All questions are for both separate science and combined science students

Q1.

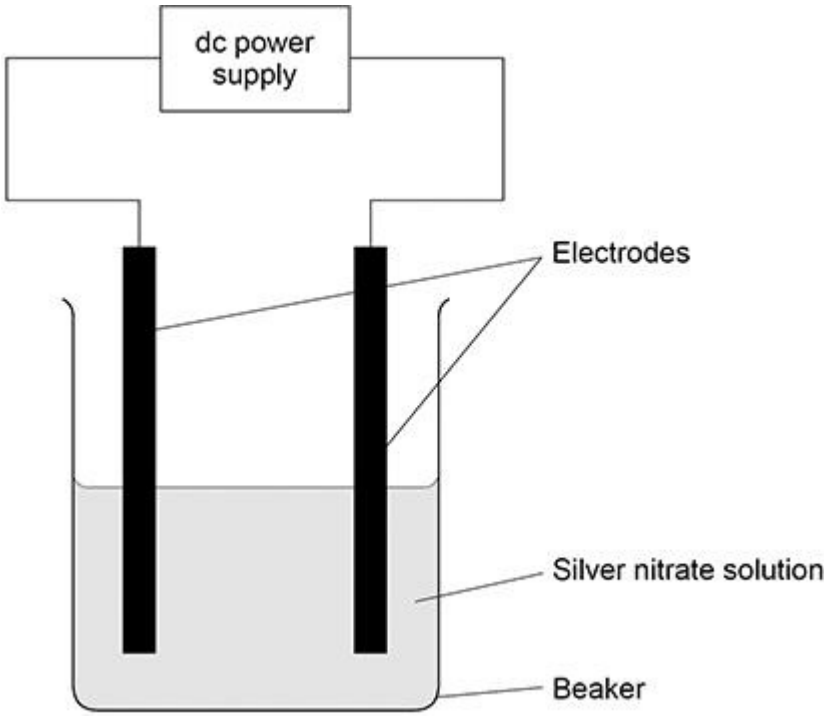
This question is about electrolysis.

Some students investigated the electrolysis of silver nitrate solution.

This electrolysis produces silver at the negative electrode.

Figure 1 shows the apparatus.

Figure 1



This is the method used.

1. Weigh the negative electrode.
2. Set up the apparatus shown in Figure 1.
3. Switch on the power supply.
4. Switch off the power supply after five minutes.
5. Rinse the negative electrode with water and allow to dry.
6. Reweigh the negative electrode.
7. Repeat steps 1 to 6 for different times.

(a) Some silver did not stick to the negative electrode but fell to the bottom of the beaker.

The students needed to weigh this silver.

How could the students separate the silver from the silver nitrate solution?

Tick (✓) one box.

By chromatography ☐

By crystallisation ☐

By distillation ☐

By filtration ☐

(1)

Table 1 shows the students' results.

Table 1

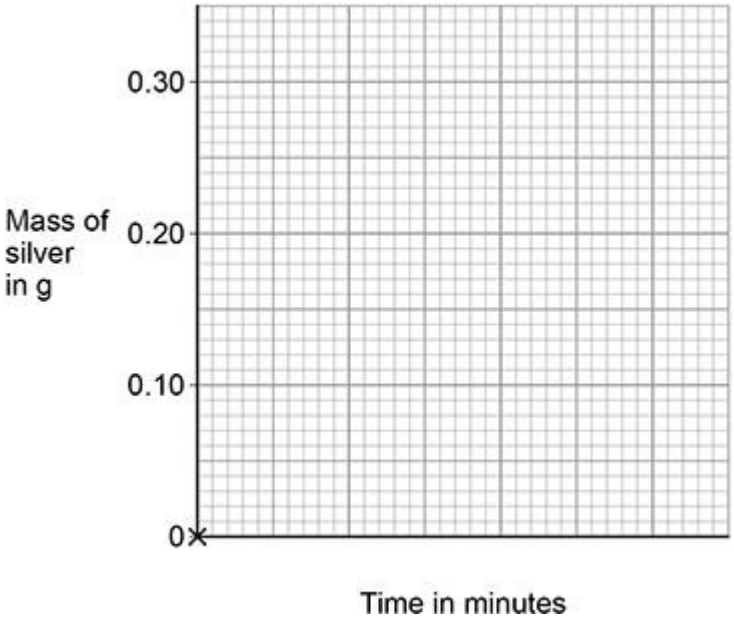
Time in minutes	Mass of silver in g
0	0.00
5	0.06
10	0.12
15	0.18
20	0.24
25	0.30

(b) Draw a graph on Figure 2.

You should:

- use a suitable scale for the x-axis
- plot the data from Table 1
- draw a line of best fit.

Figure 2



(4)

(c) Determine the mass of silver that would be produced after 12 minutes.

Use Figure 2.

Mass of silver = _____ g

(1)

(d) A student investigated the electrolysis of two aqueous salt solutions.

Hydrogen is produced at the negative electrode when the metal in the salt solution is more reactive than hydrogen.
Complete Table 2 to show what the student would observe at the negative electrode for each salt solution.

