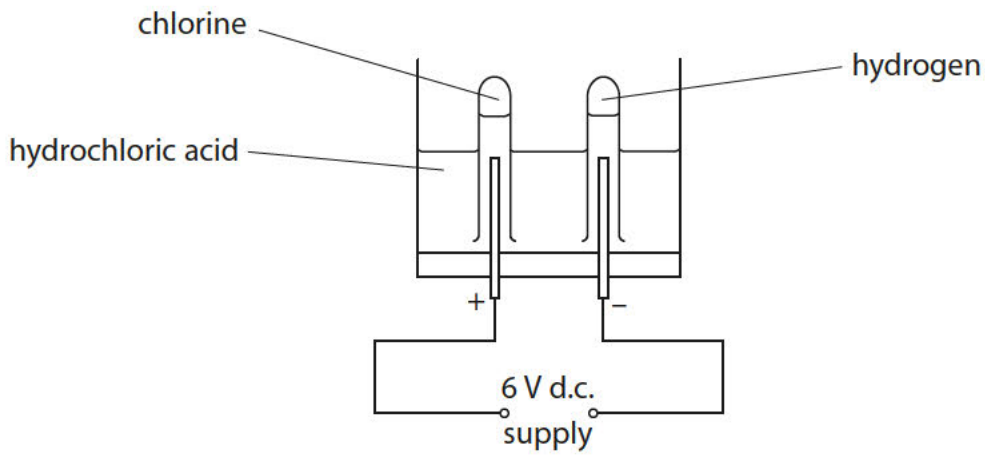
1 (a) Electrolysis of hydrochloric acid produces chlorine and hydrogen.

The apparatus used is shown.



(i) Explain what is meant by **electrolysis**.

(2)

.....

.....

(ii) Describe the test to show that a gas is chlorine.

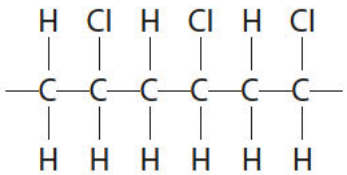
(2)

.....

.....

.....

(iii) Chlorine is used in the manufacture of a polymer.
Part of this polymer molecule is



State the name of the polymer.

(1)

.....

(b) Dilute hydrochloric acid reacts with silver nitrate solution to form silver chloride and nitric acid.

(i) Complete the sentence by putting a cross (☒) in the box next to your answer.

The reaction produces silver chloride as a precipitate.
In an equation this would be shown as

(1)

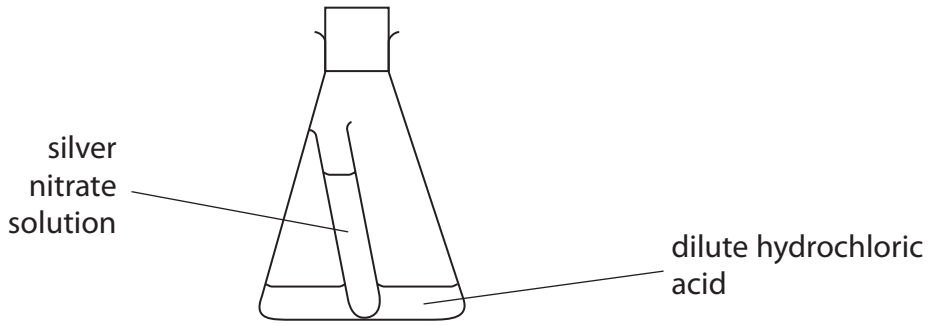
☒ **A** AgCl(aq)

☒ **B** AgCl(g)

☒ **C** AgCl(l)

☒ **D** AgCl(s)

(ii) This apparatus is used to investigate the mass of the reactants and the mass of products in this reaction.



The total mass of this apparatus was measured.
The flask was shaken to allow the silver nitrate solution and dilute hydrochloric acid to react.
After the reaction the total mass of the apparatus was measured again.

State how the total mass of the apparatus after the reaction will compare with the total mass of the apparatus before the reaction.

(1)

.....

(iii) Write the balanced equation for the reaction of silver nitrate solution, $AgNO_3$, with dilute hydrochloric acid to form silver chloride, AgCl, and nitric acid.

(2)

.....

