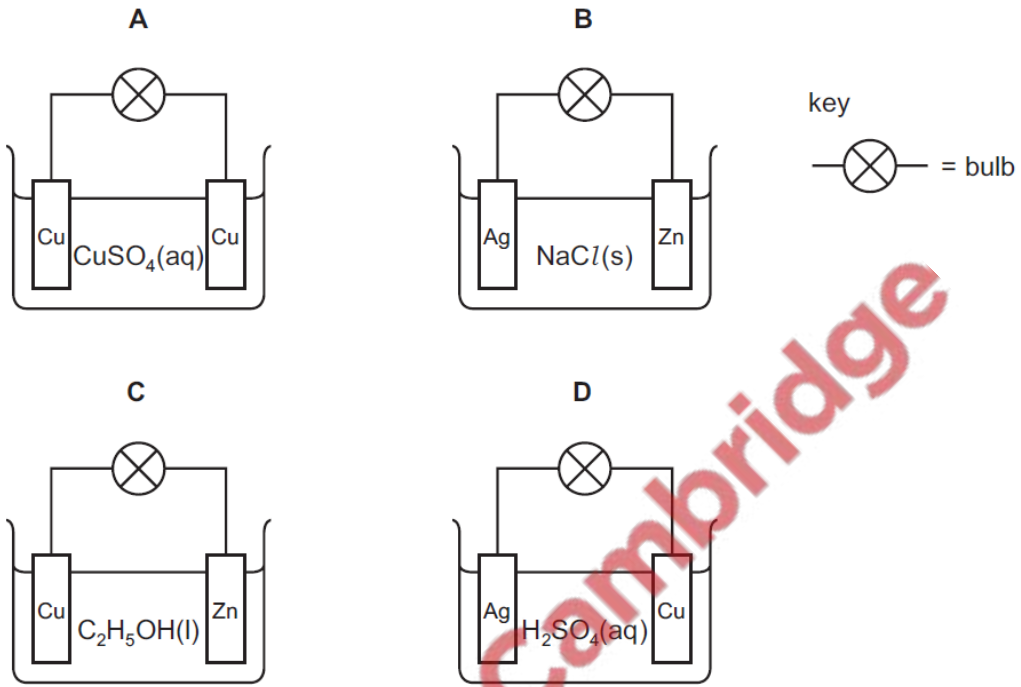
# ELECTROLYSIS : THEORY+MCQS

## Contents

# MULTIPLE CHOICE QUESTIONS

**18** In which circuit does the bulb light?




5070_s14_qp12

**13** A concentrated aqueous solution of sodium chloride is electrolysed.

What are the equations for the reactions taking place at the cathode (negative electrode) and the anode (positive electrode)?

| | cathode (–ve) | anode (+ve) |
|---|---|---|
| **A** | $2H^+ + 2e^- \rightarrow H_2$ | $2Cl^- \rightarrow Cl_2 + 2e^-$ |
| **B** | $2H^+ + 2e^- \rightarrow H_2$ | $4OH^- \rightarrow O_2 + 2H_2O + 4e^-$ |
| **C** | $Na^+ + e^- \rightarrow Na$ | $2Cl^- \rightarrow Cl_2 + 2e^-$ |
| **D** | $Na^+ + e^- \rightarrow Na$ | $4OH^- \rightarrow O_2 + 2H_2O + 4e^-$ |

5070_s14_qp12

**14** What is observed during the electrolysis of aqueous copper(II) sulfate using carbon electrodes?

**A** A pink solid is deposited on the anode.

**B** Bubbles form on the negative electrode.

**C** The colour of the solution fades.

**D** The negative electrode becomes smaller.

5070_s14_qp12

**8** Which substance can conduct electricity by the movement of ions?

**A** copper

**B** graphite

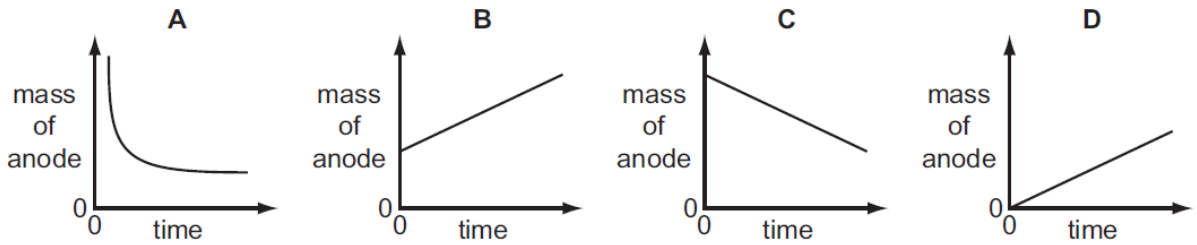
**C** mercury

**D** sodium chloride

5070_s14_qp12

**21** Aqueous copper(II) sulfate is electrolysed using copper electrodes. The current is constant and the anode (positive electrode) is weighed at regular intervals.

Which graph is obtained when the mass of the anode is plotted against time?




**22** In the extraction of aluminium by electrolysis, its oxide is dissolved in molten cryolite. Cryolite is a sodium salt.

Aluminium is deposited at the ……1…… and it can be deduced that aluminium is ……2…… sodium in the reactivity series.

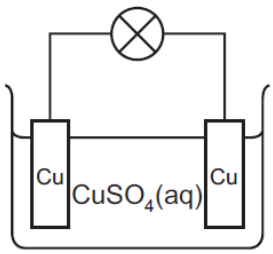
Which words correctly complete gaps 1 and 2?

| | 1 | 2 |
|---|---|---|
| **A** | +ve electrode | above |
| **B** | +ve electrode | below |
| **C** | –ve electrode | above |
| **D** | –ve electrode | below |

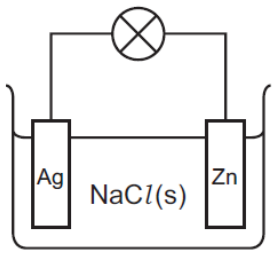
5070_s14_qp11

**16** In which circuit does the bulb light?

**A**



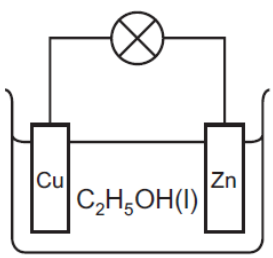

**B**



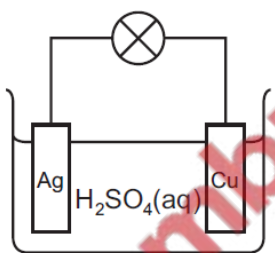

key

= bulb

**C**

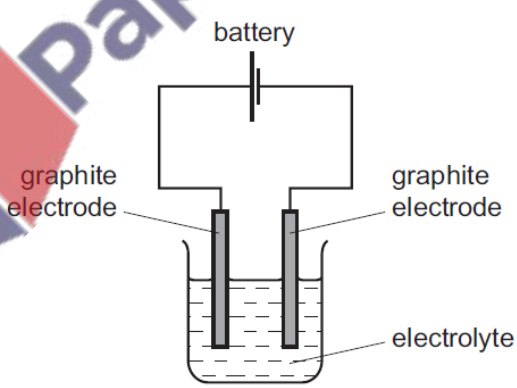



**D**




5070_s14_qp11

**7** Graphite is often used as the electrodes in the electrolysis of solutions.




Which particles are involved in the conduction of electricity by graphite?

**A** electrons only

**B** negative ions only

**C** positive ions and electrons

**D** positive ions and negative ions

5070_s14_qp11

**16** It has been suggested that the cars of the future could be powered by fuel cells. One type of fuel cell uses the chemical reaction between oxygen and hydrogen to produce electricity.

What would be a disadvantage of using this type of fuel cell to power a car?

**A** A car cannot be powered by electricity.

**B** The hydrogen tank might split in an accident, leading to an explosion.

**C** The product of the reaction between oxygen and hydrogen is toxic.

**D** The oxygen would need to be obtained from air.

5070_w13_qp12

**14** Which arrangement would be used to electroplate copper onto a steel key?

| | electrolyte | anode (positive electrode) | cathode (negative electrode) |
|---|---|---|---|
| **A** | aqueous copper(II) sulfate | piece of pure copper | steel key |
| **B** | aqueous copper(II) sulfate | steel key | piece of pure copper |
| **C** | aqueous sulfuric acid | piece of pure copper | steel key |
| **D** | aqueous sulfuric acid | steel key | piece of pure copper |

5070_w13_qp12



**12** Which process will separate an ionic compound *PQ* into its elements *P* and *Q*?

**A** distillation

**B** electrolysis

**C** filtration

**D** precipitation

5070_w13_qp12

**14** When dilute sulfuric acid is electrolysed between inert electrodes, which statements are correct?

1 Hydrogen is released at the negative electrode.

2 Oxygen is released at the positive electrode.

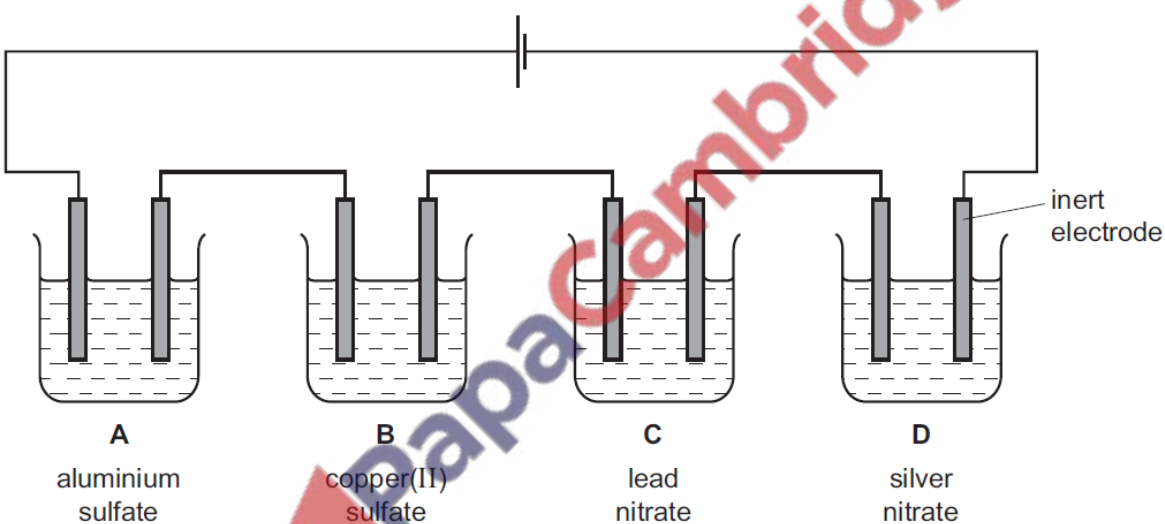
3 Sulfur dioxide is released at the positive electrode.

4 The acid becomes more concentrated.

**A** 1, 2 and 4 **B** 1 and 2 only **C** 2 and 3 **D** 3 and 4

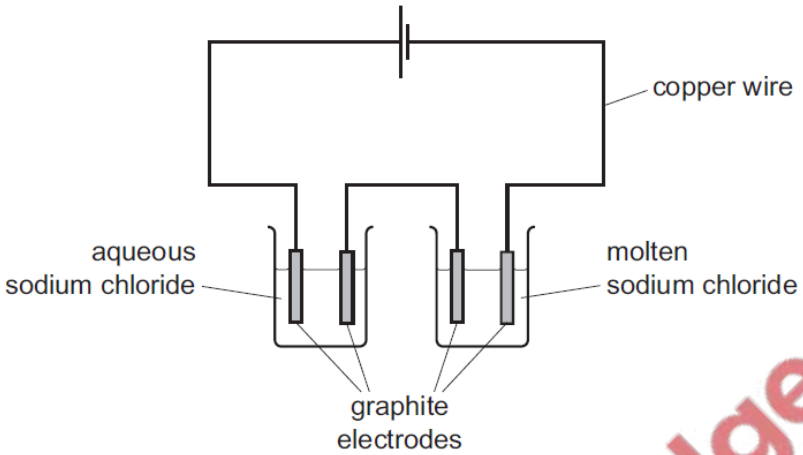
5070_w13_qp11

**15** When electrolysed using inert electrodes, which dilute solution would produce the greatest increase in mass of the cathode?
[$A_r$: Al, 27; Cu, 64; Pb, 207; Ag, 108]




5070_w13_qp11

8 The diagram shows the electrolysis of aqueous sodium chloride and of molten sodium chloride.




Which substance in the diagram has both positive ions and mobile electrons?

**A** aqueous sodium chloride

**B** copper wire

**C** graphite electrodes

**D** molten sodium chloride

5070_w13_qp11

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6 Which substance will **not** conduct electricity at room temperature and pressure?

