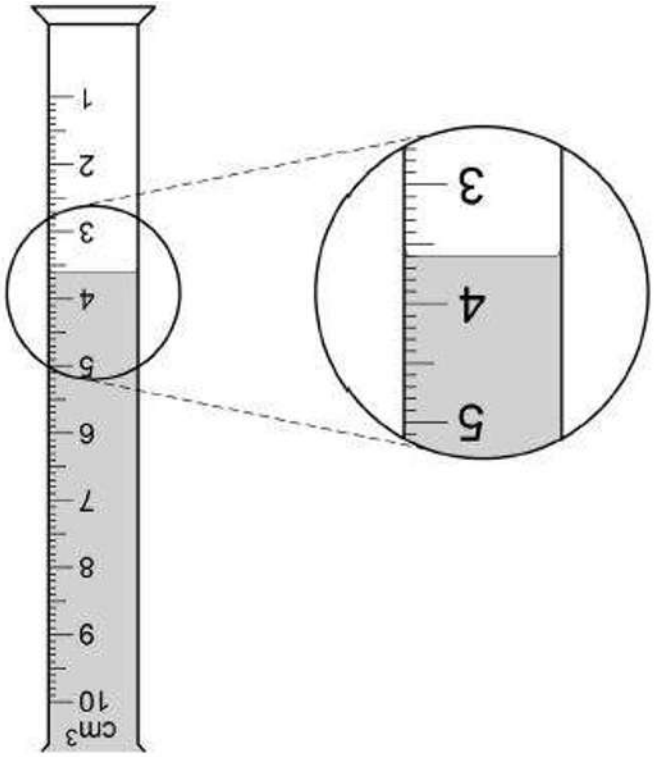
Figure 1



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



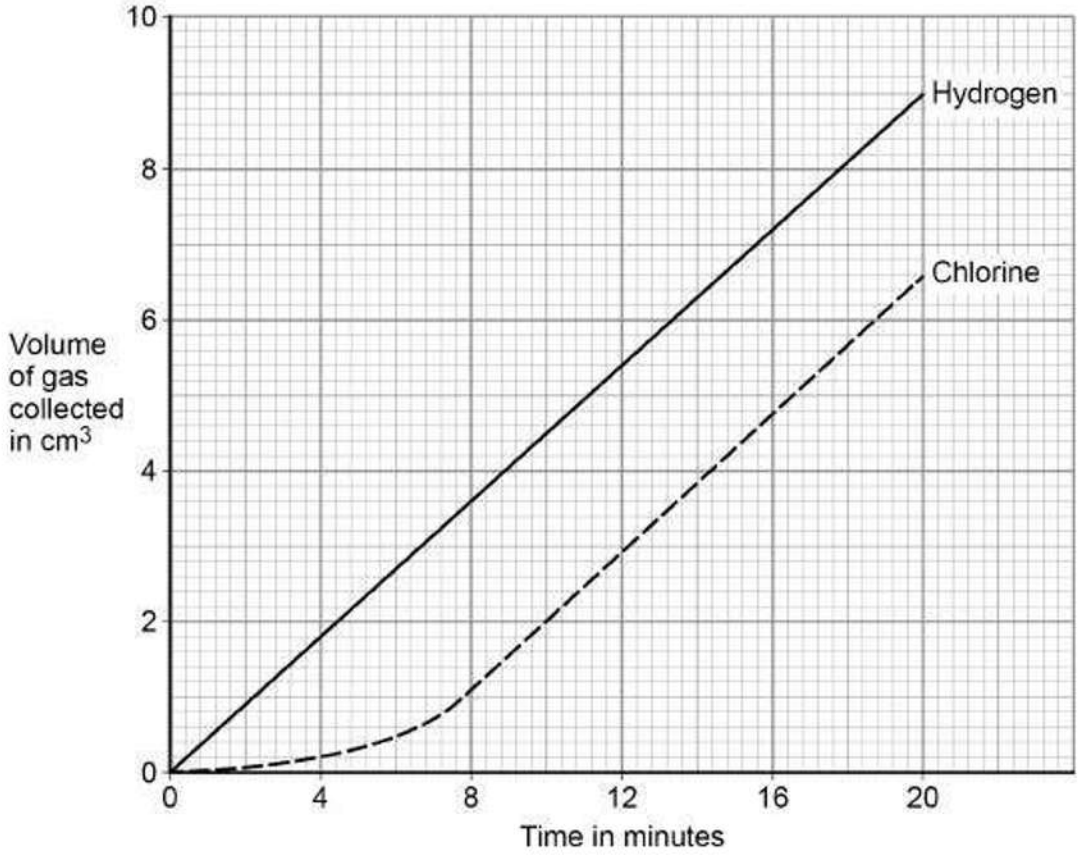
What is the volume of hydrogen gas collected?

