Write your name, centre number and candidate number in the boxes below.

Surname	Other names

Centre number | | | | | |

Candidate number | | | | |

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Electrolysis and half-equations

Time allowed: 1 hour 30 minutes

Subject code **0620**

Chemistry

Questions from Paper 3, Paper 4 and Paper 6

You must have: a ruler marked in centimetres and millimetres, a protractor, compasses, a pen, an HB pencil and an eraser.

Total marks

/ 84

Instructions

- Answer every question in the space provided on this paper.
- Write in black or dark blue ink. Pencil may be used for diagrams and graphs.
- Fill in your name, centre number and candidate number above.
- Show your working: a correct method can earn marks even if the answer is wrong.

Information

- This paper has 10 questions worth 84 marks in total.
- The marks for each question or part are shown in brackets, for example [3].

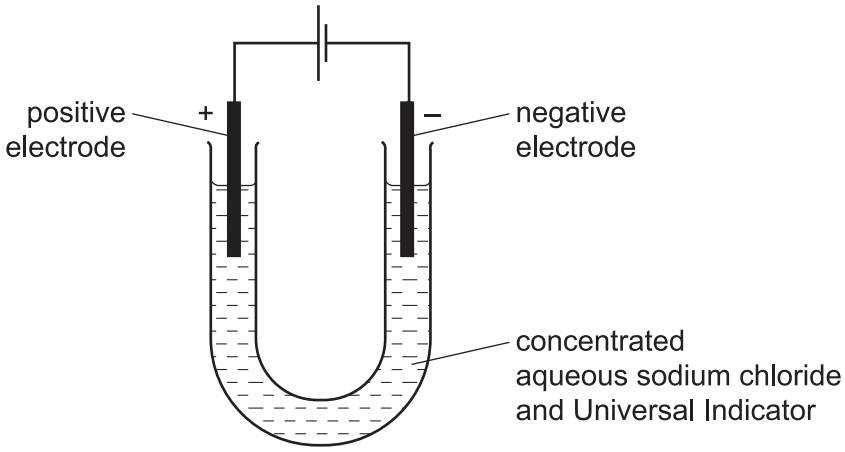
Advice

- Read every question through once before you write anything.
- Use the marks in brackets to judge how long to spend on each part.
- If you finish early, go back and check your working.

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Print at 100% (Actual size) so diagrams keep their real measurements.

1 A concentrated solution of sodium chloride was electrolysed using the apparatus below.



One observation noted was that the Universal Indicator turned purple at the negative electrode.

(a) What observation would be made at **both** electrodes?

..... [1]

(b) Why did the indicator turn purple at the negative electrode?

..... [1]

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

..... [1]

(ii) Suggest the effect of this product on the Universal Indicator.

..... [1]

[Total: 4]

Electrolysis and electroplating Click for more variations

1 **(a)** bubbles / fizzing / effervescence [1]

(b) alkali formed [1]

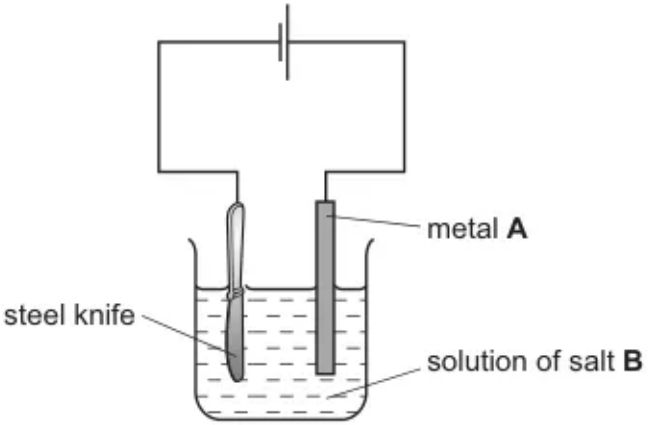
(c) **(i)** chlorine [1]

(ii) indicator bleached / decolourised **allow** yellow [1]

[Total: 4]

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2 The apparatus below was used to deposit a thin layer of chromium on a steel knife.
The knife was cleaned carefully and all grease removed before the process started.



(a) What is the name of the process when metal objects are coated with other metals?

