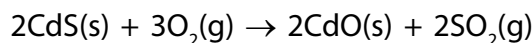
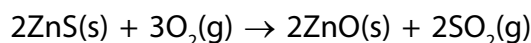


5 Zinc metal is obtained from sulfide ores.

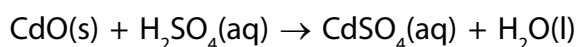
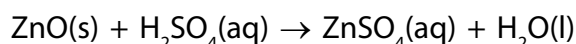
The most common ore of zinc is sphalerite, which contains zinc sulfide (ZnS) and a small amount of cadmium sulfide (CdS).

The stages involved in the extraction of zinc from sphalerite are:

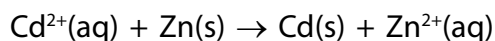
Stage 1 Sphalerite is strongly heated in air.



Stage 2 The mixture of oxides is reacted with sulfuric acid.



Stage 3 Zinc dust is added to the solution containing zinc sulfate and cadmium sulfate to remove the cadmium ions.



Stage 4 The solid cadmium is filtered off and the pure zinc sulfate solution is electrolysed.

(a) State how the reaction in stage 3 shows that zinc is more reactive than cadmium.

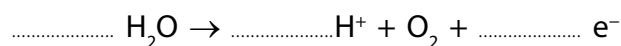
(1)

(b) (i) During the electrolysis in stage 4, zinc is deposited on the cathode.

Write an ionic half-equation for the reaction that occurs.

(1)

(ii) Complete the ionic half-equation for the reaction occurring at the anode.



(1)

(iii) Explain how the pH of the solution surrounding the anode changes during the electrolysis.

(2)

(c) Zinc is mixed with copper to make the alloy brass.

Explain why brass is harder than pure copper.

(3)

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(Total for Question 5 = 8 marks)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

6 This question is about sodium chloride.

6 (a) A student reacted hydrochloric acid and sodium hydroxide solution to produce sodium chloride solution.

The student:

- measured 50 cm³ of hydrochloric acid into a glass beaker
- measured the initial temperature of the hydrochloric acid
- added 50 cm³ of sodium hydroxide solution
- stirred the mixture and measured the highest temperature of the solution.

6 (a) (i) The hydrochloric acid and sodium hydroxide solution were the same concentration.

Suggest **one** reason why the temperature change could be greater than expected.

[1 mark]

Tick (✓) **one** box.

The volume of the sodium hydroxide solution was more than 50 cm³.

The volume of the hydrochloric acid was more than 50 cm³.

The initial temperature reading was too low.

The highest temperature reading was too low.

6 (a) (ii) The student did the investigation three times.

Table 2 shows the results.

Table 2

Experiment number	Initial temperature of the acid in °C	Highest temperature of solution in °C
1	20	33
2	19	30
3	20	32



What conclusion can you make about the reaction from the results in **Table 2**?

[1 mark]

6 (b) The student electrolysed sodium chloride solution.

6 (b) (i) Explain what happens at the negative electrode and why sodium is **not** produced.

[3 marks]

6 (b) (ii) Chlorine gas is produced at the positive electrode.
Complete the half equation.

[1 mark]



6 (b) (iii) Explain why the pH of the solution after electrolysis was 14

[2 marks]

8

END OF QUESTIONS



- 7 (a) Describe what is **seen** when chlorine water is added to potassium bromide solution and the mixture shaken.

(2)

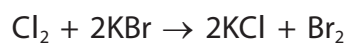
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- (b) Chlorine reacts with potassium bromide to form potassium chloride and bromine. In this reaction chlorine forms chloride ions



- (i) In this reaction, chlorine has been reduced.

Explain, using the equation, how you know that chlorine has been reduced.

(2)

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- (ii) Write the half equation for the formation of bromine from bromide ions.

(2)

.....

.....



DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(c) Aluminium reacts with chlorine to form aluminium chloride.

Write the balanced equation for this reaction.