**A** dilute nitric acid

**B** graphite

**C** mercury

**D** sodium chloride

5070_w13_qp11

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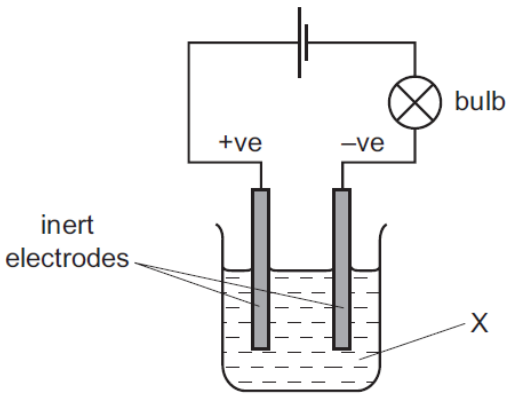
**12** In the experiment shown in the diagram, the bulb lights and two colourless gases are formed, one at each electrode.




What is X?

**A** concentrated aqueous sodium chloride

**B** dilute sulfuric acid

**C** methanol

**D** molten sodium chloride

5070_w12_qp12

**6** When concentrated aqueous sodium chloride is electrolysed using carbon electrodes, which row correctly states the products at the electrodes and the solution remaining?

| | cathode (–) | anode (+) | solution remaining |
|---|---|---|---|
| **A** | chlorine | hydrogen | hydrochloric acid |
| **B** | hydrogen | chlorine | sodium hydroxide |
| **C** | hydrogen | oxygen | sodium chloride |
| **D** | sodium | chlorine | water |

5070_w12_qp12

**18** What is a property of the hydroxide, $OH^-$, ion?

**A** It combines with hydrogen to form water.

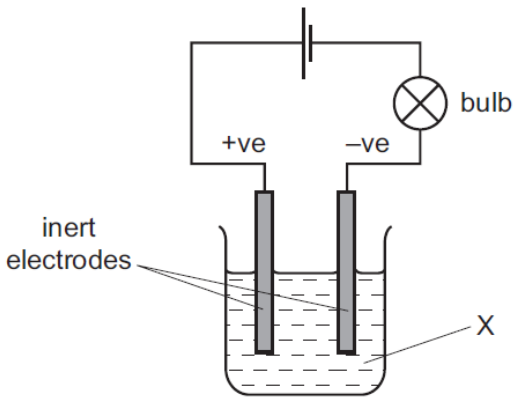
**B** It is present in water.

**C** It readily breaks down into hydrogen ions and oxide ions.

**D** It travels to the cathode in electrolysis of an aqueous solution.

5070_w12_qp11

**13** In the experiment shown in the diagram, the bulb lights and a gas is produced at each electrode.




What is X?

**A** aqueous copper(II) sulfate

**B** concentrated aqueous sodium chloride

**C** ethanol

**D** molten lead bromide

5070_w12_qp11

**11** Which element requires the largest number of electrons for one mole of the metal to be formed from its aqueous ions during electrolysis?

**A** aluminium

**B** calcium

**C** copper

**D** sodium

5070_w14_qp11

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**12** Which changes are observed during the electrolysis of aqueous copper(II) sulfate using copper electrodes?

1 A pink solid is deposited on the negative electrode.

2 Bubbles form on the positive electrode.

3 The colour of the solution does not change.

**A** 1 and 2 only **B** 1 and 3 only **C** 2 and 3 only **D** 1, 2 and 3

5070_w14_qp11

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**19** Which method is used to obtain chlorine from aqueous sodium chloride?

**A** crystallisation

**B** distillation

**C** electrolysis

**D** filtration

5070_w14_qp12

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**12** What is the correct equation for the reaction taking place at the negative electrode when molten magnesium chloride is electrolysed using inert electrodes?

**A** $Cl^- \rightarrow Cl + e^-$

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

**C** $Mg^+ + e^- \rightarrow Mg$

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

5070_w14_qp12

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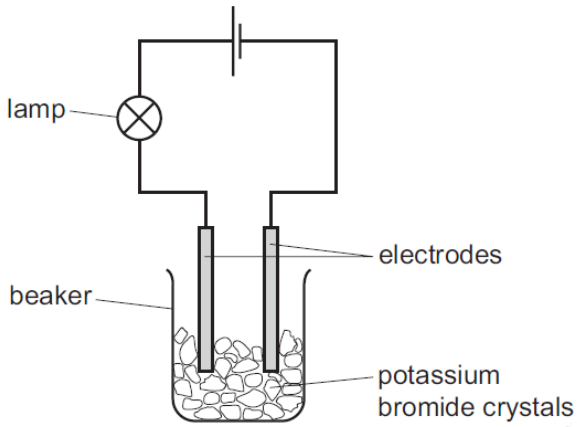
**8** The experiment shown is used to test potassium bromide crystals.




The lamp does not light.

Distilled water is then added to the beaker and the lamp lights.

Which statement explains these results?

**A** Electrons are free to move in the solution when potassium bromide dissolves.

**B** Metal ions are free to move when potassium bromide melts.

**C** Metal ions are free to move when potassium reacts with water.

**D** Oppositely charged ions are free to move in the solution when potassium bromide dissolves.

5070_w14_qp12

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**13** How can sodium be manufactured?

**A** by electrolysing aqueous sodium chloride

**B** by electrolysing aqueous sodium hydroxide

**C** by electrolysing molten sodium chloride

**D** by heating sodium oxide with carbon

5070_w11_qp11

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**14** Which statement about the electrolysis of an aqueous solution of copper(II) sulfate with platinum electrodes is correct?

**A** Oxygen is given off at the positive electrode.

**B** The mass of the negative electrode remains constant.

**C** The mass of the positive electrode decreases.

**D** There is no change in the colour of the solution.

5070_w11_qp11

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**14** A concentrated aqueous solution of copper(II) chloride is electrolysed using inert electrodes.

What is the product at the positive electrode?

**A** chlorine

**B** copper

**C** hydrogen

**D** oxygen

5070_s13_qp12

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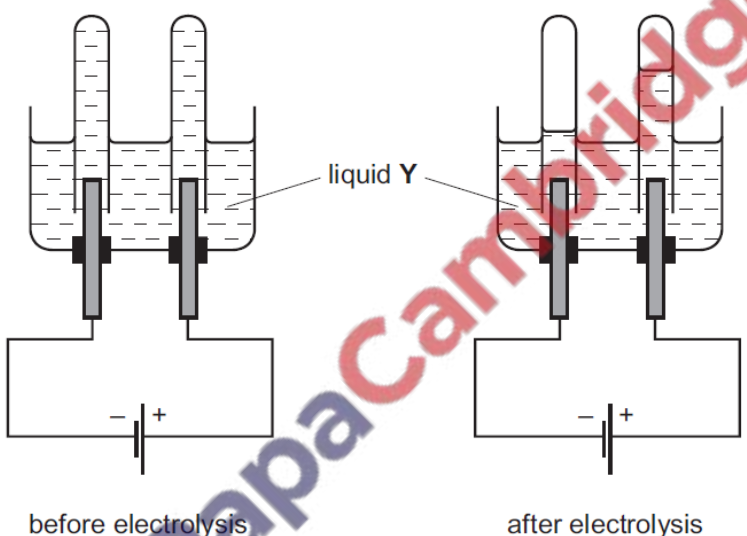
**15** The diagrams show an electrolysis experiment using inert electrodes.




Which could be liquid **Y**?

**A** aqueous copper(II) sulfate

**B** concentrated aqueous sodium chloride

**C** dilute sulfuric acid

**D** ethanol

5070_s13_qp12

**28** In the electrolysis of molten aluminium oxide for the extraction of aluminium, the following three reactions take place.

1 $Al^{3+} + 3e^- \rightarrow Al$

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

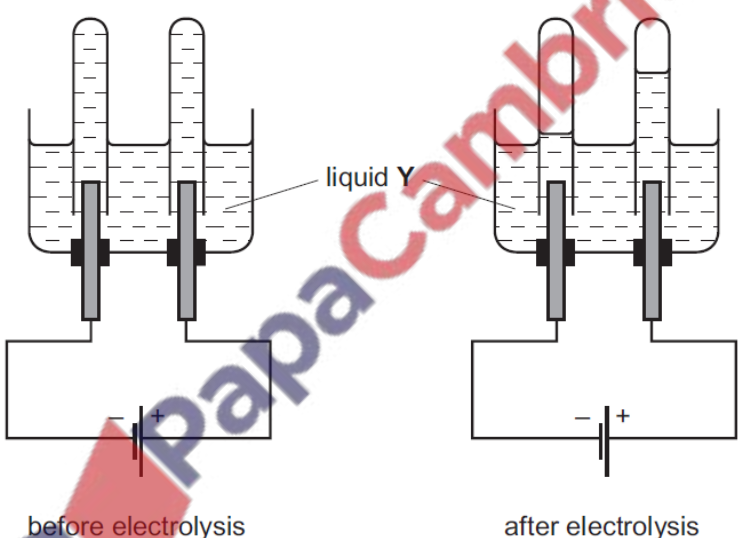
3 $C + O_2 \rightarrow CO_2$

Which reactions take place at the positive electrode?

**A** 1 only **B** 2 only **C** 1 and 3 only **D** 2 and 3 only

5070_s13_qp11

**13** The diagrams show an electrolysis experiment using inert electrodes.




Which could be liquid **Y**?

**A** aqueous copper(II) sulfate

**B** concentrated aqueous sodium chloride

**C** dilute sulfuric acid

**D** ethanol

5070_s13_qp11

**14** Which substance, when added to water, does **not** make a solution that is a good conductor of electricity?

**A** barium nitrate

**B** calcium chloride

**C** lead(II) nitrate

**D** zinc carbonate

5070_s13_qp11

**9** Which substance conducts an electric current but remains chemically unchanged?

**A** aluminium

**B** aqueous sodium chloride

**C** molten lead(II) bromide

**D** pure ethanoic acid

5070_s13_qp11

**15** Which substance will conduct electricity without being chemically changed?

**A** sodium chloride solution

**B** solid iron

**C** solid sodium chloride

**D** solid sulfur

5070_s12_qp12



**14** Which change **always** takes place when an aqueous solution of copper(II) sulfate is electrolysed?

**A** Copper is deposited at the negative electrode.

**B** Oxygen is evolved at the positive electrode.

**C** Sulfate ions move towards the negative electrode.

**D** The colour of the solution fades.

5070_s12_qp12

**11** Which statement about conduction of electricity is correct?

**A** Electricity is conducted in aqueous solution by electrons.

**B** Electricity is conducted in a metal wire by ions.

**C** Electricity is conducted in a molten electrolyte by electrons.

**D** Electricity is conducted in an acid solution by ions.

5070_s12_qp12

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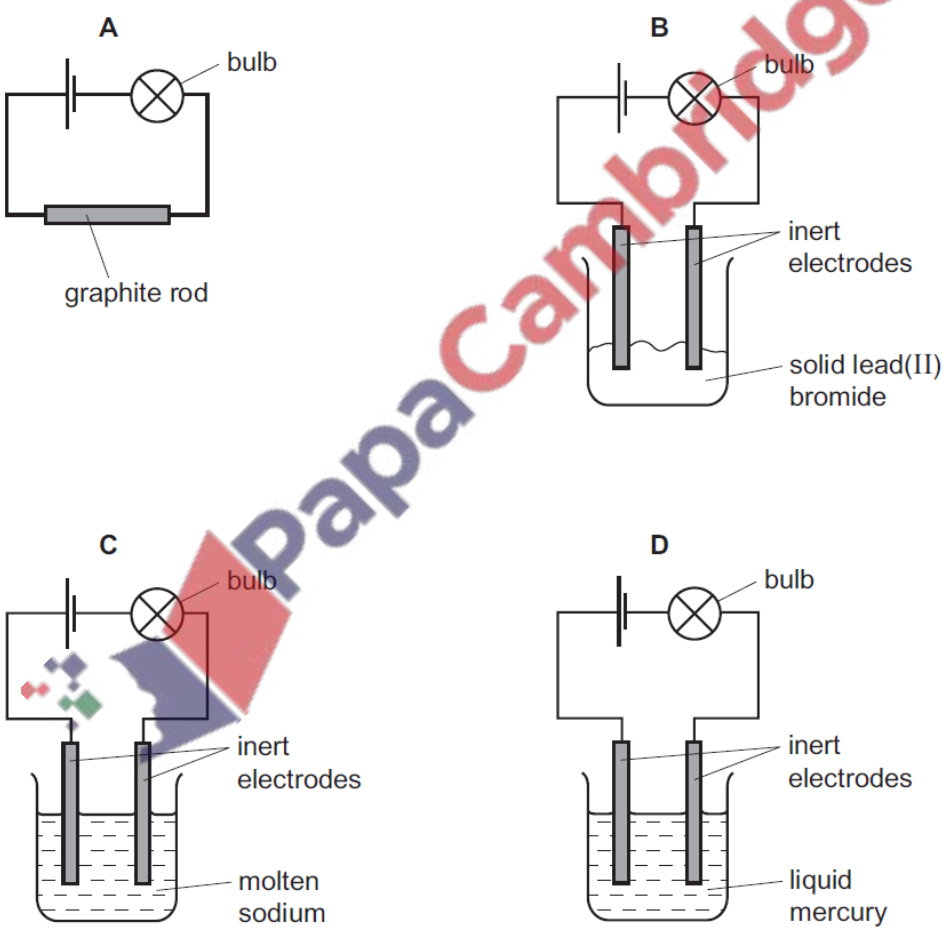
**8** In which set of apparatus will the bulb be **least** bright?