..... [1]

(b) (i) Suggest the identity of metal **A**.

..... [1]

(ii) Suggest the name of salt **B**.

..... [1]

(c) Give **two** reasons why steel knives are coated with chromium.

1. .....

2. ..... [2]

[Total: 5]

Electrolysis and electroplating Click for more variations

2 **(a)** electroplating [1]

(b) **(i)** chromium (1)

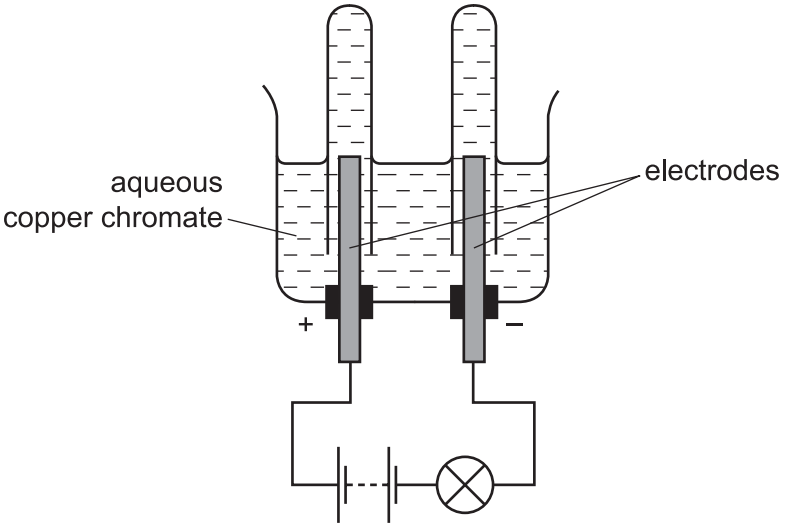
(ii) any named chromium salt (1) [2]

(c) to stop corrosion owtte (1)
to look attractive owtte (1) [2]

[Total: 5]

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3 Electricity was used to break down an aqueous solution of copper chromate, $CuCrO_4$, which is green.
The apparatus used is shown.



A brown deposit was seen forming at one electrode and oxygen was evolved at the other electrode.

(a) Suggest a suitable non-metal for the electrodes.

..... [1]

(b) Give **one** other observation expected during this experiment.

..... [1]

(c) Name the brown deposit and identify at which electrode it is formed.

..... [2]

(d) Name the process when electricity breaks down aqueous solutions.

..... [1]

[Total: 5]

Electrolysis and electroplating Click for more variations

3 **(a)** carbon / graphite (1) [1]

(b) bulb lights / fizzing / bubbles (1) [1]
ignore: names of electrodes
allow: solution gets paler / changes colour / green colour fades

(c) copper (1)
negative electrode / cathode (1) [2]

(d) electrolysis (1) [1]

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4 Metal rings can be coated with a layer of copper using electricity.
Plan an experiment to electroplate a small metal ring with copper.
You are provided with common laboratory apparatus, a copper rod, copper(II) sulfate crystals, water and a small metal ring.
Include a labelled diagram in your answer.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [6]

[Total: 6]

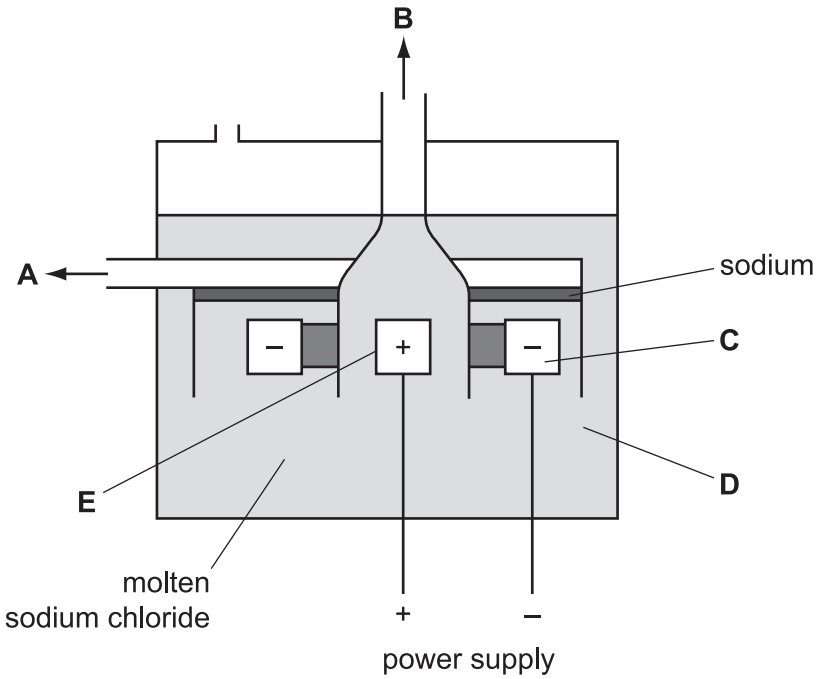
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Electrolysis and electroplating Click for more variations