Table 2

Salt solution	Observation at negative electrode
Copper sulfate	
Sodium chloride	

(2)

(e) A teacher demonstrates the electrolysis of molten lead bromide.

The products at the electrodes are lead and bromine. Why should the teacher do the demonstration in a fume cupboard?

_____

_____

(1)

(f) Two other molten compounds are electrolysed.

Complete Table 3 to show the molten compounds and the products.

Table 3

Molten compound electrolysed	Product at the negative electrode	Product at the positive electrode
Zinc chloride		
	Potassium	Iodine

(3)

(Total 12 marks)

Q2.

This question is about chemical reactions and electricity.

(a) Electrolysis and chemical cells both involve chemical reactions and electricity.

Explain the difference between the processes in electrolysis and in a chemical cell.

_____

_____

_____

_____

(2)

(b) A teacher demonstrates the electrolysis of molten lead bromide.

Bromine is produced at the positive electrode.

Complete the half equation for the production of bromine.

You should balance the half equation.

$$Br^- \rightarrow \quad + \quad$$

(2)

(c) Two aqueous salt solutions are electrolysed using inert electrodes.

Complete the table below to show the product at each electrode.

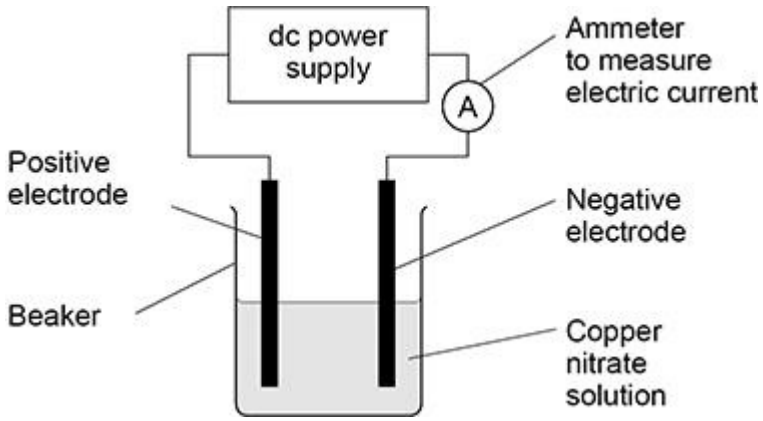
Salt solution	Product at positive electrode	Product at negative electrode
Copper nitrate		copper
Potassium iodide		

(3)

Some students investigated the electrolysis of copper nitrate solution using inert electrodes.

Figure 1 shows the apparatus.

Figure 1



The students investigated how the mass of copper produced at the negative electrode varied with:

- time
- current.

This is the method used.

1. Weigh the negative electrode.
2. Set up the apparatus shown in Figure 1.
3. Adjust the power supply until the ammeter shows a current of 0.3 A
4. Switch off the power supply after 5 minutes.
5. Rinse the negative electrode with water and allow to dry.
6. Reweigh the negative electrode.
7. Repeat steps 1 to 6 for different times.
8. Repeat steps 1 to 7 at different currents.

(d) Some of the copper produced did not stick to the negative electrode but fell to the bottom of the beaker.

Suggest how the students could find the total mass of copper produced.

_____

_____

_____

_____

_____

_____

_____

_____

_____

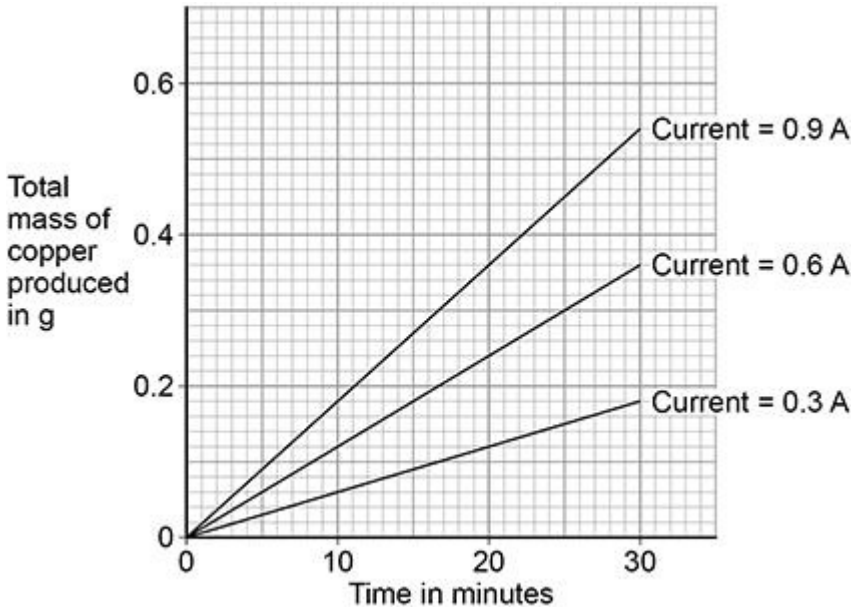
_____

(4)

The students plotted their results on a graph.

Figure 2 shows the graph.

Figure 2



A student correctly concluded that the total mass of copper produced is directly proportional both to the time and to the current.

(e) How do the results in Figure 2 support the conclusion that the total mass of copper produced is directly proportional to the time?

