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

Surname	Other names

Centre number | | | | | |

Candidate number | | | | |

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Electrochemistry

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

/ 79

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 79 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)** Molten lead(II) bromide is electrolysed using carbon electrodes.

(i) State the products of this electrolysis at:

the negative electrode .....

the positive electrode. .....

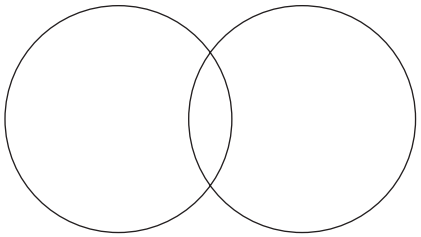
[2]

(ii) State the name of **another** substance which can be used as an inert electrode.

..... [1]

(b) When aqueous magnesium chloride is electrolysed using carbon electrodes, hydrogen gas is produced at the negative electrode.

Complete the dot-and-cross diagram to show the electron arrangement in one molecule of hydrogen.



[1]

[Total: 4]

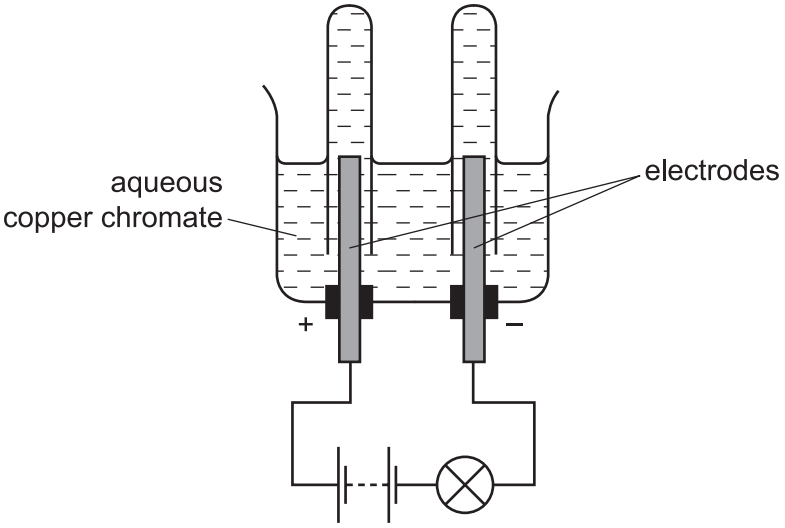
Electrolysis and electroplating Click for more variations

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1(a)(i)	negative electrode: lead (1) positive electrode: bromine (1)	**2**
1(a)(ii)	platinum (1)	**1**
1(b)	1 shared pair of electrons AND no other electrons on either H atom (1)	**1**

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2 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

2 **(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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3 Metal spoons can be electroplated with silver.

Describe how a metal spoon can be electroplated with silver. Include in your answer how you could determine the mass of the silver electroplated onto the metal spoon.

You are provided with solid silver nitrate, a metal spoon, a piece of solid silver, distilled water and common laboratory apparatus.

You must include a diagram in your answer.

.....

.....

.....

.....

.....

.....

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.....

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..... [6]

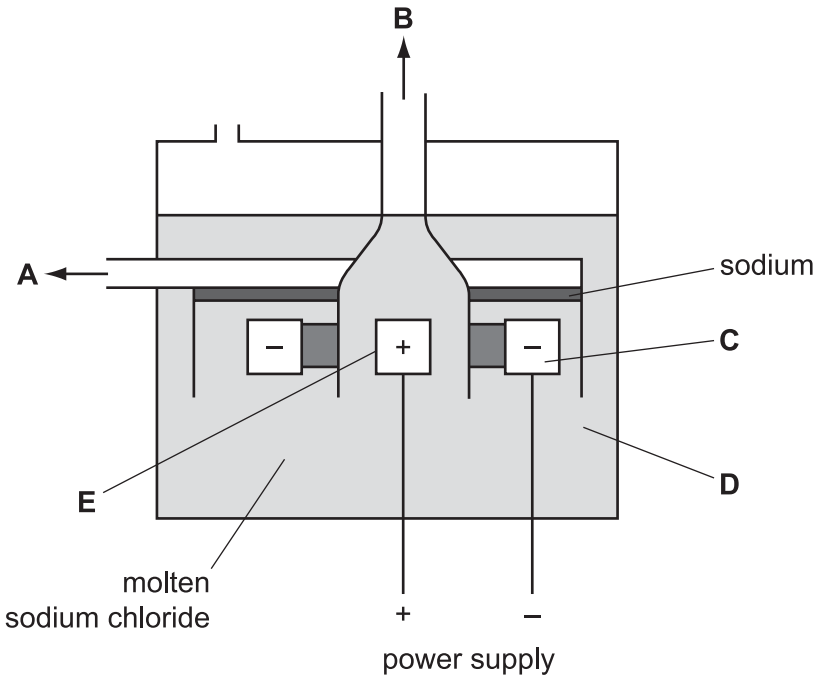
Electrolysis and electroplating Click for more variations