4	clean / sandpaper the metal ring dissolve copper(II) sulfate in water / copper(II) sulfate solution set up circuit / switch on electricity / complete circuit copper rod anode(+ ve electrode) metal ring cathode(– ve electrode) rotate the metal ring / agitate remove the metal ring, wash and dry	**6**

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5 The diagram shows an electrolysis cell for extracting sodium from molten sodium chloride.



(a) **(i)** Which letter on the diagram represents

the electrolyte? .....

the cathode? ..... [2]

(ii) Which one of the following substances is most likely to be used as the anode? Put a ring around the correct answer.

graphite **sodium** **sulfur** **zinc** [1]

(b) What information from the diagram suggests that sodium is less dense than molten sodium chloride?

..... [1]

(c) Predict the product formed at the anode during this electrolysis.

..... [1]

(d) Name the gases formed at the anode and cathode when an **aqueous** solution of sodium chloride is electrolysed.

product at the anode .....

product at the cathode ..... [2]

[Total: 7]

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Electrolysis and electroplating Click for more variations

5 **(a)** **(i)** electrolyte → D [1]
allow: (molten) sodium chloride
cathode → C [1]

(ii) graphite [1]

(b) floats on top of the sodium chloride [1]
allow: sodium is on top

(c) chlorine / Cl_2 [1]
allow: Cl
reject: chloride

(d) (anode →) chlorine / Cl_2 [1]
allow: oxygen / O_2
allow: Cl / O
reject: chloride / oxide
(cathode →) hydrogen / H_2 [1]
allow: H

[Total: 7]

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6 Electrolysis of concentrated aqueous sodium chloride using inert electrodes forms chlorine, hydrogen and sodium hydroxide.

(a) What is meant by the term *electrolysis*?

.....

.....

..... [2]

(b) Name a substance that can be used as the inert electrodes.

..... [1]

(c) Write an ionic half-equation for the formation of hydrogen during this electrolysis.

..... [1]

(d) Give the formulae of the **four** ions present in concentrated aqueous sodium chloride.

..... [2]

(e) Explain how sodium hydroxide is formed during this electrolysis.

.....

.....

..... [2]

[Total: 8]

Electrolysis and electroplating Click for more variations

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6(a)	**breakdown** of an ionic **compound** when molten or in aqueous solution (1) (using) electricity / electric current / electrical energy (1)	**2**
6(b)	platinum / graphite	**1**
6(c)	$2H^+ + 2e \rightarrow H_2$	**1**

6(d)	Na^+ H^+ Cl^- OH^- **all** four (2) 3 or 2 (1)	**2**
6(e)	H^+ and Cl^- are discharged / removed (1) Na^+ and OH^- remain (1)	**2**

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7 This question is about electrolysis.

(a) State the meaning of the term electrolysis.

.....

..... [2]

(b) Table 2.1 gives some information about the electrolysis of two electrolytes using graphite electrodes.

Table 2.1

	anode (positive electrode)		cathode (negative electrode)	
electrolyte	observation	name of product	observation	name of product
concentrated aqueous potassium iodide			bubbles of colourless gas	
aqueous copper(II) sulfate	bubbles of colourless gas	oxygen	pink-brown solid	

(i) Complete Table 2.1. [4]

(ii) Oxygen is produced at the anode by the electrolysis of aqueous copper(II) sulfate.

Write the ionic half-equation for this reaction.