_____

_____

(1)

(f) How do the results in Figure 2 support the conclusion that the total mass of copper produced is directly proportional to the current?

Use data from Figure 2 in your answer.

_____

_____

(1)

(g) Copper nitrate solution is blue.

Suggest why the blue colour of the copper nitrate solution fades during the electrolysis.

_____

_____

(1)

(h) Determine the number of atoms of copper produced when copper nitrate solution is electrolysed for 20 minutes at a current of 0.6 A

Give your answer to 3 significant figures.

Use Figure 2.

Relative atomic mass (*A*r): Cu = 63.5

The Avogadro constant = 6.02 × 1023 per mole

_____

_____

_____

_____

_____

_____

Number of atoms (3 significant figures) = _____

(3)

(Total 17 marks)

Q3.

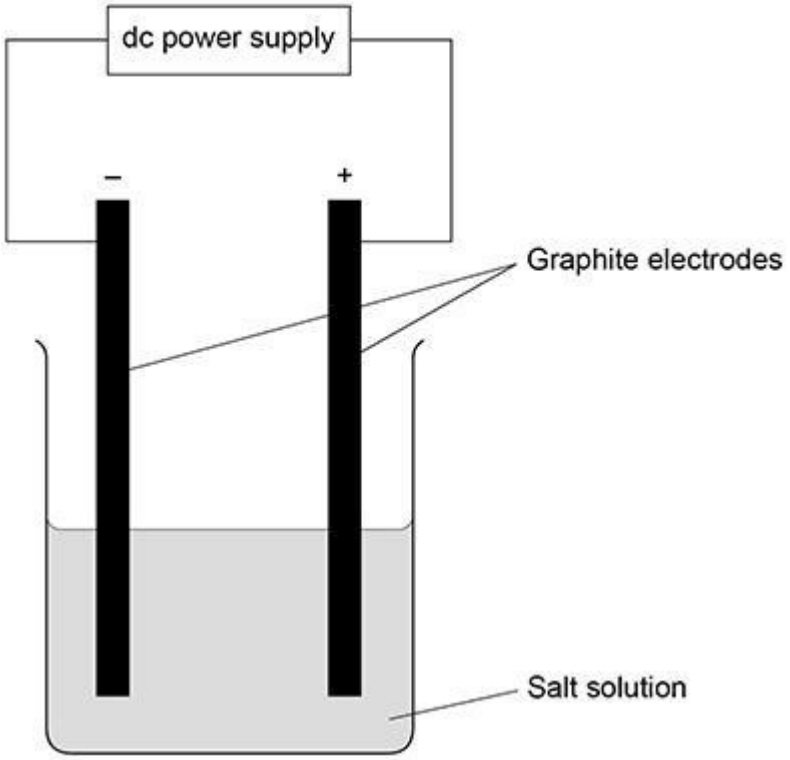
This question is about electrolysis.

A student investigated the hypothesis:

'The electrolysis of a salt solution produces a metal at the negative electrode and a gas at the positive electrode.'

Figure 1 shows the apparatus used.

Figure 1



(a) What observation would be made at each electrode if the hypothesis is correct?

Observation if metal produced at the negative electrode

_____

_____

Observation if gas produced at the positive electrode

_____

_____

(2)

The table below shows the student's results.

Salt solution	Product at the negative electrode	Product at the positive electrode
Copper chloride	Copper	Chlorine
Potassium nitrate	Hydrogen	Oxygen
Silver nitrate	Silver	Oxygen

(b) Which salt solution in table above does not match the student's hypothesis?

Give one reason why.

Salt solution _____

Reason _____

_____

_

(2)

(c) Give two reasons why graphite is used for the electrodes.

1 _____

_____

2 _____

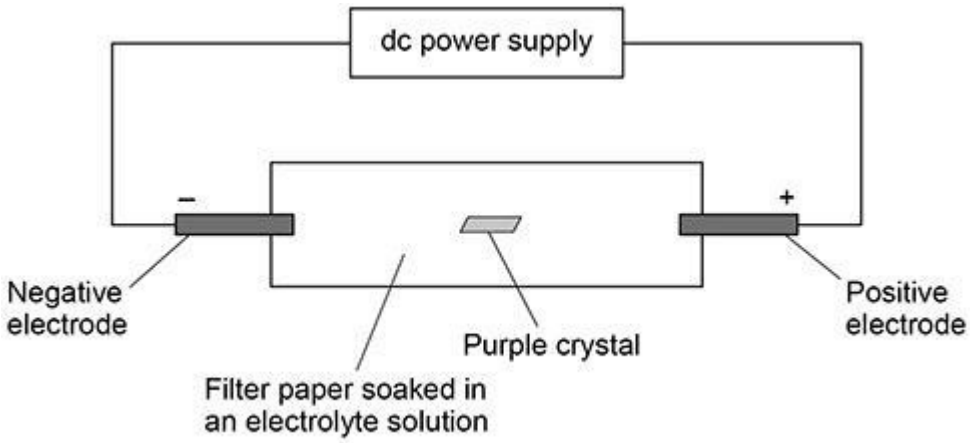
_____

(2)

A different student investigated what happens during electrolysis.

