

C2 PAG Electrolysis

Question	Maximum Mark	Mark Awarded
1	8	
2	7	
3	7	
4	6	
5	7	
Total Mark		

1.

The electrolysis of water can be used to produce hydrogen. The following table shows the results of an experiment carried out to determine the effect of current on the volume of hydrogen produced after 30 seconds.

Current (mA)	Volume of hydrogen produced after 30 seconds (cm ³)			
	Experiment 1	Experiment 2	Experiment 3	Mean
100	0.7	0.2	0.6
200	1.0	0.8	1.0	0.93
300	1.4	1.3	1.2	1.30
400	1.6	1.6	1.6	1.60
500	2.3	2.2	2.1	2.20

- (a) Using only the reliable results, calculate the mean volume of hydrogen produced using a current of 100 mA. [1]

Mean volume of hydrogen = cm³

- (b) Describe the relationship between the current and the mean volume of hydrogen produced. [1]

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- (c) Using the results for a current of 300 mA and the following equation, calculate the percentage error in these measurements. [2]

$$\text{percentage error} = \frac{\text{furthest volume from mean volume} - \text{mean volume}}{\text{mean volume}} \times 100\%$$

Percentage error = %

(d) Balance the following electrode equations showing the electrolysis of water. [2]



(e) In your opinion, do the advantages of using hydrogen as a fuel outweigh the disadvantages? Give reasons to support your answer. [2]

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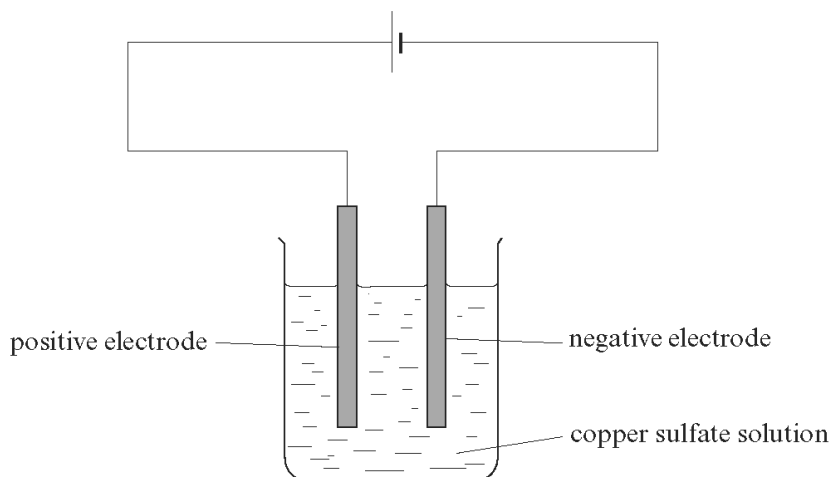
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2.

The electrolysis of copper sulfate solution was carried out using the apparatus shown in the diagram below. During the electrolysis, copper metal was deposited on the negative electrode.



(a) Identify the electrolyte. [1]

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(b) State the name given to a positive electrode. [1]