..... [2]

(c) Aqueous copper(II) sulfate is electrolysed using copper electrodes instead of graphite electrodes.

(i) Explain why the mass of the anode decreases during this electrolysis.

..... [1]

(ii) Name the product formed at the cathode.

..... [1]

(iii) State what change, if any, is observed in the appearance of the aqueous copper(II) sulfate.

..... [1]

[Total: 11]

Electrolysis and electroplating Click for more variations

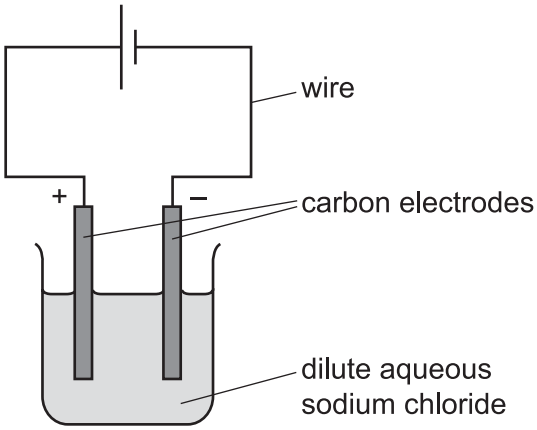
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7(a)	**M1** breakdown by (the passage of) electricity **M2** of an ionic compound in molten or aqueous (state)	**2**
7(b)(i)	**M1** brown solution **OR** black solid **M2** iodine **M3** hydrogen **M4** copper	**4**

7(b)(ii)	$4OH^- \rightarrow 2H_2O + O_2 + 4e^-$ **M1** OH^- **AND** e^- **M2** correct equation	**2**
7(c)(i)	copper **OR** anode forms Cu^{2+} which goes into the solution	**1**
7(c)(ii)	copper	**1**
7(c)(iii)	no change	**1**

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8 A student carries out an electrolysis experiment using the apparatus shown.



The student uses dilute aqueous sodium chloride.

(a) State the name given to any solution which undergoes electrolysis.

..... [1]

(b) Hydroxide ions are discharged at the anode.

(i) Complete the ionic half-equation for this reaction.

.....$OH^-(aq) \rightarrow$ ..... + $O_2(g)$ + $4e^-$ [2]

(ii) Explain how the ionic half-equation shows the hydroxide ions are being oxidised.

..... [1]

(c) Describe what the student observes at the cathode.

..... [1]

(d) Write the ionic half-equation for the reaction at the cathode.

..... [2]

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(e) The student repeats the experiment using concentrated aqueous sodium chloride.

(i) Describe what the student observes at:

- the cathode .....
- the anode. .....

[2]

(ii) The student added litmus to the solution after the electrolysis of concentrated aqueous sodium chloride.

State the colour seen in the solution. Give a reason for your answer.

colour of solution .....

reason .....

[2]

(f) Carbon electrodes are used because they are inert.

State another element that can be used instead of carbon.

..... [1]

[Total: 12]

Electrolysis and electroplating Click for more variations

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8(a)	electrolyte	**1**
8(b)(i)	$4OH^- \rightarrow 2H_2O + O_2 + 4e^-$ balance of charge (1) rest of equation (1)	**2**
8(b)(ii)	(OH^-(aq) ions) lose electrons	**1**
8(c)	fizzing	**1**
8(d)	$2H^+ + 2e^- \rightarrow H_2$ species correct (1) fully correct equation (1)	**2**
8(e)(i)	fizzing (1) green gas (1)	**2**
8(e)(ii)	(litmus turns) blue **and** alkali / base forms (1) Sodium hydroxide / NaOH (forming) (1)	**2**
8(f)	platinum	**1**

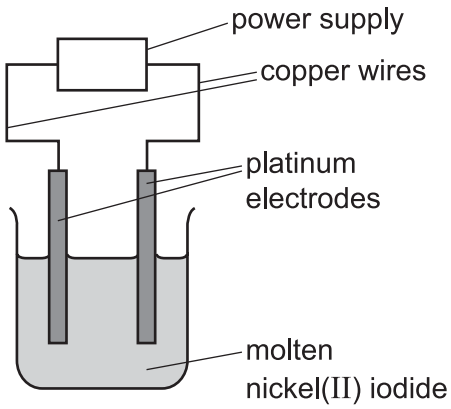
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9 **(a)** Nickel(II) iodide crystals are hydrated. A sample of hydrated nickel(II) iodide crystals has the following composition by mass: Ni, 14.01%; I, 60.33%; H, 2.85%; O, 22.81%.