Figure 2 shows the apparatus.

Figure 2



The purple crystal contained:

- colourless positive ions
- purple coloured negative ions.

The purple crystal dissolved in the electrolyte solution.

(d) What happens to the purple coloured ions?

Give one reason for your answer.

Tick (✓) one box.

The ions do not move. ☐

The ions move towards the negative electrode. ☐

The ions move towards the positive electrode. ☐

Reason _____

_____

(2)

(Total 8 marks)

Q4.

This question is about aluminium.

(a) Aluminium is a metal.

Draw one line from each property of aluminium to the correct reason for that property.

Property	Reason
	Aluminium has delocalised electrons
Conducts electricity	Aluminium has layers of atoms which can slide
	Aluminium has strong metallic bonds
High melting point	Aluminium has weak intermolecular forces
	Aluminium has a random arrangement of atoms

(2)

(b) Aluminium can be used to make alloys.

What is meant by an 'alloy'?

_____

_____

(1)

Aluminium is extracted from bauxite.

Bauxite is a mixture which contains aluminium oxide.

(c) Bauxite contains between 15% and 25% aluminium.

Aluminium oxide always contains 53% aluminium.

How does this show that bauxite is a mixture and not a compound?

_____

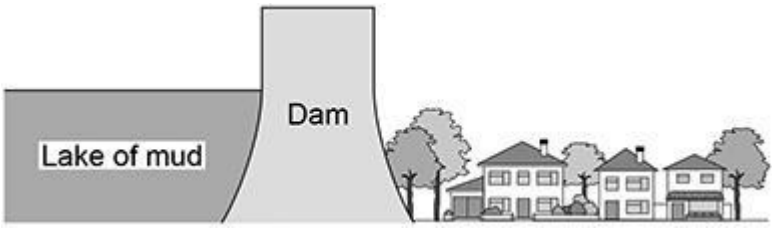
_____

(1)

(d) The waste material from the bauxite is stored in lakes of mud.

The lakes of mud are held in place by dams.

The image below shows one of these lakes.



Suggest two possible problems with storing the waste material in lakes of mud.

1 _____

_____

2 _____

_____

(2)

Aluminium is extracted by electrolysis.

The aluminium oxide is mixed with cryolite and melted.

The mixture is then electrolysed.

(e) The formula of cryolite is Na_3AlF_6

Give the total number of atoms in the formula.

Number of atoms = _____

(1)

(f) What is the reason for adding cryolite to the aluminium oxide?

Tick (✓) one box.

To increase the amount of aluminium extracted ☐

To lower the melting point of the mixture ☐

To reduce the amount of aluminium oxide needed ☐

(1)

(g) Complete the sentences.

Choose answers from the box.

aluminium	carbon	fluorine
oxygen	sodium	

When the molten aluminium oxide and cryolite mixture is electrolysed the product at

the positive electrode is _____.

This product reacts with the positive electrode because the positive electrode is

made of _____.

(2)

(h) A sample of bauxite contains 25% aluminium.

Calculate the maximum mass of aluminium that can be extracted from 300 000 kg of the sample of bauxite.

Give your answer in standard form.

_____

_____

_____

_____

_____

Maximum mass (in standard form) = _____ kg

(3)

(Total 13 marks)

Q5.

This question is about electrolysis.

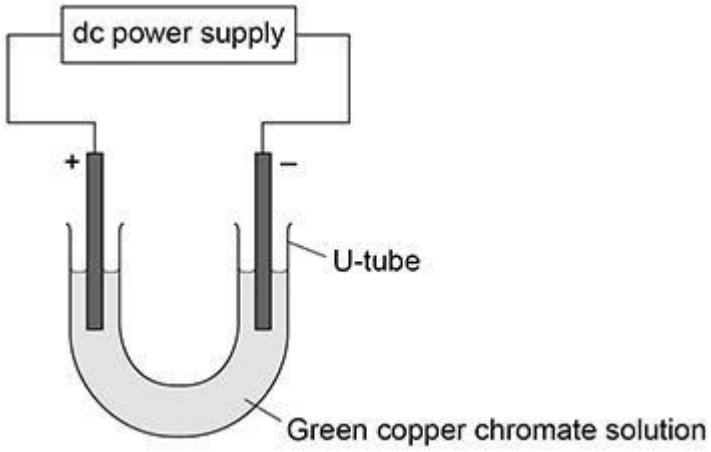
A student investigated the electrolysis of copper chromate solution.

Copper chromate solution is green.

Copper chromate contains:

- blue coloured Cu^{2+} ions
- yellow coloured CrO_4^{2-} ions.

The diagram below shows the apparatus used.



The student switched the power supply on.

The student observed the changes at each electrode.

The table below shows the student's observations.

Changes at positive electrode	Changes at negative electrode
Solution turned yellow Bubbles formed at the electrode	Solution turned blue Solid formed on the electrode

(a) Explain why the colour changed at the positive electrode.

_____

_____

_____

_____

(2)

(b) The gas produced at the positive electrode was oxygen.

The oxygen was produced from hydroxide ions.

Name the substance in the solution that provides the hydroxide ions.

_____

(1)

(c) Describe how the solid forms at the negative electrode.