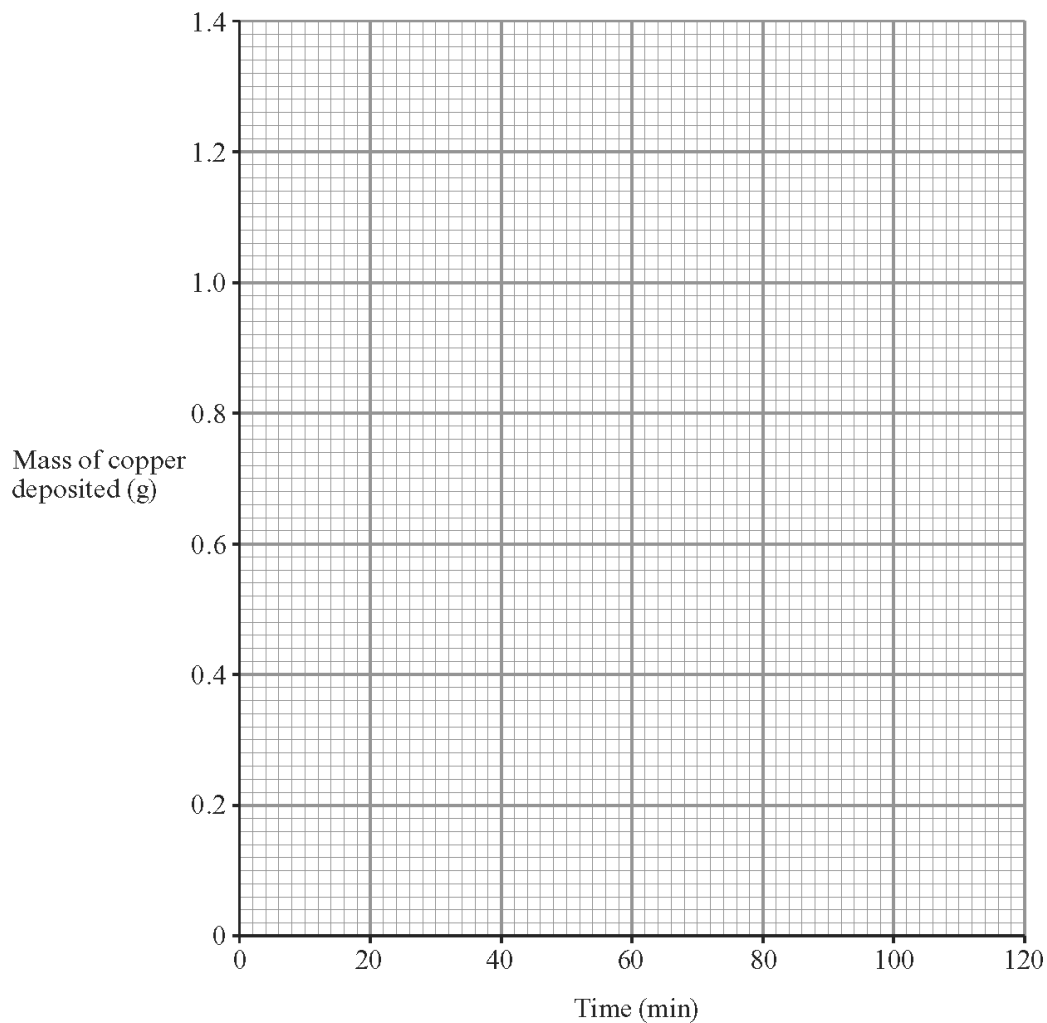
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(c) The following results were obtained during the electrolysis of copper sulfate solution. The mass of the negative electrode was measured at intervals.

Initial mass of the negative electrode = 20.2 g

Time (min)	Mass of negative electrode and deposited copper (g)	Mass of copper deposited (g)
0	20.2	0.0
20	20.7	0.5
40	21.0
60	21.2	1.0
90	21.4	1.2
120	21.4	1.2

- (i) Complete the table opposite by calculating the mass of copper deposited after 40 minutes. [1]
- (ii) Plot the data on the grid below and draw a suitable line. [3]



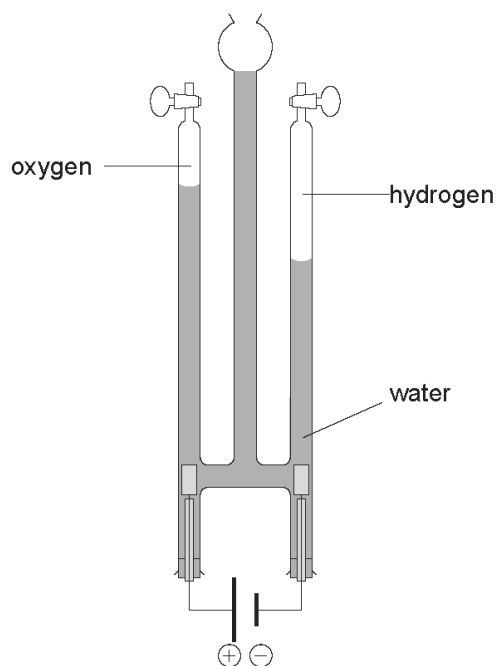
- (iii) Use the graph to find the mass of copper deposited after 30 minutes. [1]

..... g

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3.