Calculate the empirical formula of the hydrated nickel(II) iodide crystals.

empirical formula = ... [2]

(b) Molten nickel(II) iodide can be electrolysed using the apparatus shown.



During electrolysis, charge is transferred through the copper wires and through the molten nickel(II) iodide.

(i) Name the type of particles which transfer charge through the copper wires.

..... [1]

(ii) Name the type of particles which transfer charge through the molten nickel(II) iodide.

..... [1]

(iii) Predict the products of the electrolysis of molten nickel(II) iodide. Write an ionic half-equation for the formation of **one** of these products.

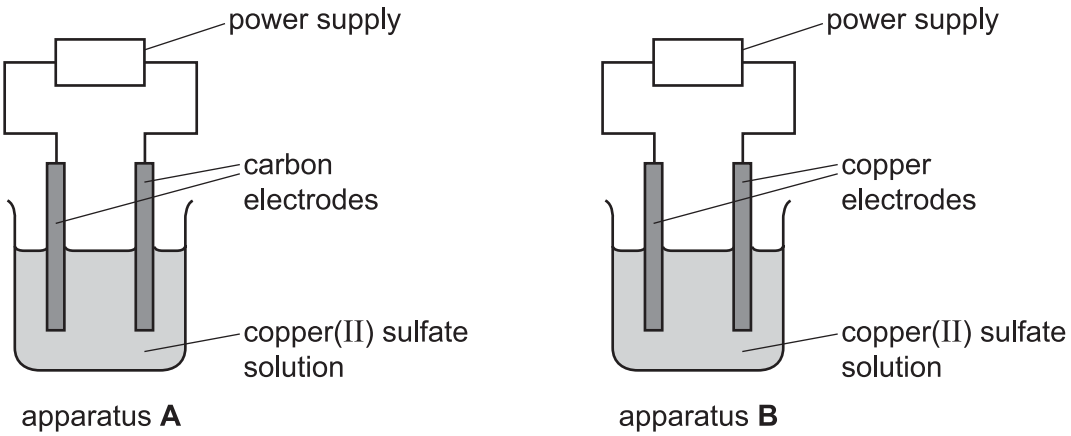
products .....

ionic half-equation .....

[3]

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(c) A student electrolysed copper(II) sulfate solution using the two sets of apparatus shown.



In apparatus **A** the student used carbon electrodes.
In apparatus **B** the student used copper electrodes.

The student made the following observations.

apparatus **A**	apparatus **B**
The mass of the negative electrode increased.	The mass of the negative electrode increased.
The mass of the positive electrode stayed the same.	The mass of the positive electrode decreased.
Bubbles were seen at the positive electrode.	No bubbles were seen at the positive electrode.

(i) Explain why the mass of the negative electrode increased in **both** sets of apparatus.

.....

..... [1]

(ii) Name the gas that formed the bubbles seen in apparatus **A**.

..... [1]

(iii) Explain why the mass of the positive electrode decreased in apparatus **B**.

.....

..... [1]

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(iv) Suggest what happens to the colour of the solution in apparatus **A** and apparatus **B** as the electrolysis progresses.
Explain your answer.

colour of the solution in apparatus **A** .....

colour of the solution in apparatus **B** .....

explanation .....

.....

.....