_____

_____

_____

_____

_____

_____

(3)

(d) The student repeated the investigation using potassium iodide solution instead of copper chromate solution.

Name the product at each electrode when potassium iodide solution is electrolysed.

Negative electrode

_____

Positive electrode

_____

(2)

(Total 8 marks)

Q6.

This question is about electrolysis.

Aluminium is produced by electrolysing a molten mixture of aluminium oxide and cryolite.

(a) Explain why a mixture is used as the electrolyte instead of using only aluminium oxide.

_____

_____

_____

_____

(2)

(b) What happens at the negative electrode during the production of aluminium?

Tick (✓) one box.

Aluminium atoms gain electrons. ☐

Aluminium atoms lose electrons. ☐

Aluminium ions gain electrons. ☐

Aluminium ions lose electrons. ☐

(1)

(c) Oxygen is produced at the positive electrode.

Complete the balanced half-equation for the process at the positive electrode.

→ O2 +

(2)

(d) Explain why the positive electrode must be continually replaced.

_____

_____

_____

_____

_____

_____

(3)

(e) The overall equation for the electrolysis of aluminium oxide is:

$$2\,Al_2O_3 \rightarrow 4\,Al + 3\,O_2$$

Calculate the mass of oxygen produced when 2000 kg of aluminium oxide is completely electrolysed.

Relative atomic masses (*Ar*): O = 16 Al = 27

_____

_____

_____

_____

_____

_____

_____

_____

Mass of oxygen = _____ kg

(4)

Sodium metal and chlorine gas are produced by the electrolysis of molten sodium chloride.

(f) Explain why sodium chloride solution cannot be used as the electrolyte to produce sodium metal.

_____

_____

_____

_____

(2)

(g) Calculate the volume of 150 kg of chlorine gas at room temperature and pressure.

The volume of one mole of any gas at room temperature and pressure is 24.0 dm3

Relative formula mass (*Mr*): Cl2 = 71

_____

_____

_____

_____

Volume = _____ dm3

(2)

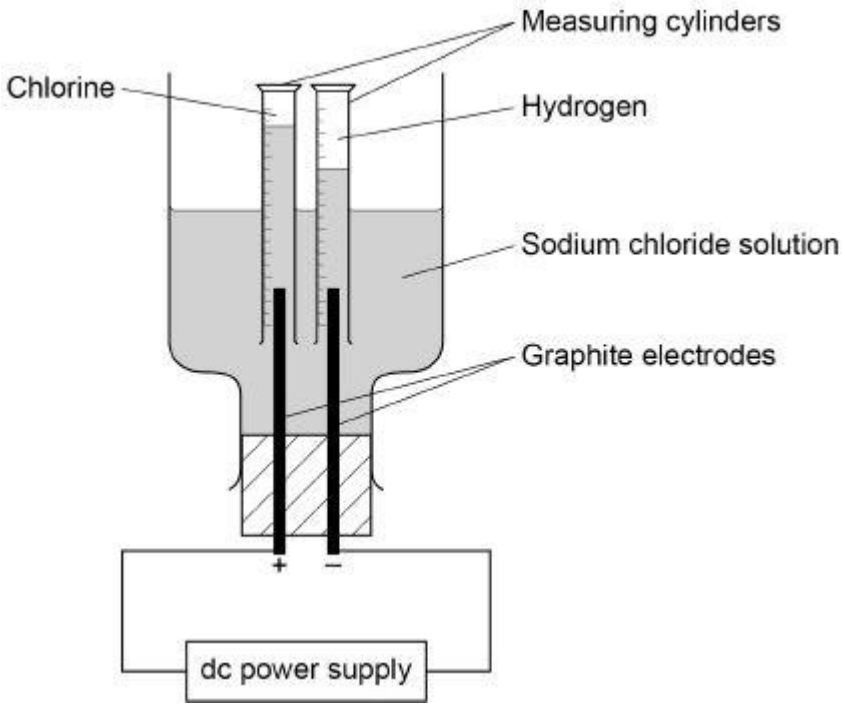
(Total 16 marks)

Q7.

A student investigated the electrolysis of sodium chloride solution.

Figure 1 shows the apparatus.