(a) The apparatus below is used to break down water into hydrogen and oxygen using an electric current.



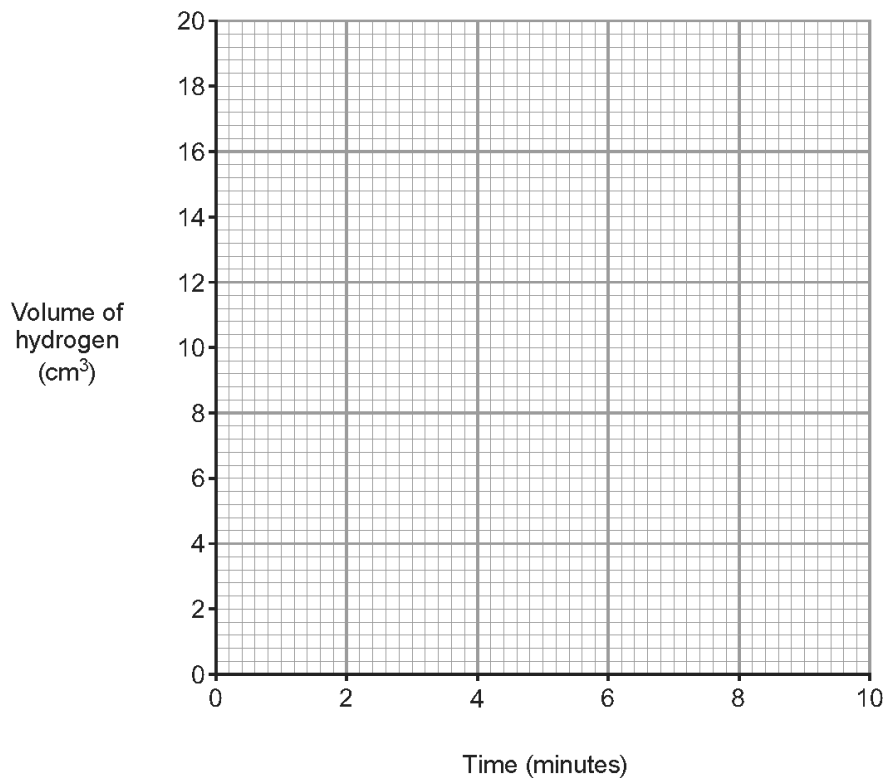
(i) Name this process. [1]

(ii) The table below shows the total volume of hydrogen formed over 10 minutes.

Time (minutes)	0	2	4	6	8	10
Volume of hydrogen (cm ³)	0	4	8	12	16	20

I Plot the results from the table on the grid opposite and draw a suitable line.
Label this line 'hydrogen'. [2]

II Draw a second line on the grid to show the volume of oxygen that would be collected during the same 10 minutes.
Label this line 'oxygen'. [2]



(b) Hydrogen burns in air forming water. This reaction is represented by the following symbol equation.

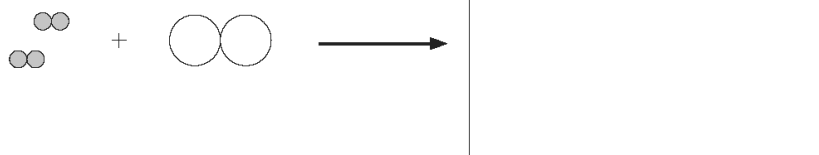


Use this and the key below to complete the equation in the form of a diagram.