5070_s12_qp12

**15** Aqueous copper(II) sulfate is electrolysed using copper electrodes.

Which equation represents the reaction taking place at the anode (positive electrode) in this electrolysis?

**A** $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$

**B** $SO_4^{2-}(aq) \rightarrow SO_2(g) + O_2(g) + 2e^-$

**C** $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

**D** $4OH^-(aq) \rightarrow 2H_2O(l) + O_2(g) + 4e^-$

5070_s12_qp11

**13** Which statement about conduction of electricity is correct?

**A** Electricity is conducted in aqueous solution by electrons.

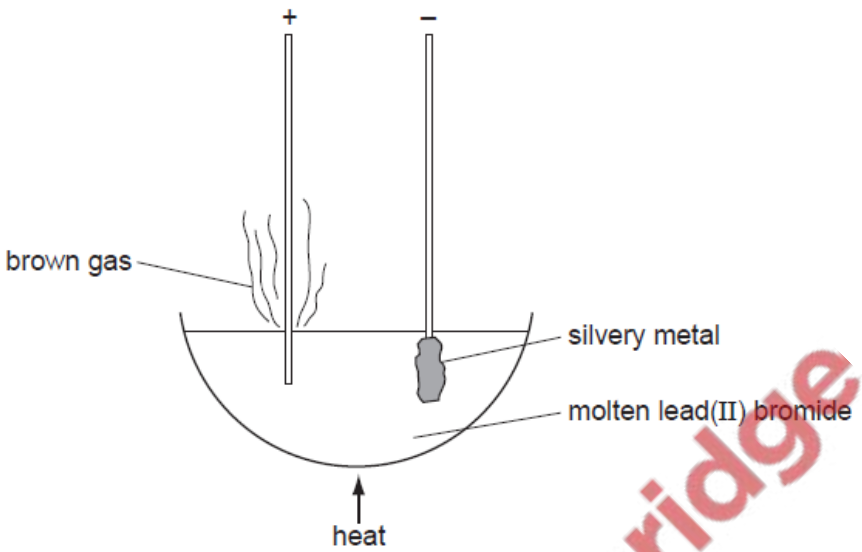
**B** Electricity is conducted in a metal wire by ions.

**C** Electricity is conducted in a molten electrolyte by electrons.

**D** Electricity is conducted in an acid solution by ions.

5070_s12_qp11

**13** The diagram shows the electrolysis of molten lead(II) bromide using inert electrodes.




What happens during this electrolysis?

**A** Atoms change to ions.

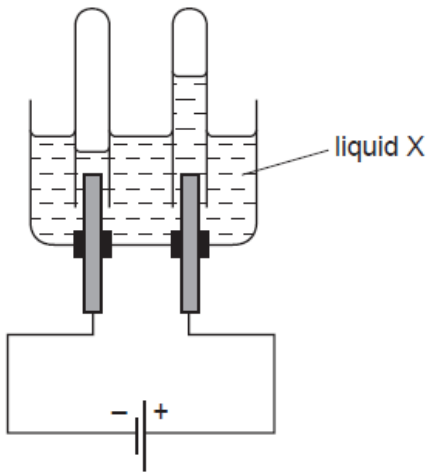
**B** Covalent bonds are broken.

**C** Ions change to atoms.

**D** New compounds are formed.

5070_s11_qp11

12 The diagram shows the results of an electrolysis experiment using inert electrodes.




Which could be liquid X?

**A** aqueous copper(II) sulfate

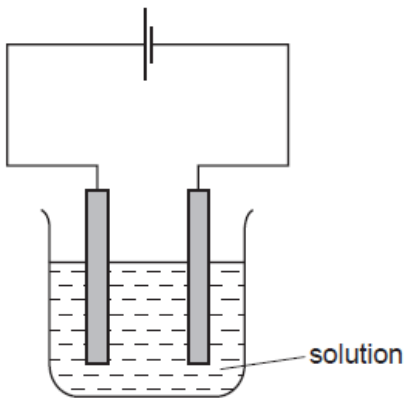
**B** concentrated aqueous sodium chloride

**C** dilute sulfuric acid

**D** ethanol

5070_w10_qp11

**11** The diagram shows the electrolysis of a concentrated aqueous solution containing both copper(II) ions and sodium ions.

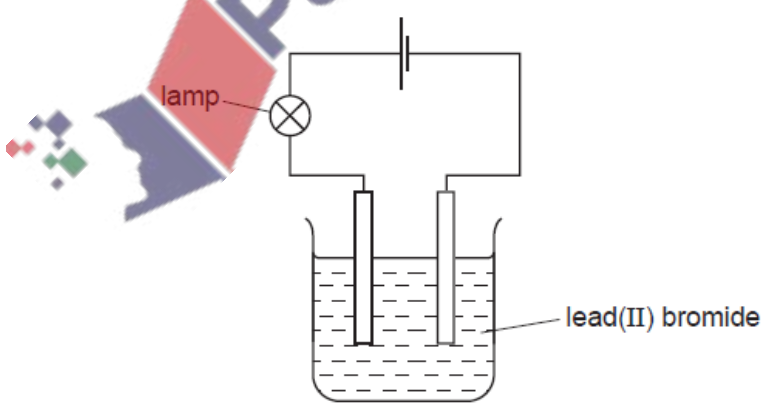



Which metal is deposited at the negative electrode and why?

| | metal deposited | reason |
|---|---|---|
| **A** | copper | copper is less reactive than sodium |
| **B** | copper | copper is more reactive than hydrogen |
| **C** | sodium | copper is less reactive than hydrogen |
| **D** | sodium | copper is more reactive than sodium |

5070_s10_qp11

**12** The diagram shows the apparatus used to electrolyse lead(II) bromide using inert electrodes.




Why does the lamp light up only when the lead(II) bromide is melted?

**A** Bromine atoms in the lead(II) bromide are converted to ions when it is melted.

**B** Electrons flow through the lead(II) bromide when it is melted.

**C** The ions in lead(II) bromide are free to move only when the solid is melted.

**D** There are no ions in solid lead(II) bromide.

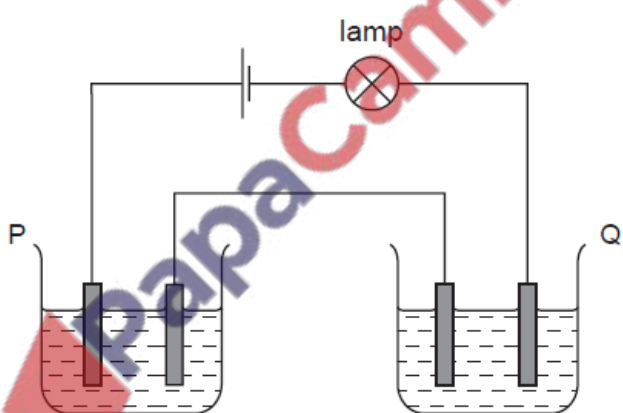
5070_s10_qp11

**17** Which row in the table describes the processes occurring at the electrodes when molten sodium chloride is electrolysed?

| | anode (positive) | cathode (negative) |
|---|---|---|
| **A** | oxidation | reduction |
| **B** | reduction | oxidation |
| **C** | oxidation | oxidation |
| **D** | reduction | reduction |

5070_w09_qp1

**13** Two cells, P and Q, containing different liquids, were connected in series with a battery, a suitable lamp and inert electrodes, as shown in the diagram.




For which pair of liquids did the lamp light up?

| | in P | in Q |
|---|---|---|
| **A** | concentrated sodium chloride solution | concentrated sugar solution |
| **B** | copper(II) sulfate solution | propanol |
| **C** | ethanol | molten lead(II) bromide |
| **D** | mercury | dilute hydrochloric acid |

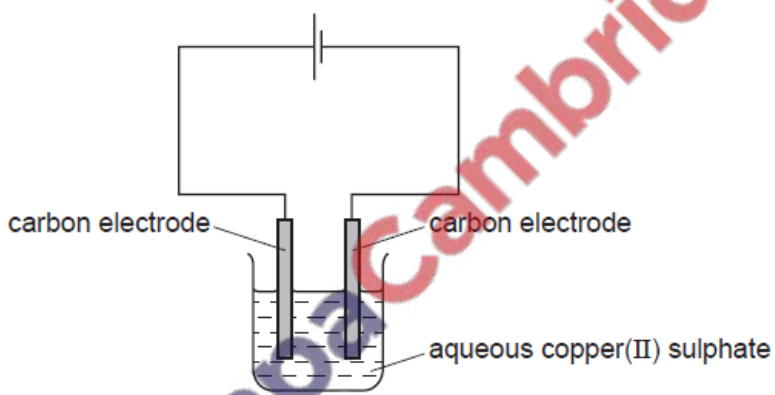
5070_w09_qp1

**11** What products are formed when concentrated aqueous potassium chloride is electrolysed?

| | at the anode (positive) | at the cathode (negative) |
|---|---|---|
| **A** | chlorine | hydrogen |
| **B** | chlorine | potassium |
| **C** | oxygen | hydrogen |
| **D** | oxygen | potassium |

5070_w09_qp1

**30** Aqueous copper(II) sulphate is electrolysed using inert electrodes as shown.




Which ionic equations show the reactions at the electrodes?

1 $Cu^{2+} + 2e^- \rightarrow Cu$

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

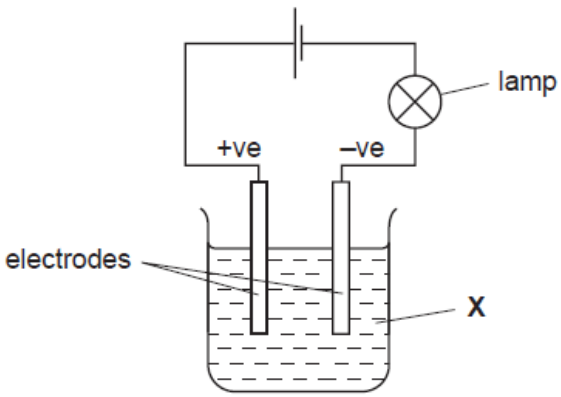
3 $2H^+ + 2e^- \rightarrow H_2$

4 $4OH^- \rightarrow 2H_2O + O_2 + 4e^-$

**A** 1 and 2 only **B** 1 and 4 only **C** 2 and 3 only **D** 3 and 4 only

5070_w08_qp1

**15** When the experiment shown is set up, the bulb lights, but there are no decomposition products at the electrodes.




What is **X**?

**A** aqueous sodium chloride

**B** bromine

**C** molten sodium chloride

**D** mercury

5070_w08_qp1

**16** What are the products formed at the electrodes during the electrolysis of molten magnesium chloride between carbon electrodes?

| | positive electrode | negative electrode |
|---|---|---|
| **A** | oxygen | magnesium |
| **B** | magnesium | chlorine |
| **C** | chlorine | magnesium |
| **D** | chlorine | hydrogen |

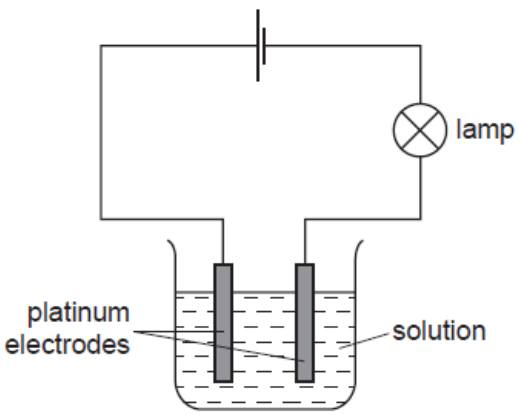
5070_w08_qp1

**13** Which reactions take place during the electrolysis of aqueous copper(II) sulfate with copper electrodes?

| | reaction at positive electrode | reaction at negative electrode |
|---|---|---|
| **A** | $Cu^{2+} + 2e^- \rightarrow Cu$ | $Cu \rightarrow Cu^{2+} + 2e^-$ |
| **B** | $4OH^- \rightarrow 2H_2O + O_2 + 4e^-$ | $Cu^{2+} + 2e^- \rightarrow Cu$ |
| **C** | $Cu \rightarrow Cu^{2+} + 2e^-$ | $2H^+ + 2e^- \rightarrow H_2$ |
| **D** | $Cu \rightarrow Cu^{2+} + 2e^-$ | $Cu^{2+} + 2e^- \rightarrow Cu$ |

5070_s09_qp1

**14** The diagram shows apparatus used to investigate the conductivity of different solutions.




Which substance, in aqueous solution of concentration 1 mol / $dm^3$, would cause the lamp to give the brightest light?