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 ☐

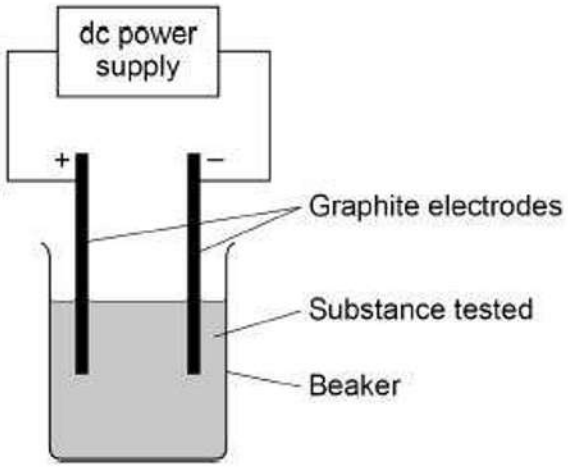
Neither line ☐

(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**

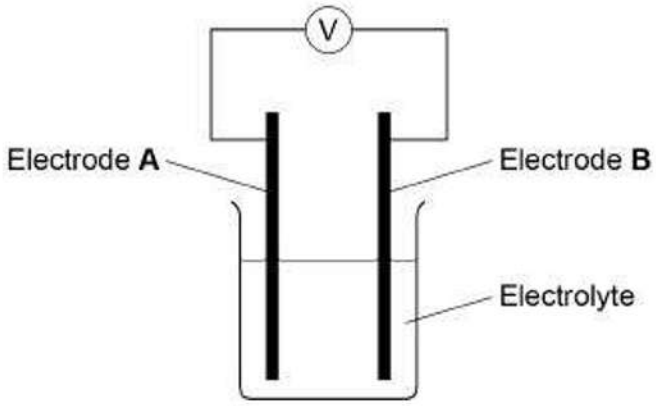
Substance electrolysed	**Product at cathode (negative electrode)**	**Product at anode (positive electrode)**
Molten zinc chloride		
Potassium bromide solution		

(4)

(Total 8 marks)

2. 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)

3. 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 _____

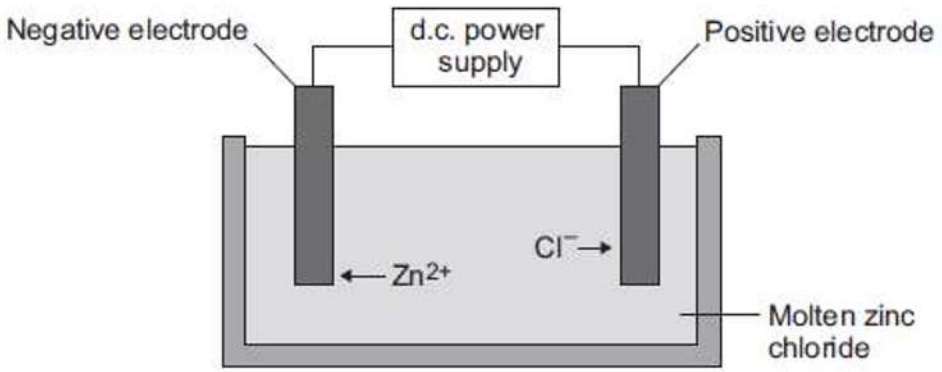
(2)