[2]

●● hydrogen gas (H₂)

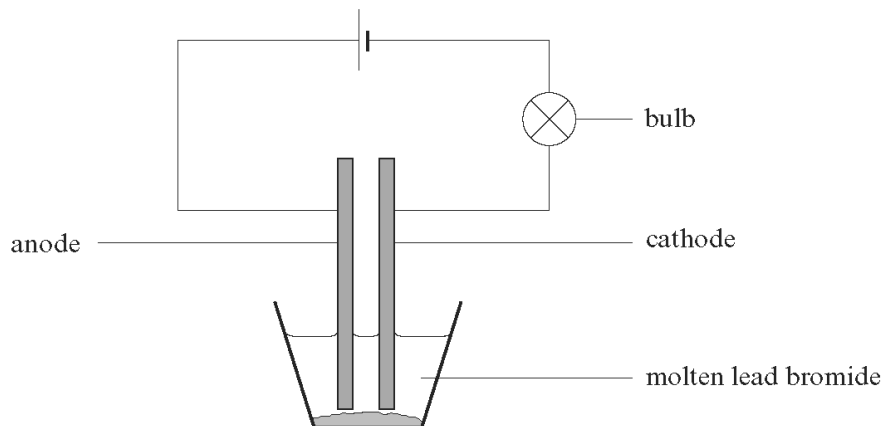
○○ oxygen gas (O₂)



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4.

The diagram below shows the apparatus used during the electrolysis of molten lead bromide.



(a) For electricity to flow the lead bromide must be molten. Give the reason for this. [1]

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(b) Balance the electrode equation which takes place at the anode. [1]



(c) (i) State, in terms of electrons, what happens to the lead ions at the cathode. [1]

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(ii) Describe what you would expect to observe at the cathode. [1]

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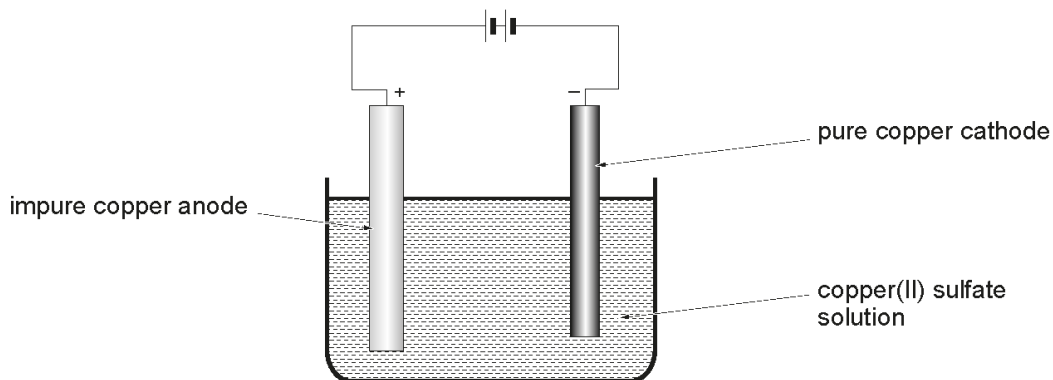
(iii) Electrolysis is allowed to continue for some time before the apparatus is cooled to room temperature. The bulb remains lit. Explain this observation. [2]

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5.

Copper can be purified by electrolysis using the apparatus shown below.



(a) During the process copper(II) ions move to the cathode where they become copper atoms.

(i) Explain why copper(II) ions move towards the cathode. [2]

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(ii) Complete and balance the following electrode equation that shows how copper forms at the cathode. [1]



- (b) A student carried out an investigation to find out how the amount of copper deposited on the cathode varied with the voltage used. He weighed the cathode at the beginning and then after 1 minute. He repeated the experiment 3 times at 5 different voltages. The results obtained are shown below.