**A** ammonia

**B** ethanoic acid

**C** ethanol

**D** sulfuric acid

5070_s09_qp1

**15** When dilute sulphuric acid is electrolysed between platinum electrodes, which statements are correct?

1 Hydrogen is released at the cathode.

2 Oxygen is released at the anode.

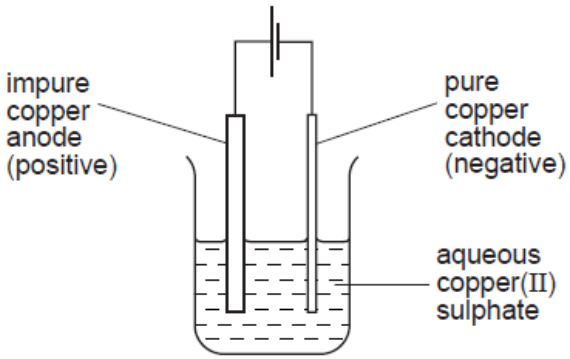
3 Sulphur is released at the anode.

4 The acid becomes more dilute.

**A** 1 and 2 **B** 1 and 3 **C** 2 and 4 **D** 4 only

s/08/qp1

**12** A sample of copper contains a metal impurity which is below copper in the reactivity series. The diagram shows the apparatus used for refining the sample.




The loss in mass of the anode (positive electrode) is 50 g and the gain in mass of the cathode (negative electrode) is 45 g.

What is the percentage purity of this sample of copper?

**A** 10.0 % **B** 11.1 % **C** 90.0 % **D** 95.0 %

s/08/qp1

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**9** Why does molten sodium chloride conduct electricity?

**A** An electron is completely transferred from sodium to chlorine.

**B** Sodium ions are only weakly attracted to the chloride ions.

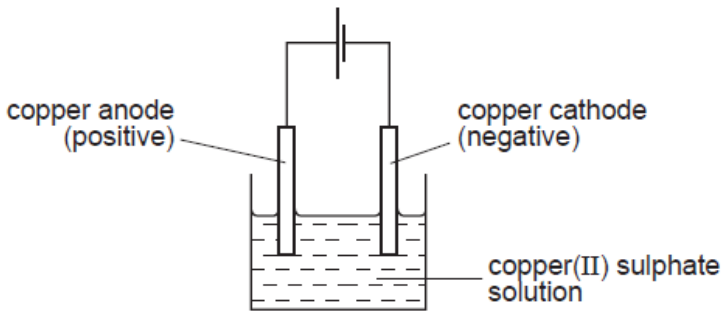
**C** The electrons in the sodium chloride are free to move.

**D** The sodium ions and the chloride ions are free to move.

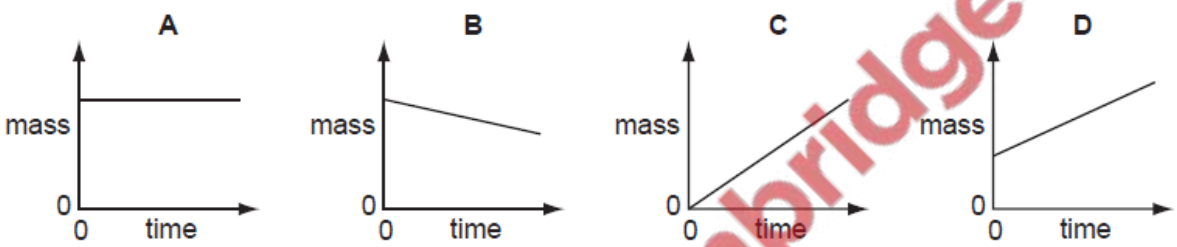
s/08/qp1

---

**13** The diagram shows the electrolysis of aqueous copper(II) sulphate using copper electrodes.




Which graph shows how the mass of the cathode changes during electrolysis?




s/07/qp1

**14** Which statement is correct about the electrolysis of an aqueous solution of copper(II) sulphate with platinum electrodes?

**A** Oxygen is given off at the positive electrode.

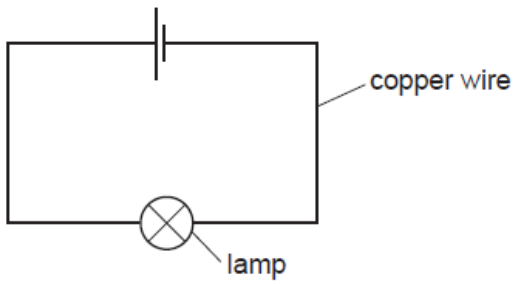
**B** The mass of the negative electrode remains constant.

**C** The mass of the positive electrode decreases.

**D** There is no change in the colour of the solution.

w/07/qp1

**10** An electrical circuit is set up using copper wire.




Which process takes place in the copper wire?

**A** Electrons move along the wire to the negative terminal, positive ions stay in position.

**B** Electrons move along the wire to the positive terminal, positive ions move to the negative terminal.

**C** Electrons move along the wire to the positive terminal, positive ions stay in position.

**D** Negative ions move along the wire to the positive terminal, positive ions move to the negative terminal.

w/07/qp1

---

**12** Aqueous copper(II) sulphate is electrolysed using copper electrodes.

Which observations will be made?

| | at anode (+ve) | at cathode (–ve) | electrolyte |
|---|---|---|---|
| **A** | anode dissolves | pink solid forms | blue colour fades |
| **B** | anode dissolves | pink solid forms | no change |
| **C** | colourless gas forms | colourless gas forms | no change |
| **D** | colourless gas forms | pink solid forms | blue colour fades |

w/06/qp1

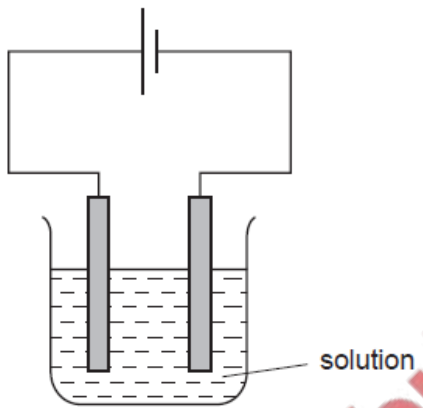
---

**17** In which line in the table is **all** the information correct?

| | reaction at electrode | electrode | product |
|---|---|---|---|
| **A** | $2X^- \rightarrow X_2 + 2e^-$ | cathode | metal |
| **B** | $X^+ + e^- \rightarrow X$ | anode | metal |
| **C** | $2X^- \rightarrow X_2 + 2e^-$ | anode | non-metal |
| **D** | $X^+ + e^- \rightarrow X$ | cathode | non-metal |

w/05/qp1

**12** The diagram shows the electrolysis of a concentrated aqueous solution containing both copper(II) ions and sodium ions.




Which metal is deposited at the negative electrode and why?

| | metal deposited | reason |
|---|---|---|
| **A** | copper | copper is less reactive than sodium |
| **B** | copper | copper is more reactive than hydrogen |
| **C** | sodium | copper is less reactive than hydrogen |
| **D** | sodium | copper is more reactive than sodium |

w/05/qp1

**14** Dilute sulphuric acid is electrolysed using inert electrodes.

Which equation represents the reaction at the anode (+ve)?

**A** $O_2^{2-} \rightarrow O_2 + 2e^-$

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

**C** $4OH^- \rightarrow O_2 + 2H_2O + 4e^-$

**D** $SO_4^{2-} \rightarrow O_2 + SO_2 + 2e^-$

w/04/qp1

**15** What are the products when concentrated aqueous lithium chloride is electrolysed?

| | at the anode (positive) | at the cathode (negative) |
|---|---|---|
| **A** | chlorine | hydrogen |
| **B** | chlorine | lithium |
| **C** | oxygen | hydrogen |
| **D** | oxygen | lithium |

w/04/qp1

**16** A solid deposit of element **R** is formed at the cathode(-ve) when an aqueous solution containing ions of **R** is electrolysed.

Which statement about element **R** must be correct?

**A** **R** forms negative ions.

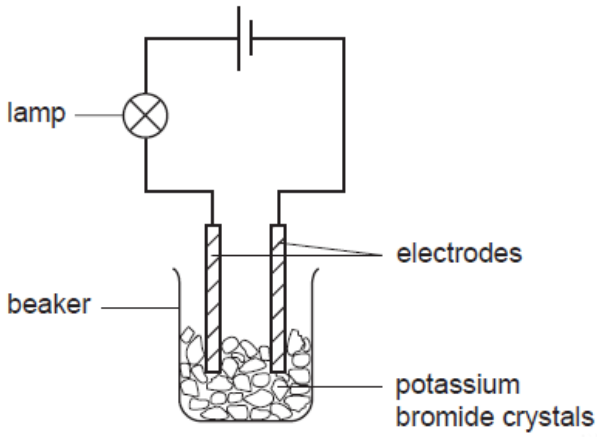
**B** **R** ions gain electrons at the cathode.

**C** **R** ions lose electrons at the cathode.

**D** **R** is above hydrogen in the reactivity series.

w/04/qp1

**9** The experiment shown is used to test potassium bromide crystals.




The lamp does not light.

Distilled water is then added to the beaker and the lamp lights.

Which statement explains these results?

**A** Electrons are free to move in the solution when potassium bromide dissolves.

**B** Metal ions are free to move when potassium bromide melts.

**C** Metal ions are free to move when potassium reacts with water.

**D** Oppositely charged ions are free to move in the solution when potassium bromide dissolves.

w/04/qp1

---

**31** Aqueous copper(II) sulphate is electrolysed using carbon electrodes.

What happens to the electrolyte?

**A** It becomes more acidic.

**B** It becomes more alkaline.

**C** It turns deeper blue.

**D** It remains unchanged.

w/03/qp1

---

**14** Which of the following, when added to water, makes a solution that is a good conductor of electricity?

**A** calcium carbonate

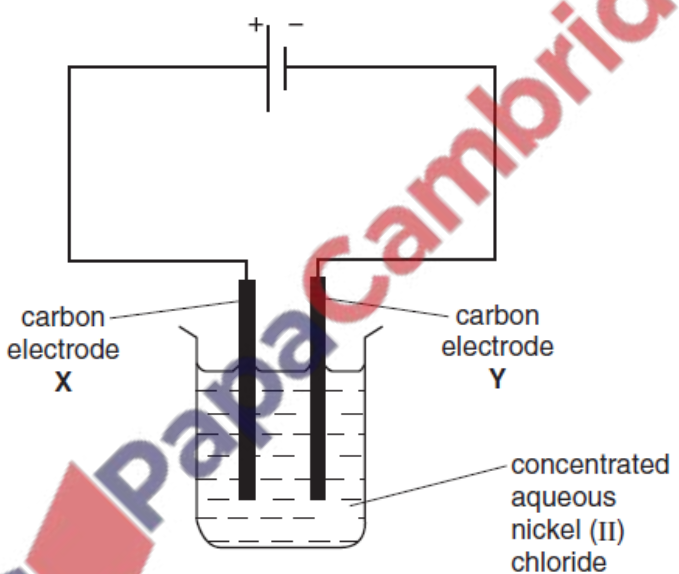
**B** copper

**C** ethanol

**D** sodium hydroxide

w/03/qp1

**13** Apparatus is set up as shown in the diagram.




What occurs at electrode **X**?