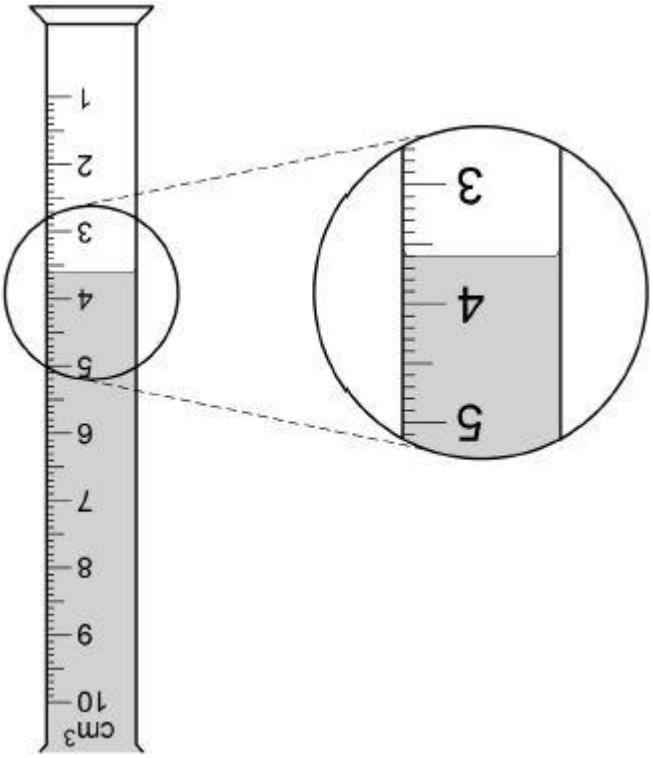
Figure 1



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



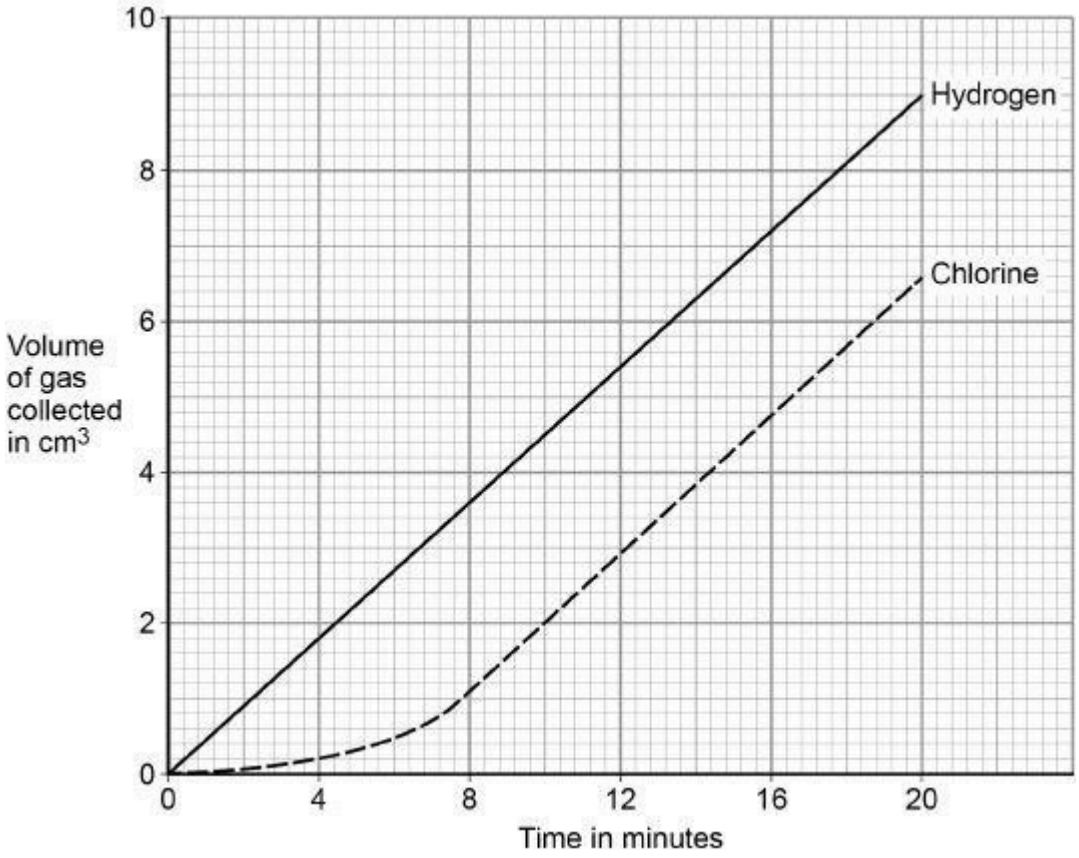
What is the volume of hydrogen gas collected?

Volume = _____ cm3

(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 ☐

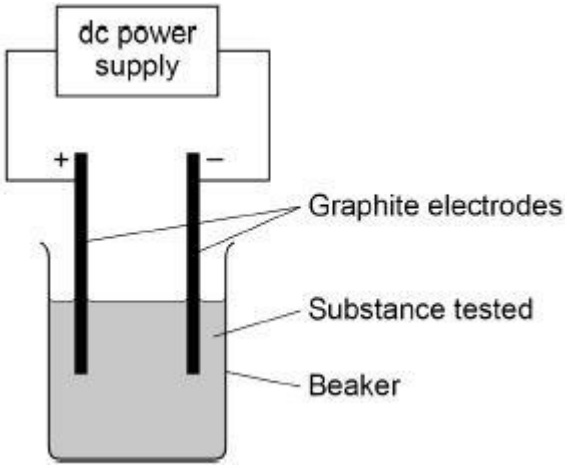
Neither line ☐

(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)

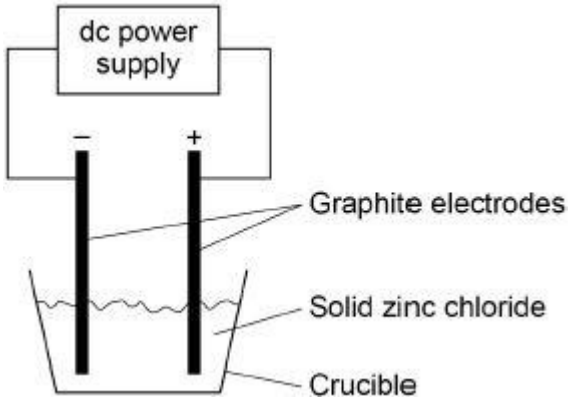
(Total 8 marks)

Q8.