[3]

[Total: 13]

Electrolysis and electroplating Click for more variations

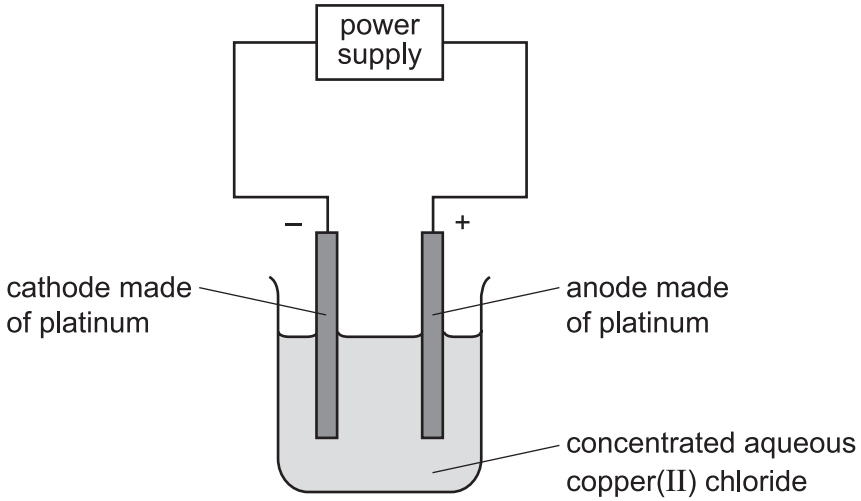
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9(a)	14.01/59 : 60.33/127 : 2.85/1 : 22.81/16 **OR** 0.237 : 0.475 : 2.85 : 1.43	**1**
	$NiI_2H_{12}O_6$	**1**
9(b)(i)	electrons	**1**
9(b)(ii)	(positive and negative) ions	**1**
9(b)(iii)	nickel	**1**
	iodine	**1**
	$Ni^{2+} + 2e^- \rightarrow Ni$ **OR** $2\,I^- \rightarrow I_2 + 2\,e^-$	**1**
9(c)(i)	copper formed/copper deposited	**1**
9(c)(ii)	oxygen	**1**
9(c)(iii)	copper removed or copper lost **or** copper forms ions	**1**
9(c)(iv)	any **three** from: (apparatus **A**): solution becomes paler/fades in **A** (apparatus **B**): solution stays the same colour in **B** (explanation): copper ions removed (but not added) copper ions not replaced in **A** **OR** copper ions both removed and added (at the same rate) copper ions are being replaced (continually)	**3**

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10 Solutions of ionic compounds can be broken down by electrolysis.

(a) Concentrated aqueous copper(II) chloride was electrolysed using the apparatus shown.



The ionic half-equations for the reactions at the electrodes are shown.

negative electrode: $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

positive electrode: $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$

(i) Platinum is a solid which is a good conductor of electricity.

State **one** other property of platinum which makes it suitable for use as electrodes.

.....

..... [1]

(ii) State what would be **seen** at the positive electrode during this electrolysis.

.....

..... [1]

(iii) State and explain what would happen to the mass of the negative electrode during this electrolysis.

.....

.....

..... [2]

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(iv) The concentrated aqueous copper(II) chloride electrolyte is green.

Suggest what would happen to the colour of the electrolyte during this electrolysis.
Explain your answer.

.....

.....

..... [2]

(v) Identify the species that is oxidised during this electrolysis.
Explain your answer.

species that is oxidised .....

explanation .....

.....
[2]

(b) Metal objects can be electroplated with silver.

(i) Describe how a metal spoon can be electroplated with silver.
Include:

- what to use as the positive electrode and as the negative electrode
- what to use as the electrolyte
- an ionic half-equation to show the formation of silver.

You may include a diagram in your answer.

.....

.....

.....

ionic half-equation .....
[4]

(ii) Give **one** reason why metal spoons are electroplated with silver.

.....

..... [1]

[Total: 13]

Electrolysis and electroplating Click for more variations

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10(a)(i)	inert / unreactive / does not react with chlorine	1
10(a)(ii)	bubbles / fizzing / effervescence	1
10(a)(iii)	**M1** increases **M2** (solid) copper deposited	2
10a(iv)	**M1** colour fades / becomes pale(r) / becomes colourless / becomes lighter **M2** copper (ions) removed (from solution)	2
10(a)(v)	**M1** species oxidised: chloride (ions) / Cl^- **M2** explanation: loss of electrons / increase in oxidation state	2
10(b)(i)	**M1** spoon as cathode **M2** (pure)silver as anode **M3** aqueous silver nitrate as electrolyte **M4** $Ag^+ + e^- \rightarrow Ag$	4
10(b)(ii)	any one from: • Improves appearance • prevent / resist corrosion / oxidation • antibacterial	max 1

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