**A** Chloride ions are oxidised.

**B** Chloride ions are reduced.

**C** Nickel ions are oxidised.

**D** Nickel is deposited.

w/03/qp1

**34** Which statement describes what happens when hydrogen and oxygen are used in a fuel cell?

**A** Electricity is generated directly.

**B** Electricity is used to produce water.

**C** Hydrogen is burned to form steam.

**D** Hydrogen reacts to form a hydrocarbon fuel.

w/02/qp1

---

**13** Four electrolytes were electrolysed using carbon electrodes.

Which set of data is correct?

| | electrolyte | product at | |
|---|---|---|---|
| | | anode | cathode |
| **A** | $CuSO_4$ (aq) | oxygen | copper |
| **B** | NaC*l* (aq) | chlorine | sodium |
| **C** | NaH (l) | sodium | hydrogen |
| **D** | $PbBr_2$ (l) | lead | bromine |

w/02/qp1

---

**18** Which statement about conduction of electricity is correct?

**A** Electricity is conducted in aqueous solution by electrons.

**B** Electricity is conducted in a metal wire by ions.

**C** Electricity is conducted in a molten electrolyte by electrons.

**D** Electricity is conducted in an acid solution by ions.

s/06/qp1

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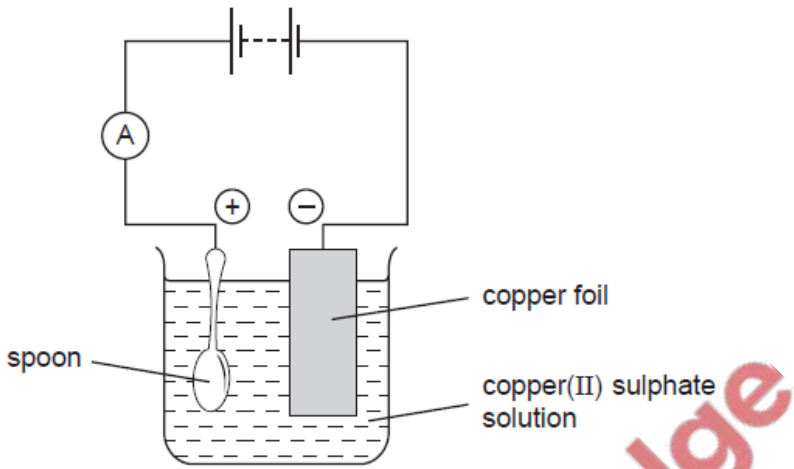
**12** The apparatus shown below was set up to copper plate the metal spoon.




The experiment did **not** work.

What was the mistake in the apparatus?

**A** A variable resistor should be included in the electrical circuit.

**B** Dilute sulphuric acid should be used as the electrolyte.

**C** The copper electrode should all be in the solution.

**D** The spoon should be the negative electrode.

s/06/qp1

**10** Which reactions take place during the electrolysis of aqueous copper(II) sulphate with copper electrodes?

| | reaction at positive electrode | reaction at negative electrode |
|---|---|---|
| **A** | $Cu^{2+} + 2e^- \rightarrow Cu$ | $Cu \rightarrow Cu^{2+} + 2e^-$ |
| **B** | $4OH^- \rightarrow 2H_2O + O_2 + 4e^-$ | $Cu^{2+} + 2e^- \rightarrow Cu$ |
| **C** | $Cu \rightarrow Cu^{2+} + 2e^-$ | $2H^+ + 2e^- \rightarrow H_2$ |
| **D** | $Cu \rightarrow Cu^{2+} + 2e^-$ | $Cu^{2+} + 2e^- \rightarrow Cu$ |

s/05/qp1

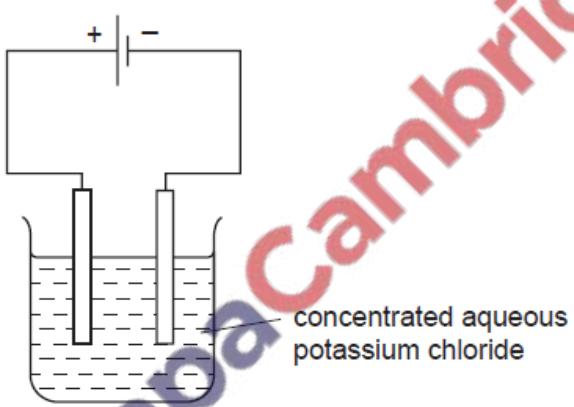
**11** The heat-reflecting shields of some space rockets are gold-plated, using electrolysis.

Which electrodes and electrolyte would be used to gold-plate the heat shield?

| | negative electrode | positive electrode | electrolyte |
|---|---|---|---|
| **A** | carbon | heat shield | gold compound |
| **B** | gold | heat shield | copper compound |
| **C** | heat shield | carbon | copper compound |
| **D** | heat shield | gold | gold compound |

s/05/qp1

**16** A current was passed through concentrated aqueous potassium chloride, KC*l*, as shown.

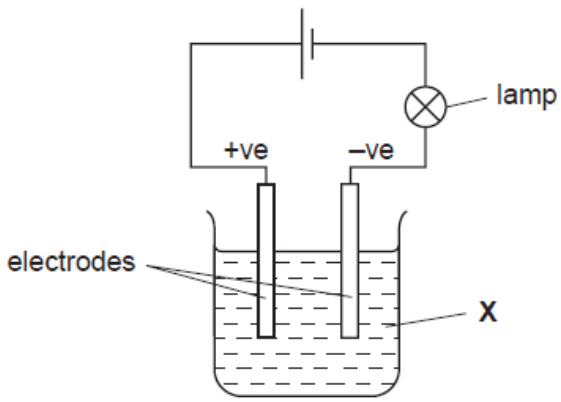



Which entry in the table is correct?

| | ions moving towards | |
|---|---|---|
| | the cathode (-ve) | the anode (+ve) |
| **A** | $K^+$ only | $Cl^-$ and $OH^-$ |
| **B** | $K^+$ only | $Cl^-$ only |
| **C** | $K^+$ and $H^+$ | $Cl^-$ only |
| **D** | $K^+$ and $H^+$ | $Cl^-$ and $OH^-$ |

s/04/qp1

**17** When the experiment shown was set up, the bulb lit, but there were no decomposition products a the electrodes.




What is **X**?

**A** aqueous sodium chloride

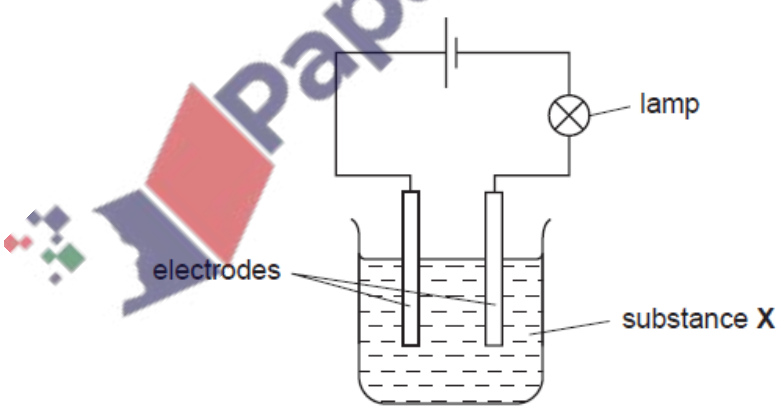
**B** bromine

**C** molten sodium chloride

**D** mercury

s/04/qp1

**11** In the circuit below, the lamp lights up.




What could **X** be?

**A** a solution of ethanol in water

**B** a solution of sodium chloride in water

**C** liquid ethanol

**D** solid sodium chloride

s/04/qp1

**14** A piece of metal is to be electroplated.

Which set of conditions give the thickest plate?

| | type of current | size of current | time |
|---|---|---|---|
| **A** | a.c. | low | short |
| **B** | d.c. | high | long |
| **C** | a.c. | high | short |
| **D** | d.c. | low | long |

s/03/qp1

**15** Rubidium is above sodium in the reactivity series.

What is formed when concentrated aqueous rubidium chloride is electrolysed?

| | products | |
|---|---|---|
| | cathode (–) | anode (+) |
| **A** | chlorine | hydrogen |
| **B** | hydrogen | rubidium |
| **C** | hydrogen | chlorine |
| **D** | rubidium | chlorine |

s/03/qp1

# THEORY QUESTIONS

**(d)** The electrode reactions occurring when molten sodium chloride is electrolysed are shown below.

negative electrode $Na^+ + e^- \longrightarrow Na$

positive electrode $2Cl^- \longrightarrow Cl_2 + 2e^-$

Refer to these equations to explain why this electrolysis involves both oxidation and reduction.

.....

.....

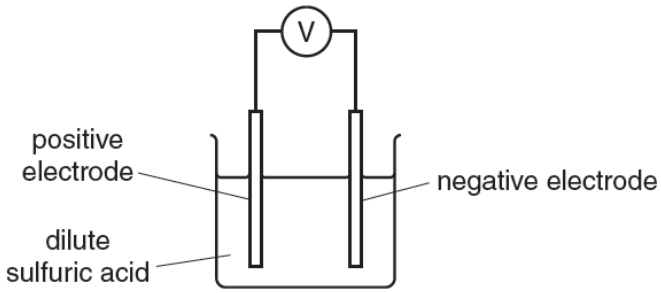
.....[2]

**(e)** Chlorine reacts with excess ammonia, $NH_3$, to form hydrogen chloride and nitrogen. Construct an equation for this reaction.

.....[1]

w/14/qp22

**A4** The diagram shows a simple electrochemical cell.




The voltages produced by different combinations of metal electrodes are shown in the table below. The more reactive metal is always the negative electrode.

| positive electrode | negative electrode | voltage/V |
|---|---|---|
| copper | zinc | 1.10 |
| copper | tin | 0.48 |
| copper | magnesium | 2.70 |
| copper | iron | 0.78 |
| silver | copper | 0.46 |

**(a) (i)** Write an equation showing the conversion of zinc to zinc ions.

.....[1]

**(ii)** How does the table above show that copper is above silver in the reactivity series?

.....

.....[1]

**(iii)** Which combination of metals in the table above will give the highest voltage?

.....[1]

**(iv)** Use the information in the table to deduce the order of reactivity of the metals copper, iron, magnesium, tin and zinc. Explain your answer.

most reactive .....

.....

.....

.....

.....

least reactive .....

.....

.....[2]

**(d)** **(i)** Name the products formed at the anode and cathode when molten calcium chloride is electrolysed.

anode .....

cathode .....[1]

**(ii)** Predict the product formed at the cathode when a dilute aqueous solution of calcium chloride is electrolysed.

.....[1]

**(iii)** Explain why solid calcium chloride does not conduct electricity.

.....[1]

**A4** Only liquids that contain moving ions can be electrolysed. These liquids are called electrolytes.

**(a)** Complete the following table which shows the products formed when some liquids are electrolysed using inert graphite electrodes.

| electrolyte | ions present in electrolyte | product formed at the positive electrode | product formed at the negative electrode |
|---|---|---|---|
| aqueous copper(II) sulfate | $Cu^{2+}$, $H^+$, $OH^-$ and $SO_4^{2-}$ | ..... | ..... |
| concentrated aqueous sodium chloride | $H^+$, $Na^+$, $Cl^-$ and $OH^-$ | chlorine | hydrogen |
| molten lead(II) bromide | $Pb^{2+}$ and $Br^-$ | ..... | ..... |

[3]

**(b)** When concentrated aqueous sodium chloride is electrolysed, chlorine is formed at the positive electrode (anode) and hydrogen at the negative electrode (cathode).

**(i)** Construct the ionic equation to show the formation of chlorine at the positive electrode.

.....[1]

**(ii)** Explain why hydrogen is formed at the negative electrode rather than sodium.

.....

.....[1]

**(c)** Name a metal manufactured by the electrolysis of a molten ionic compound.

.....[1]

[Total: 6]

s/14/qp22

**(b)** **(i)** Explain why pure sodium chloride can be electrolysed at 1000 °C but not at 600 °C.

.....

.....

..... [2]

**(ii)** Construct an equation for the anode reaction in the electrolysis of pure sodium chloride at 1000 °C.

..... [1]

s/13/qp22

**B10** Aqueous silver nitrate can be electrolysed using inert electrodes.
Solid silver is formed on the cathode (negative electrode).

The table shows how the mass of silver formed is affected by four factors.

| temperature of solution /°C | duration of electrolysis /seconds | current passed through solution/amps | concentration of solution /mol/dm$^3$ | mass of silver formed /g |
|---|---|---|---|---|
| 25 | 100 | 9.65 | 1.0 | 0.108 |
| 30 | 100 | 9.65 | 1.0 | 0.108 |
| 25 | 100 | 9.65 | 0.5 | 0.108 |
| 25 | 200 | 9.65 | 0.5 | 0.216 |
| 25 | 100 | 19.3 | 1.0 | 0.216 |

**(a)** The electrode reaction at the cathode is reduction.

**(i)** Construct the equation for the reaction which occurs at the cathode.

..... [1]

**(ii)** Explain why this reaction is reduction.

.....

..... [1]

**(b)** State how each of the following factors affects the mass of silver formed at the cathode.

temperature of solution

.....

.....

duration of electrolysis

.....

.....

current used

.....

.....

concentration of solution

.....

.....

**(c)** Explain why aqueous silver nitrate can be electrolysed but solid silver nitrate cannot.

.....

.....

..... [2]

**(d)** Aqueous silver nitrate reacts with dilute hydrochloric acid to form a white precipitate.

Construct the ionic equation, including state symbols, for the formation of this white precipitate.

..... [2]

[Total: 10]

s/13/qp21

**(d)** The electrode reactions in an oxygen-hydrogen fuel shell are shown below.

Equation 1 $O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$

Equation 2 $H_2(g) + 2OH^-(aq) \rightarrow 2e^- + 2H_2O(l)$

Explain why the reaction in a fuel cell involves both oxidation **and** reduction.