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3	**any 6 from** **MP1** find mass of spoon **MP2** silver nitrate dissolved in water **MP3** diagram showing complete circuit with electrodes in silver nitrate (solution) / electrolyte and a power supply **MP4** spoon / object to be plated as negative electrode / cathode in electrolysis **MP5** silver used as one of the electrodes in electrolysis After electrolysis **MP6** wash and dry spoon **MP7** find mass of spoon again (**after electrolysis)** and mass of silver = new mass – original mass	**6**

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4 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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4 **(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

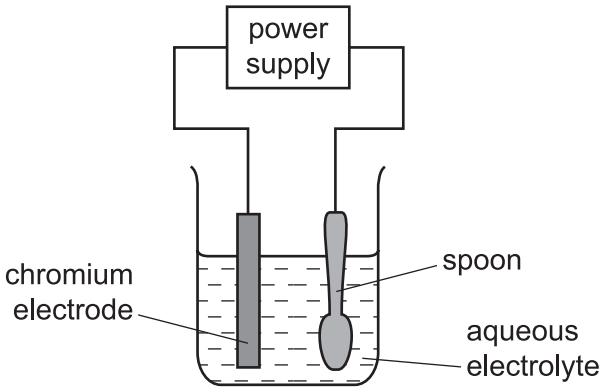
(c) chlorine / Cl_2 [1]
allow: Cl
reject: chloride

(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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5 A steel spoon can be coated in chromium using electrolysis. The spoon has to be very clean and free of grease.



(a) Name this process of coating a metal object with another metal.

..... [1]

(b) Suggest **one** advantage of putting a layer of chromium on the spoon.

..... [1]

(c) Which electrode should be the spoon?

..... [1]

(d) Suggest the name of a compound that could dissolve in water to form the electrolyte.

..... [2]

(e) Why must the spoon be very clean and free of grease?

..... [1]

(f) Suggest **one** mistake in the apparatus set up.

..... [1]

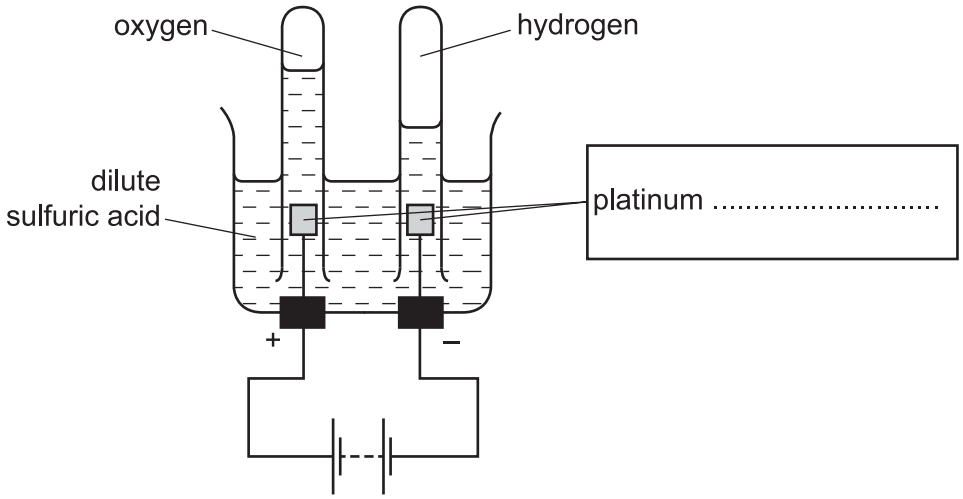
[Total: 7]

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Electrolysis and electroplating Click for more variations

5(a)	electroplating;	1	**R:** electrolysis
5(b)	prevent rusting / corrosion / attractive appearance / shiny;	1	
5(c)	the negative / cathode;	1	
5(d)	**M1** chromium (salt) / chromium + *any named* anion; **M2** nitrate / sulfate / chloride / ethanoate / *suitable* named anion;	1 1	**M2** is dependent on **M1**
5(e)	coating will not stick / be even / dirt or grease will be trapped;	1	**I:** it will not conduct
5(f)	spoon not completely immersed in electrolyte / only half of spoon will be plated;	1	

6 The diagram shows the apparatus used to electrolyse dilute sulfuric acid.



(a) Complete the box to show the role of the platinum. [1]

(b) Give **one** observation made during this electrolysis.

..... [1]

(c) **(i)** Compare the volumes of oxygen and hydrogen produced.

.....

..... [2]

(ii) Which substance breaks down to form these gases?