(Total for Question 1 = 9 marks)

2 (a) The ions in sodium chloride solution are

sodium ions, Na^+
chloride ions, Cl^-
hydrogen ions, H^+
hydroxide ions, OH^-

Sodium chloride solution is electrolysed using a direct electric current.

(i) Which of these ions will be attracted to the cathode during the electrolysis of sodium chloride solution?

Put a cross (☒) in the box next to your answer.

(1)

☐ **A** H^+ ions only

☐ **B** H^+ and Na^+ ions

☐ **C** Cl^- ions only

☐ **D** Cl^- and OH^- ions

(ii) Chlorine is one of the products of the electrolysis.

The half-equation for the production of chlorine is

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

Explain how the half-equation shows that chloride ions are oxidised.

(2)

.....

.....

(iii) Suggest why the solution remaining at the end of the electrolysis is alkaline.

(1)

.....

.....

(iv) The electrolysis of sodium chloride solution does not produce metallic sodium.

State what change you would make to the electrolyte to obtain metallic sodium.

(1)

.....

.....

(b) (i) When copper sulfate solution is electrolysed using inert electrodes, oxygen is formed at the positively charged anode.

Explain how the oxygen is formed from ions in the solution.

(2)

.....

.....

.....

.....

(ii) The other product is copper.

1.27 g of copper were produced in an experiment.

Calculate the number of moles of copper, Cu, produced in this experiment.

(Relative atomic mass: Cu = 63.5)

(1)

.....

amount of copper produced = ... mol

(Total for Question 2 = 8 marks)

3 Objects made from transition metals are sometimes coated with a thin layer of another transition metal to improve their appearance and to protect against corrosion.

(a) Figure 10 shows equipment that can be used to electroplate an iron spoon with silver.

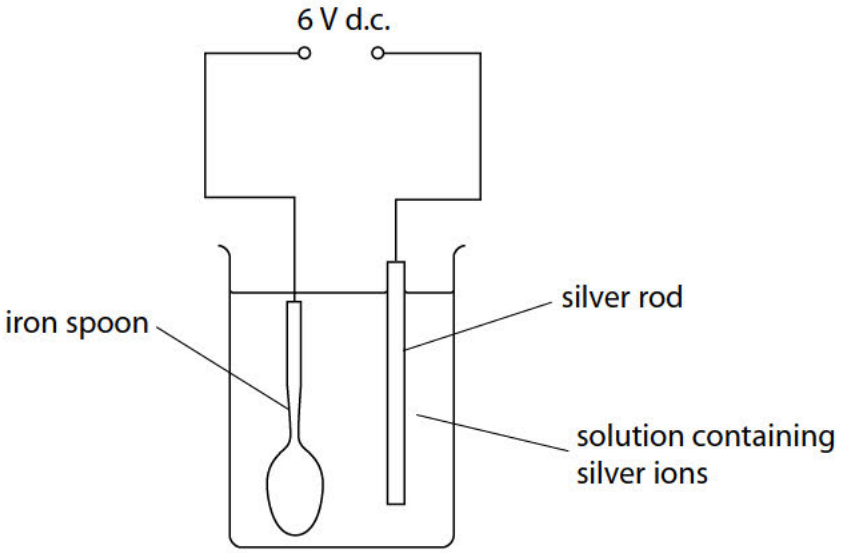


Figure 10

(i) Which row of the table correctly shows the charge on the silver rod electrode and the type of reaction occurring at this electrode?

(1)

		charge	type of reaction
☐	**A**	negative	oxidation
☐	**B**	negative	reduction
☐	**C**	positive	oxidation
☐	**D**	positive	reduction

(ii) Silver metal is deposited on the spoon.

Which half-equation represents this reaction?

(1)

☒ **A** $Ag + e \rightarrow Ag^+$

☒ **B** $Ag \rightarrow Ag^+ + e^-$

☒ **C** $Ag^+ + e \rightarrow Ag$

☒ **D** $Ag^+ \rightarrow Ag + e^-$

(b) The voltage of a cell is 1.5 V.

Give a reason why this voltage of the cell decreases when the cell is left connected in a circuit.

(1)

.....

.....

(c) Duralumin is an alloy of aluminium and copper.

The radii of the aluminium and copper atoms are shown in Figure 11.

	radius of atom / m
aluminium	1.43×10^{-12}
copper	1.27×10^{-12}

Figure 11

Explain why copper added to aluminium to form the alloy makes the alloy stronger than pure aluminium.