.....

.....

.....

..... [2]

**(e)** Name one source of the hydrogen needed for a fuel-cell.

..... [1]

**(f)** State one advantage and one disadvantage of using an oxygen-hydrogen fuel cell.

advantage .....

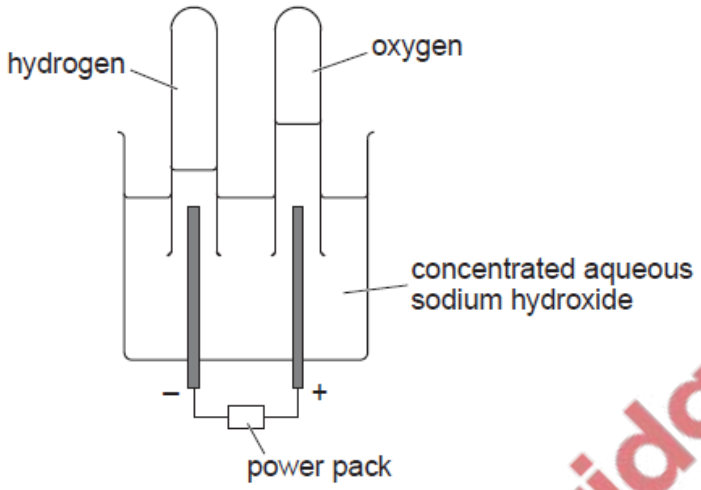
.....

disadvantage .....

..... [2]

s/12/qp22

**A5** The diagram below shows the apparatus used to electrolyse aqueous sodium hydroxide in the laboratory.




Electrolysis of the aqueous sodium hydroxide, results in the formation of hydrogen at the cathode (negative electrode) and oxygen at the anode (positive electrode).

**(a)** Complete the equation for the formation of oxygen at the anode.

$$\text{.....}OH^- \longrightarrow O_2 + \text{.....}H_2O + \text{.....} \qquad [1]$$

**(b)** **(i)** When the power pack is replaced by a voltmeter, the apparatus acts like a fuel cell. The left hand electrode in the diagram becomes the negative pole of the cell and the right hand electrode becomes the positive pole.

State the direction of the electron flow in the external circuit.
Give a reason for your answer.

.....

..... [1]

**(ii)** In this fuel cell, hydrogen reacts with aqueous hydroxide ions to form water.
Construct an equation for this reaction.

[1]

**(c)** **(i)** Suggest two advantages of using a fuel cell rather than petrol to power a car.

.....

.....

..... [2]

**(ii)** Suggest one disadvantage of fuel cells.

..... [1]

**A5** Nickel can be refined by reacting the impure metal with carbon monoxide. The impurities do not react with carbon monoxide.
A volatile compound called nickel carbonyl is formed.
This is decomposed to give pure nickel and carbon monoxide.

**(a)** **(i)** Explain the meaning of the term *volatile*.

.....[1]

**(ii)** Suggest how nickel carbonyl might be decomposed.

.....[1]

**(iii)** Explain how this method separates nickel from its impurities.

.....[1]

**(b)** Nickel carbonyl has the formula $Ni(CO)_x$.
The relative molecular mass of nickel carbonyl is 171.
Calculate the value of x.

value of x = .....[1]

**(c)** Nickel is refined by electrolysis in a similar way to copper.
Draw a labelled diagram of the apparatus you would use to purify nickel by electrolysis in the laboratory.

[4]

**(d)** Nickel is a metal.
State three physical properties shown by **all** metals.

.....

.....

.....[3]

**B7** Sulfuric acid is a strong acid. Ethanoic acid is a weak acid.

**(a)** What do you understand by the terms *strong acid* and *weak acid*?

.....

.....

..... [1]

**(b)** Compare and explain the difference in the electrical conductivity between a strong and a weak acid.

..... [1]

**(c)** A dilute solution of sulfuric acid contains hydrogen ions, hydroxide ions and sulfate ions. When this solution is electrolysed, hydrogen gas is formed at the cathode and oxygen gas is formed at the anode.

**(i)** Explain why hydrogen is formed at the cathode.

.....

..... [1]

**(ii)** Write the ionic equation for the reaction at the anode.

..... [2]

**(d)** The electrode reactions in an oxygen-hydrogen fuel shell are shown below.

Equation 1 $O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$

Equation 2 $H_2(g) + 2OH^-(aq) \rightarrow 2e^- + 2H_2O(l)$

Explain why the reaction in a fuel cell involves both oxidation **and** reduction.

.....

.....

.....

..... [2]

**(e)** Name one source of the hydrogen needed for a fuel-cell.

..... [1]

**(f)** State one advantage and one disadvantage of using an oxygen-hydrogen fuel cell.

advantage .....

.....

disadvantage .....

..... [2]

[Total: 10]

**B8** Solid sodium hydroxide, NaOH, has a giant ionic structure.

**(a)** How many electrons are there in one hydroxide ion?

..... [1]

**(b)** Explain why solid sodium hydroxide cannot be electrolysed but aqueous sodium hydroxide can be electrolysed.

.....

.....

..... [2]

**(c)** The electrolysis of aqueous sodium hydroxide produces hydrogen and oxygen as shown by the electrode reactions.

at anode $4OH^-(aq) \longrightarrow O_2(g) + 2H_2O(l) + 4e^-$

at cathode $2e^- + 2H_2O(l) \longrightarrow H_2(g) + 2OH^-(aq)$

Explain why the electrolysis of aqueous sodium hydroxide involves both oxidation **and** reduction.

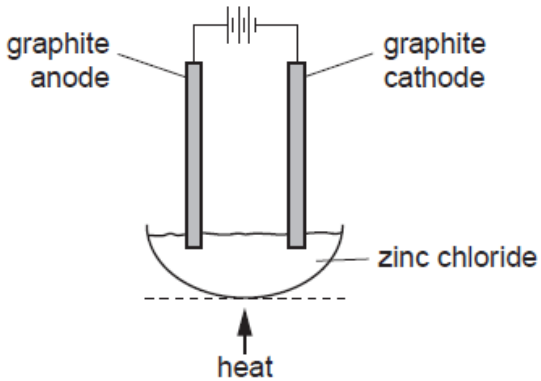
.....

.....

.....

..... [2]

**B7** Zinc chloride is an ionic solid. It can be electrolysed using the apparatus shown below.




**(a)** Explain why zinc chloride conducts electricity when molten, but not when solid.

.....

.....[2]

**(b)** Predict the products of this electrolysis at

the anode, .....

the cathode. .....[1]

**(c)** When a dilute aqueous solution of zinc chloride is electrolysed, hydroxide ions are converted to oxygen at the anode.
Write the ionic equation for this reaction.

[2]

**(d)** Describe a positive test for zinc ions.

test .....

observations .....

.....[3]

**A5** A student electrolysed an aqueous solution of potassium bromide using carbon electrodes.

**(a)** Draw a labelled diagram of a suitable apparatus that can be used for this electrolysis.

[2]

**(b)** The ions present in an aqueous solution of potassium bromide are $H^+$, $OH^-$, $K^+$ and $Br^-$.

**(i)** Describe what you would observe in the region of the anode during the electrolysis.

.....[1]

**(ii)** At the cathode, hydrogen gas is given off.

Describe a test for hydrogen.

test .....

result .....[2]

**(iii)** Write an equation for the reaction at the cathode.

.....[1]

**(iv)** Explain why potassium is **not** discharged at the cathode.

.....

.....[1]

[Total: 7]

**B7** Copper is purified by the electrolysis of aqueous copper(II) sulfate using copper electrodes.

**(a)** Explain how this process is carried out in the laboratory and give relevant equations for the electrode reactions.

.....

.....

.....

.....

.....

.....

.....

.....[4]

**(b)** Aqueous copper(II) sulfate can also be electrolysed using carbon electrodes.

**(i)** Write an equation for the reaction which takes place at the anode in this electrolysis.

.....[1]

**(ii)** Explain why the colour of the copper(II) sulfate solution fades during this electrolysis.

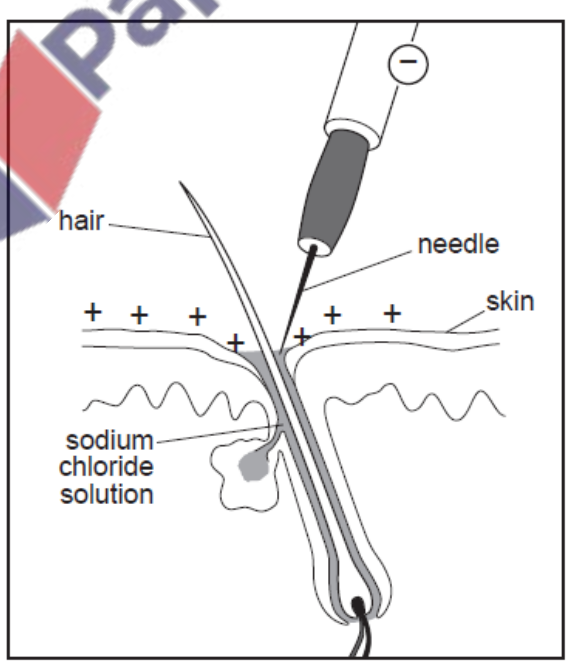
.....

.....[1]

**B9** Electrolysis can be used to remove unwanted hair. The customer holds a metal bar which acts as a positive electrode. A needle, which acts as the negative electrode, is held by the operator.


**(a)** What do you understand by the term *electrolysis*? [1]

**(b)** The solution around the tip of the needle is mainly a dilute aqueous solution of sodium chloride.



**(i)** Name all the ions present in the solution during this electrolysis. [1]

**(ii)** During electrolysis a small amount of chlorine is formed at the surface of the skin. Write an ionic equation for this reaction. [1]

**(iii)** During electrolysis, a gas forms at the tip of the needle and the solution changes from pH 7 to pH 10.
Explain both these changes. [2]

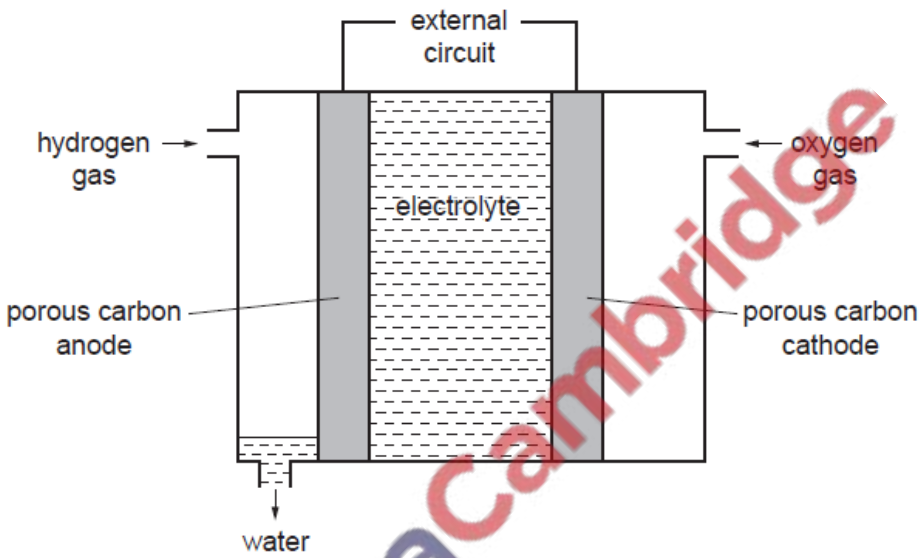
**(c)** Explain why aqueous sodium chloride solution conducts electricity but solid sodium chloride does not. [2]

**B9** One of the first buses to use hydrogen as a fuel was operated in Erlangen, Germany, in 1996. The hydrogen was stored in thick pressurised tanks on the roof of the bus.

**(a)** Describe **two** advantages of using hydrogen as a fuel rather than petrol. [2]

**(b)** Suggest one disadvantage of using hydrogen as a fuel. [1]

**(c)** Some buses use hydrogen to generate electrical energy from a fuel cell.
The structure of a typical fuel cell is shown.