..... [1]

(d) Give **one** test to distinguish between oxygen and hydrogen.

test .....

result with oxygen .....

result with hydrogen .....

[2]

[Total: 7]

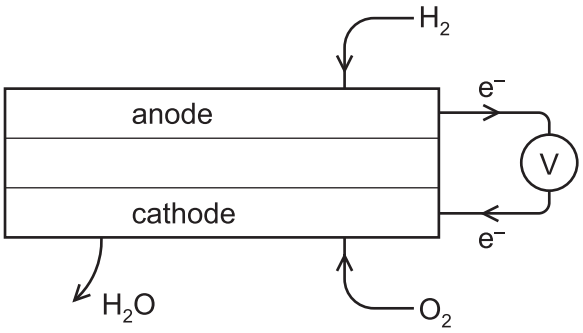
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Electrolysis and electroplating Click for more variations

6(a)	electrodes	**1**
6(b)	bubbles / fizz / effervescence	**1**
6(c)(i)	more hydrogen twice as much hydrogen / half as much oxygen	**1** **1**
6(c)(ii)	water	**1**
6(d)	*lighted splint* no effect / brighter light for oxygen 'pops' for hydrogen **OR** *glowing splint* relights for oxygen no effect for hydrogen	 **1** **1** **1** **1**

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7 A fuel cell produces electrical energy by the oxidation of a fuel by oxygen.
The fuel is usually hydrogen but methane and methanol are two other fuels which may be used.
A diagram of a hydrogen fuel cell is given below.



(a) When the fuel is hydrogen, the only product is water.
What additional product would be formed if methane was used?

..... [1]

(b) Write the equation for the chemical reaction that takes place in a hydrogen fuel cell.

..... [1]

(c) **(i)** At which electrode does oxidation occur? Explain your choice.

..... [1]

(ii) Write an ionic equation for the reaction at this electrode.

..... [2]

(d) Fuel cells are used to propel cars.
Give **two** advantages of a fuel cell over a gasoline-fuelled engine.

.....

..... [2]

[Total: 7]

Electrolysis and electroplating Click for more variations

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7 **(a)** carbon dioxide/CO_2 [1]

(b) $2H_2 + O_2 \rightarrow 2H_2O$ [1]

(c) **(i)** anode/negative electrode **and** electrons lost(by hydrogen/H/H_2)/electrons move from this electrode [1]

(ii) $H_2 \rightarrow 2H^+ + 2e(^-)$ / $H_2 - 2e(^-) \rightarrow 2H^+$ / $H_2 + 2OH^- \rightarrow 2H_2O + 2e(^-)$ / $H_2 + 2OH^- - 2e(^-) \rightarrow 2H_2O$ [2]
Species (1) Balancing (1)

(d) Any **two** from:

CELL:	lightweight
	quieter
	fewer working parts/less maintenance
	more efficient **or** less energy wasted **or** more energy produced
SUSTAINABILITY:	conserves a limited resource/petroleum/fossil fuels
	unlimited supplies of renewable resource(of hydrogen from water)
POLLUTION:	No or less greenhouse effect
	No or less acid rain
	No or less toxic gases
	No or less smog
POLLUTANTS:	No or less C/soot
	No or less CO_2
	No or less CO
	No or less SO_2
	No or less oxides of nitrogen/NO/NO_2/N_2O_4/NO_x
	No or less (unburnt) hydrocarbons
	No or less low level ozone
	H_2O is the **only** product

[2]

[Total: 7]

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8 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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8(a)	**breakdown** of an ionic **compound** when molten or in aqueous solution (1) (using) electricity / electric current / electrical energy (1)	**2**
8(b)	platinum / graphite	**1**
8(c)	$2H^+ + 2e \rightarrow H_2$	**1**

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

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9 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]

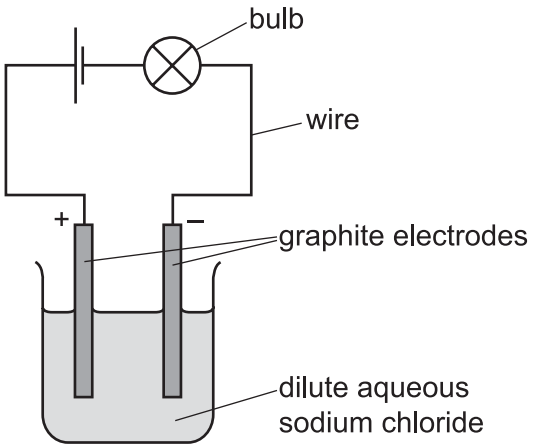
Electrolysis and electroplating Click for more variations

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9(a)	**M1** breakdown by (the passage of) electricity **M2** of an ionic compound in molten or aqueous (state)	**2**
9(b)(i)	**M1** brown solution **OR** black solid **M2** iodine **M3** hydrogen **M4** copper	**4**
9(b)(ii)	$4OH^- \rightarrow 2H_2O + O_2 + 4e^-$ **M1** OH^- **AND** e^- **M2** correct equation	**2**
9(c)(i)	copper **OR** anode forms Cu^{2+} which goes into the solution	**1**
9(c)(ii)	copper	**1**
9(c)(iii)	no change	**1**

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10 A student sets up the following electrolysis experiment.