Voltage (V)	Mass of copper deposited after 1 minute (g)			
	1	2	3	Mean
1.0	0.12	0.13	0.11	0.12
2.0	0.13	0.13	0.14	0.13
3.0	0.16	0.10	0.16	0.16
4.0	0.18	0.18	0.17	0.18
5.0	0.19	0.21	0.29

- (i) Using only the reliable results, calculate the mean mass of copper deposited on the cathode at 5.0V. [1]

Mean mass of copper deposited = g

- (ii) Calculate the percentage error of the unreliable result at 5.0V. [1]

$$\text{Percentage error} = \frac{\text{difference between result and mean}}{\text{mean result}} \times 100\%$$

Percentage error = %

- (iii) Use the results to predict the mass of copper deposited after 1 minute when a voltage of 8.0V is applied. Give a reason for your answer. [2]

Mass deposited g

Reason

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Marking Scheme





1.

Question Number		Sub-section	Mark	Answer	Accept	Neutral answer	Do not accept
FT	HT						
	9	(a)	1	0.65			
		(b)	1	the greater the current, the more hydrogen produced			
		(c)	2	difference to mean = 0.1 (1) (0.1 ÷ 1.3) × 100 = 7.7% (1) cao (2)			
		(d)	2	2, 2 (1) 2, 4 (1)			
		(e)	2	must clearly imply an opinion if yes – award (1) each for up to two advantages if no – award (1) each for up to two disadvantages advantages = doesn't produce carbon dioxide / doesn't contribute to global warming / water is only product / readily available / renewable disadvantages = explosive / storage issues / availability / extraction costs (need for electricity)	don't know – (1) each for one advantage and one disadvantage (2) if opinion given and clearly states that one advantage outweighs one disadvantage (or vice versa)		

2.

Question Number		Sub-section	Mark	Answer	Accept	Neutral answer	Do not accept
FT	HT						
6		(a)	1	copper sulfate (solution)	CuSO ₄		
		(b)	1	anode			
		(c) (i)	1	0.8			
		(ii)	3	plotting six correct points (2) five correct points (1) smooth line of best fit (1)			
		(iii)	1	0.66 (graph) ±0.02			

3.

Question Number		Sub-section		Mark	Answer	Accept	Neutral answer	Do not accept
7	HT	(a)	(i)	1	electrolysis			
			(ii)	I	all points plotted correctly $\pm \frac{1}{2}$ square (1) straight line through all points - ruler must be used (1)			
				II	straight line (ruler used) from (0,0) to (10,10) (2) or straight line from (0,0) and anywhere below hydrogen line (1)			
		(b)		2	 correct representation of a water molecule (1)  two water molecules shown (1)	H—O—H 2 		

4.

Question Number		Sub-section		Mark	Answer	Accept	Neutral answer	Do not accept
	9	(a)		1	allows the ions to be mobile / move		allows electricity to flow	
		(b)		1	$2\text{Br}^- - 2e^- \rightarrow \text{Br}_2$			
		(c)	(i)	1	lead ions would gain electrons			
			(ii)	1	shiny or grey substance		lead – needs qualifying	
			(iii)	2	lead metal formed would link the two electrodes (1) lead/metals conduct electricity (1)			

5.

Question Number		Sub-section		Mark	Answer	Accept	Neutral answer	Do not accept
FT	HT							
	6	(a)	(i)	2	Cu ions are positively charged (1) must be correct to award second mark opposite charges attract / attracted to negative electrode (1)	Cu^{2+}		
			(ii)	1	$\text{Cu}^{2+} + 2\text{e}^{-} \rightarrow \text{Cu}$			
		(b)	(i)	1	0.20			
			(ii)	1	45% error carried forward (ecf) possible from (i)			
			(iii)	2	0.26 (1) increase of approximately 0.02 g per 1.0 V / last 3 results increase by 0.02 g per 1.0V (1) ecf possible from (i)			