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.

_____

_____

_____

_____

_____

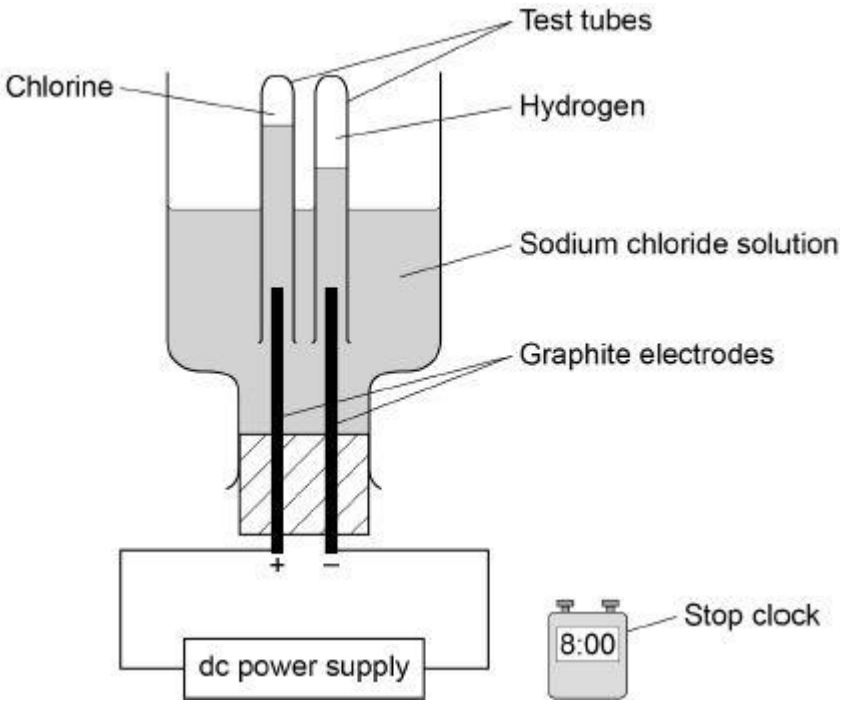
_____

(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.

_____

_____

_____

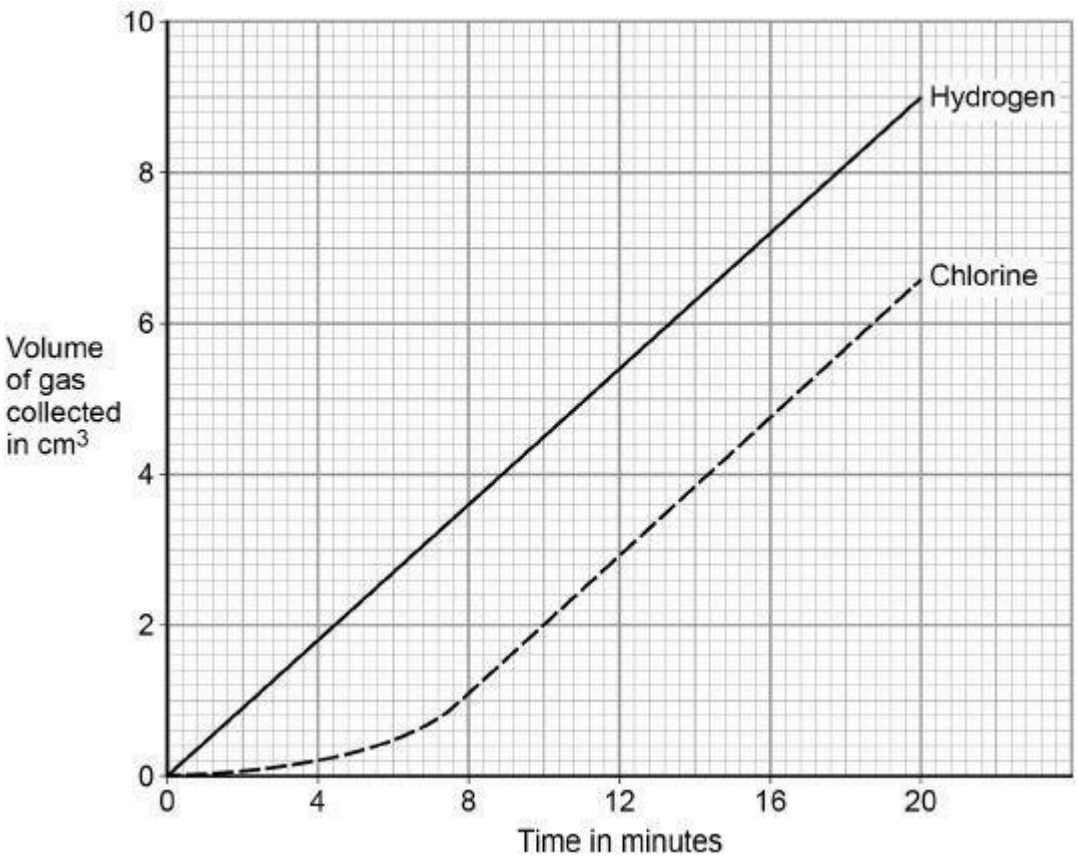
_____

(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 dm3
Give your answer in standard form.