(a) Define the term *electrolysis*.

.....

..... [2]

(b) The student observes bubbles of colourless gas forming at each electrode.

(i) Name the main gas produced at the positive electrode (anode).

..... [1]

(ii) Describe a test for the gas produced in **(b)(i)**.

test .....

result .....
[2]

(iii) Write the ionic half-equation for the reaction taking place at the negative electrode (cathode).

..... [2]

(c) Charge is transferred during electrolysis.

Name the type of particle responsible for the transfer of charge in

the wires, ...

the electrolyte. .....
[2]

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(d) The student replaces the dilute aqueous sodium chloride with **concentrated** aqueous sodium chloride.

Suggest **two** differences that the student observes.

1 .....

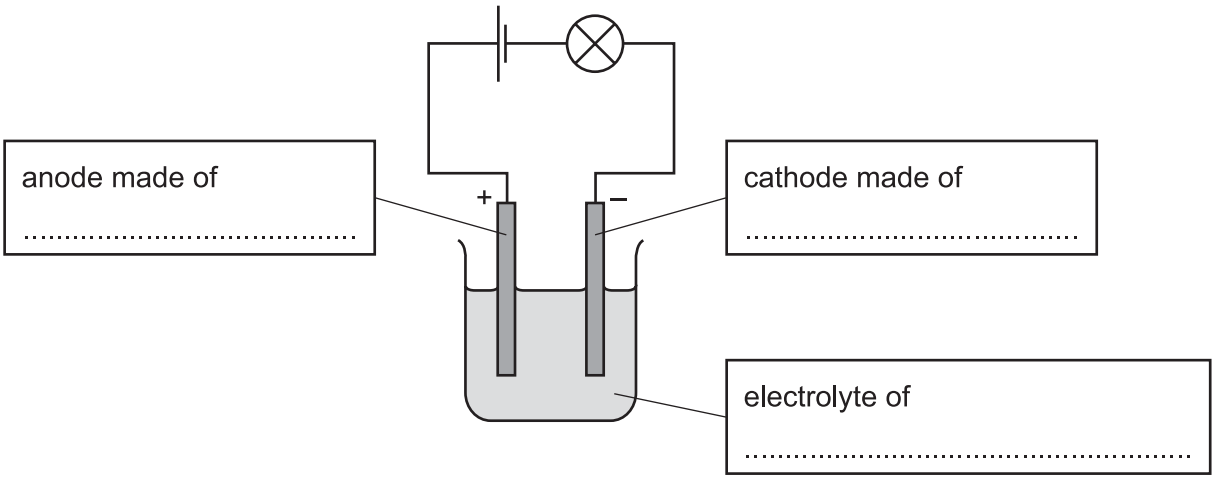
2 .....

[2]

(e) The student has a small piece of impure copper. The main impurities in the copper are small quantities of silver and zinc.

The student uses electrolysis to extract pure copper from the small piece of impure copper.

(i) Complete the labels on the diagram of the student's electrolysis experiment.



[3]

(ii) Use your knowledge of the reactivity series to suggest what happens to the silver and zinc impurities. Explain your answers.

silver impurities .....

.....

.....

zinc impurities .....

.....

.....

[3]

[Total: 17]

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Electrolysis and electroplating Click for more variations

10(a)	the breakdown (into elements)	**1**
	of an (ionic) compound by (the passage of) electricity	**1**
10(b)(i)	oxygen	**1**
10(b)(ii)	**glowing** splint	**1**
	relights	**1**

10(b)(iii)	$2H^+ + 2e^- \rightarrow H_2$ **M1** gain of electrons by H^+ **M2** rest of equation	**2**
10(c)	*the wires:* electrons	**1**
	the electrolyte: ions	**1**
10(d)	any 2 from: • green gas at positive electrode • bulb is brighter • rate of bubbles increases	**2**
10(e)(i)	*anode made of:* impure copper	**1**
	cathode made of: (pure) copper	**1**
	electrolyte of: (aqueous) copper sulfate	**1**
10(e)(ii)	silver (impurities) fall to the bottom of the cell	**1**
	zinc (impurities) (dissolve) into solution (as ions)	**1**
	because zinc is more reactive than copper **AND** silver is less reactive than copper	**1**

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