(Total 9 marks)

4. 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 ☐

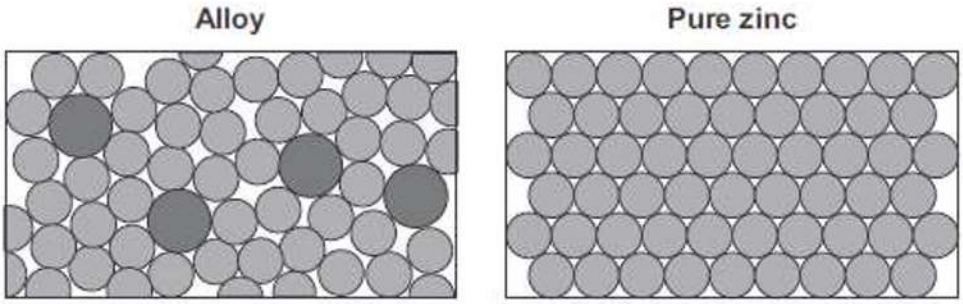
Reduction ☐

(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)

5. 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.

_____

_____

_____

_____

_____

_____

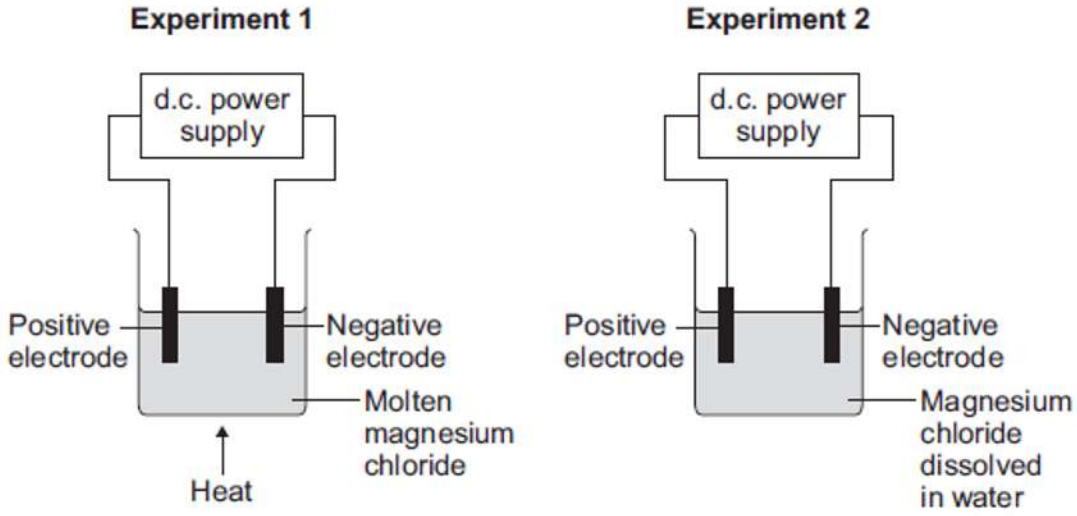
_____

_____

(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)

6. 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.

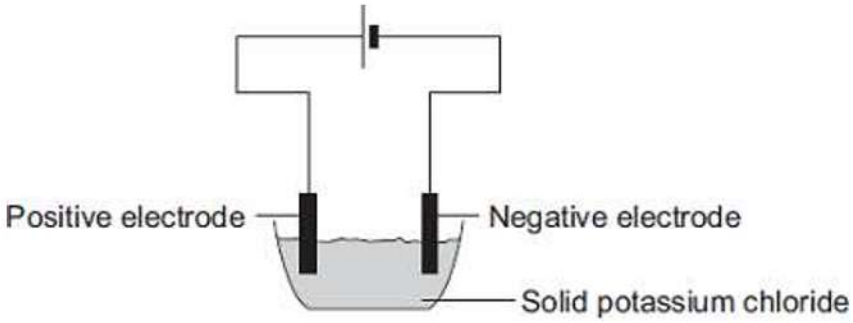
Being able to repeat Davy's experiment is important because

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)