_____

_____

_____

_____

Moles of chlorine = _____ mol

(3)

(Total 14 marks)

Q9.

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)

Q10.

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:

$$Cl2(aq) + 2KI(aq) \rightarrow I2\ (aq) + 2KCl(aq)$$

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)

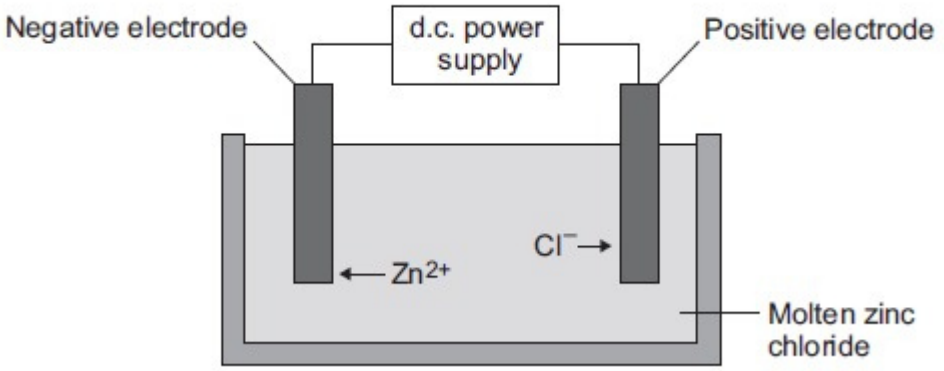
(Total 6 marks)

Q11.

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 ☐

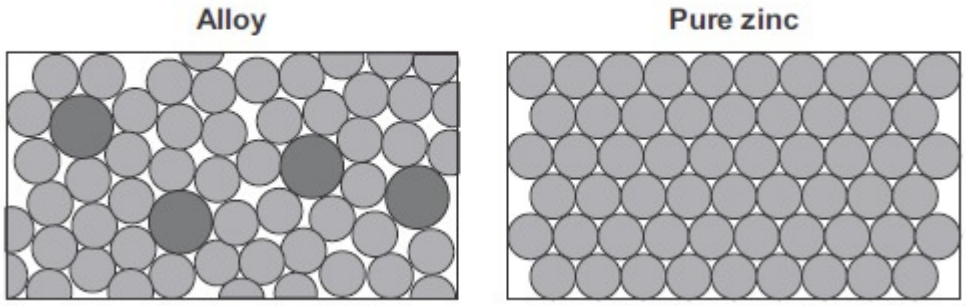
Reduction ☐

(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)

Q12.

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.

_____

_____

_____

_____

_____

_____

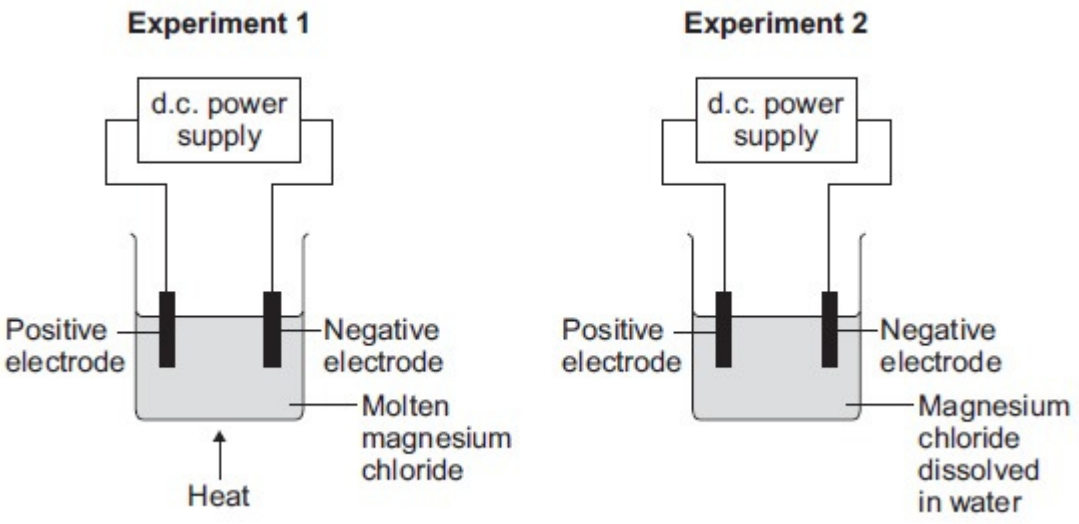
_____

_____

(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.

$$\_\_\_\_\_\ Cl^- \rightarrow Cl_2 \quad + \quad \_\_\_\_$$

(1)

(c) Magnesium is a metal. Explain why metals can be bent and shaped.

_____

_____

_____

_____

(2)
(Total 14 marks)