**(i)** The equation for the reaction at the anode is shown.

$$H_2(g) + 2OH^-(aq) \rightarrow 2H_2O(l) + 2e^-$$

What type of reaction is this? Explain your answer. [1]

**(ii)** At the cathode oxygen reacts with water to form hydroxide ions. Write an ionic equation for this reaction. [1]

**(d)** In some fuel cells an acidic electrolyte is used.

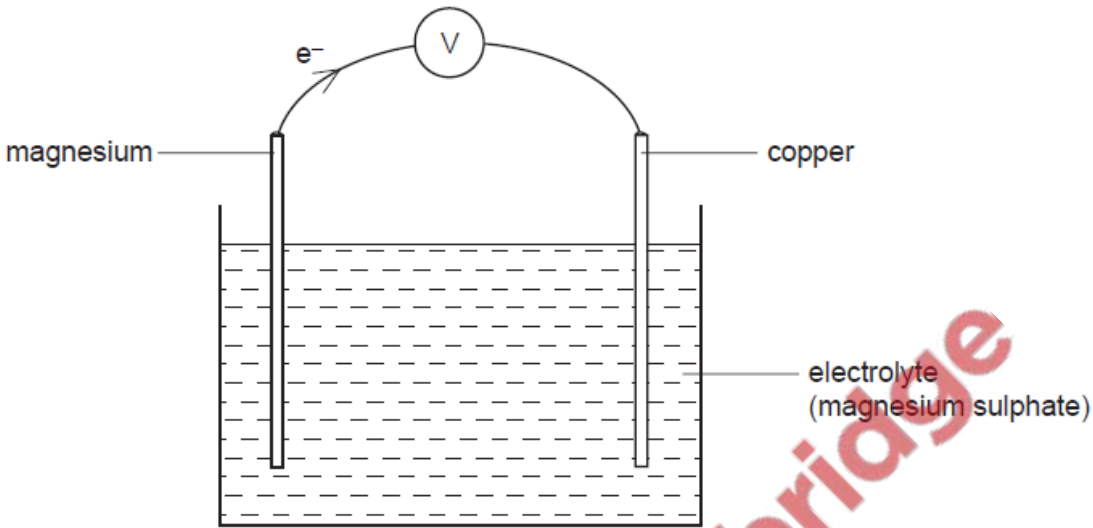
anode reaction: $H_2(g) \rightarrow 2H^+(aq) + 2e^-$

cathode reaction: $O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$

**(i)** Write an overall equation for the reaction occurring in this fuel cell. [1]

**(ii)** Suggest a suitable electrolyte for this fuel cell. [1]

**(e)** An electric current can also be generated by a simple electrochemical cell such as the one shown.



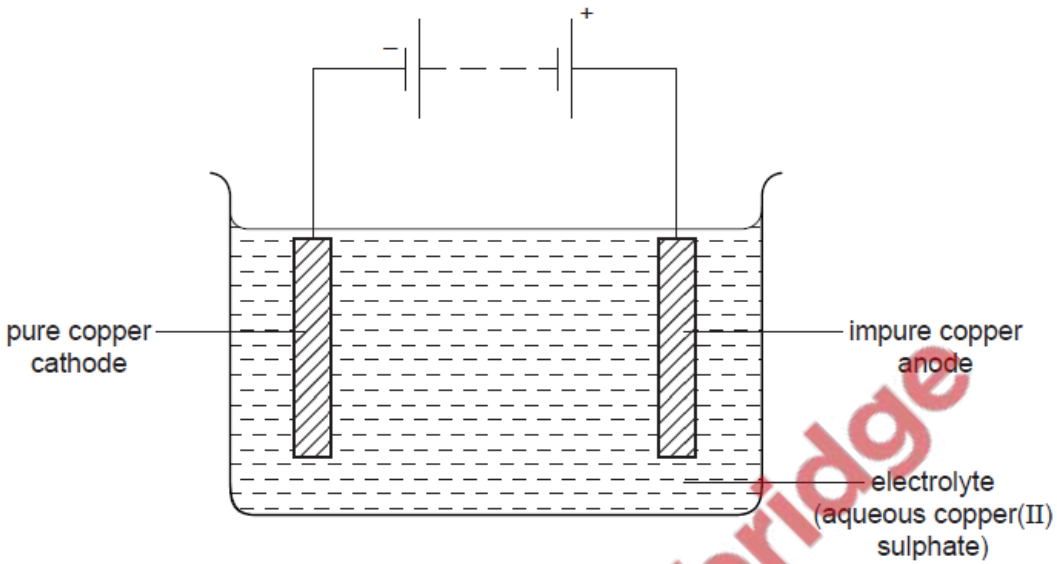

**(i)** Explain why the flow of electrons is in the direction shown in the diagram. [2]

**(ii)** Suggest why silver nitrate would not be a good electrolyte to use in this cell. [1]

[Total: 10]

w/07/qp2

**B10** The diagram shows a cell for purifying copper.




**(a)** Describe what you would observe during this electrolysis and write the equations for the reactions at the electrodes. [3]

**(b)** The electrodes and the electrolyte conduct electricity.

**(i)** Explain how the structure of metals allows copper electrodes to conduct electricity. [1]

**(ii)** Explain why solid copper(II) sulphate does not conduct electricity but an aqueous solution of copper(II) sulphate does conduct. [2]

**(c)** Describe how the apparatus shown in the diagram could be modified in order to electroplate an iron object, such as a knife, with nickel. [2]

**(d)** Bronze is an alloy of copper and tin. Bronze is less malleable than pure copper. Use ideas about the structure of metals and alloys to explain why bronze is less malleable than pure copper. [2]

**B10** A student carried out an electrolysis of dilute sulphuric acid and collected the gases formed.

**(a)** Draw a labelled diagram to show the apparatus used. [2]

**(b)** **(i)** Give the formulae of all the ions present in the solution.

**(ii)** Write half equations for the reactions at the anode and cathode. Use the half equations to construct an overall equation for the reaction and give tests for any gases evolved.

**(iii)** Use your equations to explain how the composition of the solution changes after the electrolysis has been running for some time.

[6]

**(c)** Describe another method for making hydrogen from dilute sulphuric acid. Your answer should include names of the reagents you use and an equation for the reaction. [2]

[Total: 10 marks]

w/05/qp2

---

**B10** Electroplating can be used to coat nickel with a thin coating of silver.

**(a)** Draw a labelled diagram of an apparatus that can be used to electroplate silver onto nickel. [3]

**(b)** Write equations, with state symbols, for the reactions at the anode and cathode. [2]

**(c)** Solutions of two salts, **A** and **B**, were electrolysed using carbon electrodes. The following products were collected.

| *salt* | *products* |
|---|---|
| **A** | oxygen and hydrogen |
| **B** | chlorine and hydrogen |

**(i)** Suggest the names of the two salts, **A** and **B**.

**(ii)** Describe tests to confirm the identifies of the three gases collected. [5]

[Total: 10 marks]

w/04/qp2

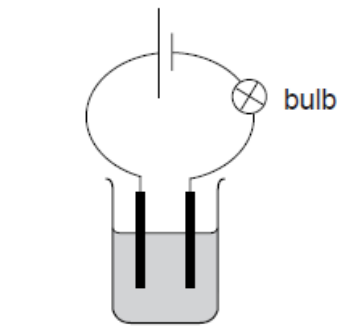
**(b)** Chlorine is manufactured by the electrolysis of concentrated sodium chloride.

**(i)** Write equations for both of the electrode reactions.

**(ii)** Calculate the maximum volume of chlorine, at r.t.p., which can be obtained from 175.5 kg sodium chloride.

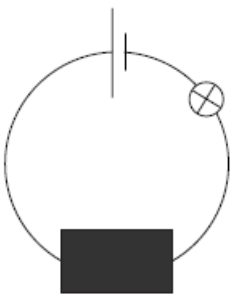
[5]

**A1** **(a)** A student tried to pass an electric current through some solids and liquids.
The six experiments are represented by the diagrams below.



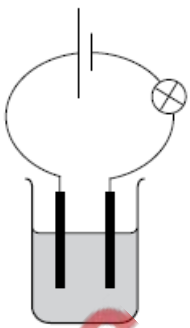

aqueous sodium sulphate

**A**



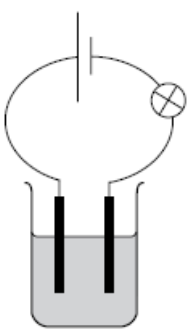
zinc

**B**



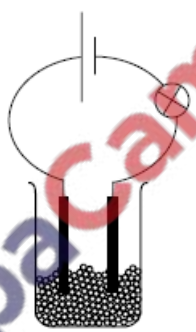
ethanol

**C**



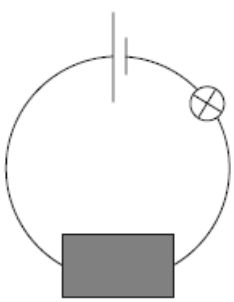
distilled water

**D**



solid copper(II) sulphate

**E**



poly(ethene)

**F**

**(i)** In which experiments will the bulb light?

.....[2]

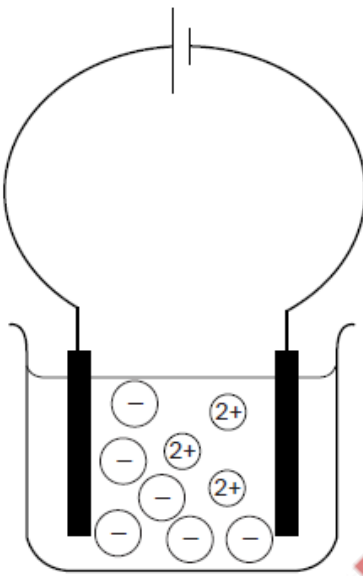
**(ii)** Give the name of an electrolyte shown in the diagram.

.....[1]

**(iii)** In which experiment will oxygen be produced?

.....[1]

**(b)** The following diagram represents the electrolysis of molten substance, **X**.




**(i)** Label the anode and cathode on the diagram.

**(ii)** Suggest the name of substance **X**.

.....

**(iii)** State the formula of the cation in **X**.

.....

**(iv)** Explain why substance **X** conducts electricity when molten, but not when solid.

.....

.....

.....

[5]

**B8** Aqueous copper(II) sulphate is electrolysed using carbon electrodes.

**(a)** Give the formulae of all the ions present in the solution. [2]

**(b)** A copper coating forms on the cathode, and a gas is evolved at the anode.

**(i)** Write a half equation for the formation of copper at the cathode.

**(ii)** Name the gas formed at the anode and describe a test for this gas.

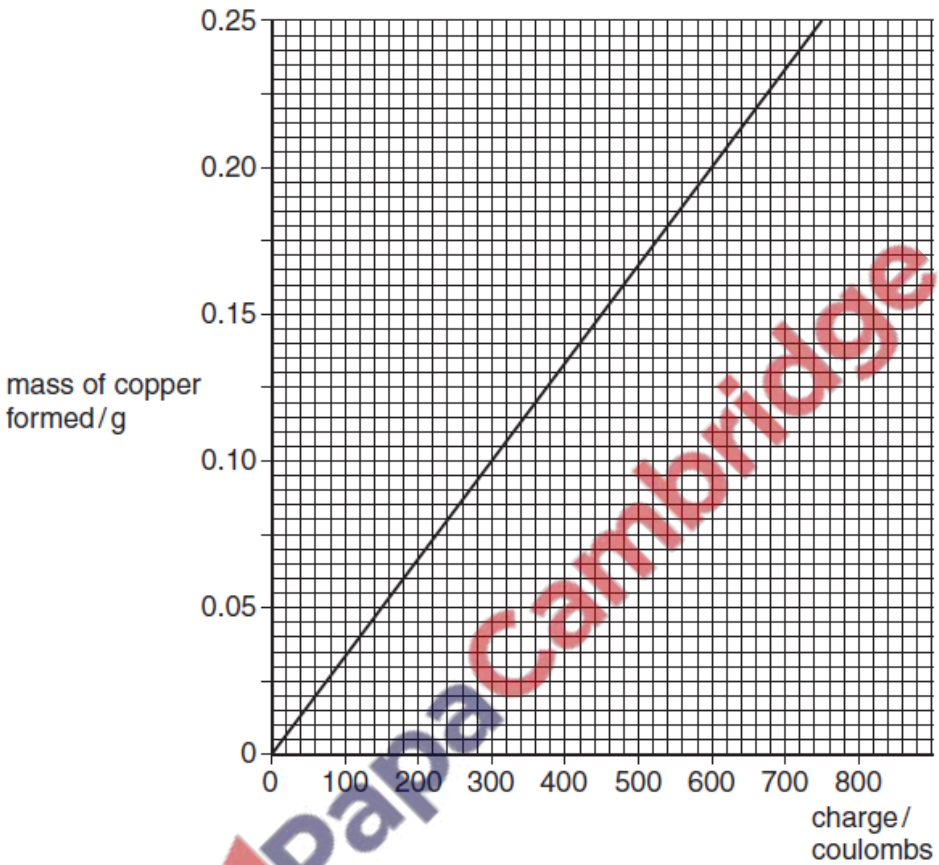
[3]

**(c)** After some time, the blue colour of the aqueous copper(II) sulphate fades and the pH of the solution decreases.

Explain why these changes take place. [2]

**(d)** A student investigated the relationship between the mass of copper formed and the total charge passed through the solution.

This is a graph of the results.