(2)

.....

.....

.....

.....

(d) Gold is often alloyed with other metals when it is used to make jewellery.

The proportion of gold in a piece of gold jewellery is measured in carats.

Pure gold is 24 carats.

A 9 carat gold ring has a mass of 12 g.

Calculate the mass of gold in this ring.

(2)

mass of gold ring = ... g

(Total for Question 3 = 7 marks)

4 Electrodes are placed in three different solutions, **J**, **K** and **L**.

A 6 V direct current source is connected to the electrodes.

Any products formed at the electrodes are identified.

The results are given in Figure 12.

solution	solution conducts electricity	product at cathode	product at anode
J	yes	copper	chlorine
K	yes	hydrogen	oxygen
L	no	none	none

Figure 12

(a) Explain which solutions are electrolytes.

(2)

.....

.....

.....

.....

(b) Which material is most suitable to make the electrodes for the electrolysis of a dilute acid?

(1)

☐ **A** zinc

☐ **B** sulfur

☐ **C** iron

☐ **D** graphite

(c) When a solution of sodium sulfate, Na_2SO_4, is electrolysed, the products formed at the electrodes are hydrogen and oxygen.

Explain the formation of the products at the electrodes.

(4)

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.....

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.....

(d) Copper is purified by the electrolysis of copper sulfate solution using an impure copper anode and a pure copper cathode.

Write the half-equation for the formation of a copper atom from a copper ion.

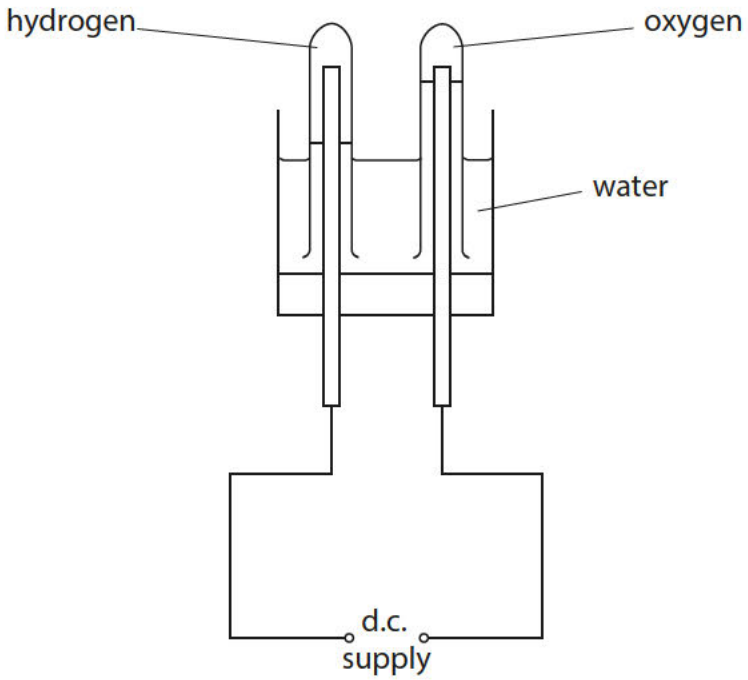
(2)

.....

(Total for Question 4 = 9 marks)

5 (a) Water can be decomposed by electrolysis.

Hydrogen and oxygen are formed.
This apparatus can be used to carry out the electrolysis.



(i) Write the balanced equation for water decomposing to form hydrogen and oxygen.

(3)

.....

(ii) Describe the test to show that a gas is hydrogen.

(2)

.....

.....

.....

.....

(iii) Describe the test to show that a gas is oxygen.

(2)

(b) Seawater can also be decomposed using electrolysis.
Seawater is sodium chloride solution.
When this is decomposed one product is a toxic gas.

(i) Complete the sentence by putting a cross (☒) in the box next to your answer. The toxic gas produced is

(1)

- ☐ **A** hydrogen
- ☐ **B** chlorine
- ☐ **C** oxygen
- ☐ **D** carbon monoxide

(ii) Give a safety precaution that should be taken when collecting this toxic gas.

(1)

.....

.....

(c) Sodium chloride solution can be prepared by reacting sodium hydroxide solution with an acid.

Give the name of the acid that must be used.

(1)

.....

(Total for Question 5 = 10 marks)