**(i)** What mass of copper is formed when a charge of 600 coulombs is passed through the solution?

**(ii)** Use your graph to predict the charge needed to form 1 g of copper, and hence predict the charge needed to deposit 1 mole of copper.

[3]

[Total : 10]

(ii) Describe how impure copper can be purified.

.....

.....

.....

.....[2]

(c) Name an alloy that contains copper.

.....[1]

s/11/qp22

B6 Electrolysis involves the chemical decomposition of a compound, either when molten or in aqueous solution, by the passage of an electric current.

(a) Explain why aqueous calcium nitrate can be electrolysed but liquid pentane cannot.

.....

.....

.....

.....[2]

(b) State the products of the electrolysis of molten sodium chloride.

.....[1]

(c) State the products of the electrolysis of concentrated aqueous sodium chloride.

.....[1]

(d) Describe the essential details of the manufacture of aluminium by electrolysis.

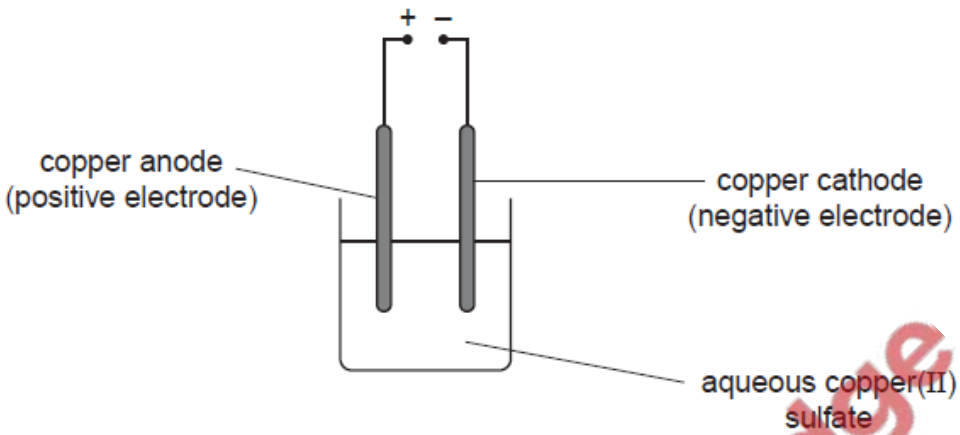
.....

.....

.....

.....[2]

**(e)** A student investigates the electrolysis of aqueous copper(II) sulfate using the apparatus shown below.




The student weighs the copper cathode before and after the electrolysis.

| experiment number | current used / A | time taken / s | mass of cathode | |
|---|---|---|---|---|
| | | | before starting / g | after electrolysis / g |
| 1 | 2.0 | 180 | 1.24 | 1.36 |
| 2 | 4.0 | 180 | 1.20 | 1.44 |
| 3 | 2.0 | 360 | 1.34 | 1.58 |

**(i)** Explain, with the aid of an equation, why the cathode increases in mass.

.....

.....

.....[2]

**(ii)** In experiment **2** the student measures the mass of the anode both before and after the electrolysis.
At the start the anode has a mass of 1.45 g.
Determine the mass of the anode at the end of the electrolysis.

mass of anode at end = ..... g [1]

**(iii)** The student does a fourth experiment, this time using a current of 8.0 A for 90 seconds. At the start the cathode has a mass of 1.51 g.
Predict the mass of the cathode at the end of the electrolysis.

mass of cathode at end = ..... g [1]

[Total: 10]

s/11/qp21

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**(c)** The copper used in mobile phones is purified using electrolysis.

For this electrolysis name

the electrolyte used, .....

the material used for the anode, .....

the material used for the cathode. ..... [3]

s/10/qp21

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**A3** Electrolysis involves the decomposition of a compound by the passage of an electric current.

**(a) (i)** Complete the table, which relates to the electrolysis of different solutions using inert electrodes.

| electrolyte | ions in electrolyte | product at anode | product at cathode |
|---|---|---|---|
| dilute aqueous potassium nitrate | $K^+$, $H^+$, $OH^-$ and $NO_3^-$ | oxygen | hydrogen |
| concentrated aqueous sodium chloride | $Na^+$, $H^+$, $OH^-$ and $Cl^-$ | chlorine | hydrogen |
| dilute aqueous copper(II) sulfate | $Cu^{2+}$, $SO_4^{2-}$, $H^+$ and $OH^-$ | ..... | ..... |
| dilute sulfuric acid | ..... ..... | oxygen | hydrogen |

[3]

**(ii)** Explain why the electrolysis of concentrated aqueous sodium chloride liberates hydrogen rather than sodium at the cathode.

.....

.....[1]

**(iii)** The electrolysis of **dilute** aqueous sodium chloride liberates oxygen at the anode. Suggest why the electrolysis of **concentrated** aqueous sodium chloride liberates chlorine rather than oxygen.

.....

.....[1]

**(b)** Aqueous copper(II) sulfate was electrolysed using copper electrodes. The copper anode lost mass as copper(II) ions were formed and the copper cathode gained mass as copper atoms were formed.

**(i)** State one industrial application of this electrolysis.

.....[1]

**(ii)** The results of an experiment involving the electrolysis of aqueous copper(II) sulfate are shown below.

| temperature of electrolyte / °C | current used / amps | time of electrolysis / s | mass of copper formed at the cathode / g |
|---|---|---|---|
| 20 | 1.0 | 1000 | 0.329 |
| 20 | 2.0 | 1000 | 0.658 |
| 20 | 2.0 | 2000 | 1.320 |
| 25 | 2.0 | 2000 | 1.320 |
| 30 | 1.0 | 1000 | 0.329 |

Use the information in the table to describe how each of the variables affects the mass of copper formed at the cathode.

temperature .....

.....

current .....

.....

time .....

.....[3]

[Total: 9]

**(c)** Complete the following table about electrolysis using inert graphite electrodes.

| electrolyte | product at cathode | product at anode |
|---|---|---|
| molten lead(II) bromide | | |
| aqueous copper(II) sulfate | copper | |
| dilute sulfuric acid | | oxygen |

[3]

**(d)** Describe one commercial use of electrolysis.

use .....

electrolyte used .....

ionic equation for reaction at the cathode .....

[3]

**A5** **(a)** Concentrated aqueous sodium chloride contains $H^+$ and $OH^-$ ions.

**(i)** Give the formulae of **two** other ions present in concentrated aqueous sodium chloride.

.....[1]

**(ii)** Concentrated aqueous sodium chloride is electrolysed using inert graphite electrodes.
Name the product formed at each electrode.

product at anode .....

product at cathode .....[2]

**(b)** Impure copper can be purified by electrolysis.

Draw a labelled diagram of the electrolytic cell that can be used to purify copper.

[3]

**A5** Chlorine, hydrogen and sodium hydroxide are made by the electrolysis of concentrated aqueous sodium chloride.

**(a)** Aqueous sodium chloride contains the following ions, $Na^+$, $H^+$, $OH^-$ and $Cl^-$.

Concentrated aqueous sodium chloride can be electrolysed using inert electrodes.

The electrode reactions are represented below.

cathode $2H^+ + 2e^- \rightarrow H_2$
anode $2Cl^- \rightarrow Cl_2 + 2e^-$

**(i)** Explain why hydrogen, **not** sodium, is formed at the cathode.

.....

.....

**(ii)** Suggest why, as the electrolysis proceeds, the concentration of sodium hydroxide in the electrolyte increases.

.....

.....

[2]

**A5** Electrolysis is the decomposition of a liquid by the passage of an electrical current.

**(a)** Aqueous copper(II) sulphate contains the following ions, $Cu^{2+}$, $H^+$, $OH^-$ and $SO_4^{2-}$.
Aqueous copper(II) sulphate can be electrolysed using inert electrodes.

The electrode reactions are represented below.

cathode $Cu^{2+} + 2e^- \longrightarrow Cu$
anode $4OH^- \longrightarrow O_2 + 2H_2O + 4e^-$

**(i)** Explain why copper, **not** hydrogen, is formed at the cathode.

.....

.....

**(ii)** Explain why the formation of oxygen at the anode is an example of oxidation.

.....

.....

**(iii)** The electrolysis of aqueous copper(II) sulphate using copper electrodes has a different anode reaction.
Give the equation for the electrode reaction at the anode.

.....

[3]

**(b)** Molten lead(II) bromide decomposes when an electric current is passed through it.

**(i)** Explain why solid lead(II) bromide will not conduct electricity but molten lead(II) bromide will.

.....

.....

.....

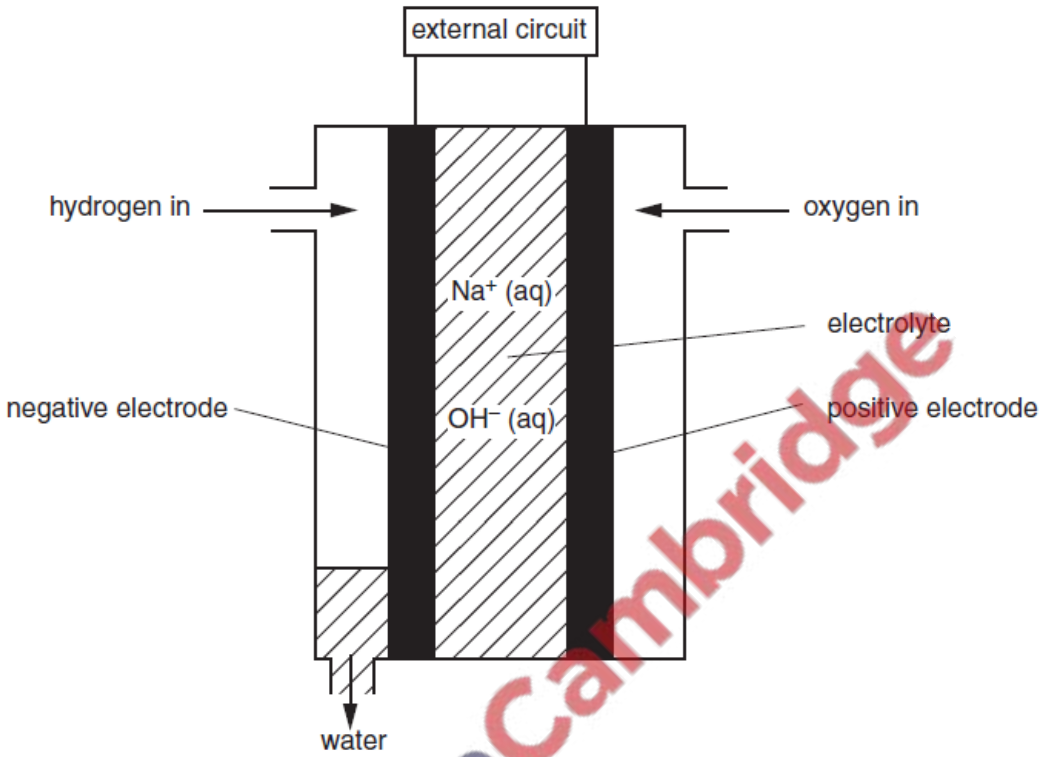
**(ii)** Construct the equations for the two electrode reactions.

cathode .....

anode .....

[4]

**B8** The NASA space shuttle uses fuel cells to generate electricity. The diagram below shows a hydrogen-oxygen fuel cell.




At the positive electrode, oxygen reacts with water as shown.

$$O_2(g) + 2H_2O(l) + 4e^- \longrightarrow 4OH^-(aq)$$

At the negative electrode, hydrogen reacts with hydroxide ions as shown.

$$H_2(g) + 2OH^-(aq) \longrightarrow 2H_2O(l) + 2e^-$$

The overall reaction in the fuel cell is the reaction between hydrogen and oxygen to make water.

**(a)** Give **one** source for hydrogen and **one** source for oxygen for use in a fuel cell. [2]

**(b)** What is the name of the electrolyte used in the fuel cell? [1]

**(c)** What type of reaction takes place, reduction or oxidation, at the positive electrode? Explain your answer. [1]

**(d)** A fuel cell uses 240 $dm^3$ of hydrogen. Calculate the volume of oxygen needed, and the mass of water formed. All gas volumes measured at room temperature and pressure. [3]

**(e)** Describe some advantages and disadvantages of using a fuel cell to generate electricity. [3]

**B6** Sodium chloride is used in making many important chemicals including chlorine and hydrogen.

**(a)** Write the electrode reactions for the electrolysis of **molten** sodium chloride.

Which electrode reaction is an oxidation? Explain your answer. [3]

**(b)** Explain why the electrolysis of **aqueous** sodium chloride using inert electrodes gives hydrogen. [1]

**(c)** Explain the three stages in the purification of water supplies. [3]

**(d)** Hydrogen is used to manufacture ammonia, $NH_3$. Calculate the volume of hydrogen needed to react completely with 240 $dm^3$ of nitrogen, all gas volumes measured at room temperature and pressure. [3]