(3)

(d) A solid ionic compound is dissolved in water to form a solution.

Describe a simple experiment to show that charged particles are present in this solution.

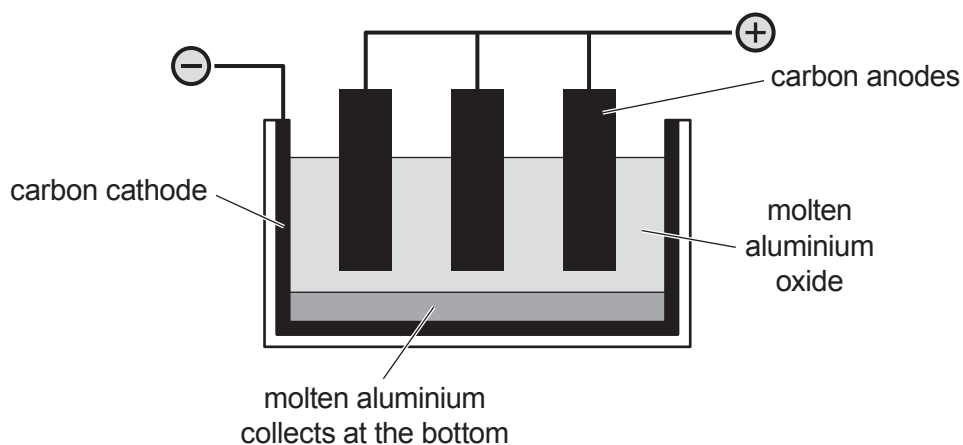
(3)

(Total for Question 7 = 12 marks)



P 5 2 4 7 1 A 0 2 1 3 2

11 Aluminium is made by the electrolysis of molten aluminium oxide.



(a) The ions present in molten aluminium oxide are Al^{3+} and O^{2-} .

Write **half-equations** for the formation of aluminium and oxygen in the electrolysis cell.

Formation of aluminium

Formation of oxygen

[2]

(b) Aluminium oxide does not conduct electricity when it is solid.

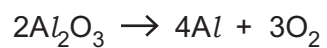
It conducts electricity when it is molten.

Explain why.

.....

[3]

(c) This is an equation for the overall reaction in the electrolysis cell.



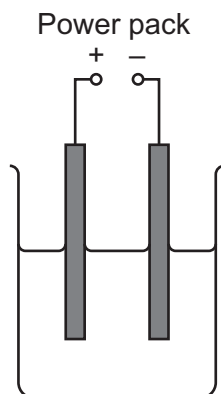
1.0 kg of aluminium is made in the cell.

Calculate the volume of oxygen (in dm^3 at room temperature and pressure) that is made.

Assume one mole of gas has a volume of 24 dm^3 at room temperature and pressure.

Volume = dm^3 [4]

24 A student is investigating the electrolysis of copper sulfate solution.



He does two experiments.

Experiment 1 uses platinum electrodes. Experiment 2 uses copper electrodes.

(a) Complete the table to show the products at each electrode.

Experiment	What happens at cathode (-)	What happens at anode (+)
1	Oxygen made
2	Copper deposited

[2]

(b) Copper electrodes are **non-inert** electrodes.

What is meant by non-inert electrodes?

..... [1]

(c) Look at the results for experiment 2 using **copper** electrodes.

At the cathode copper ions, Cu^{2+} gain electrons to make copper atoms.

Write the **half equation** for this reaction.

Use e^- to represent an electron.

..... [2]

(d) The student also electrolyses sodium chloride solution using platinum (inert) electrodes.

At the cathode, hydrogen gas is made rather than sodium metal.

Explain why.

.....

..... [2]

Question number	Answer	Mark
4(a)	endothermic	(1)

Question number	Answer	Mark
4(b)(i)	Any one from: <ul style="list-style-type: none"> • beaker (1) • polystyrene cup (1) • conical flask (1) 	(1)

Question number	Answer	Mark
4(b)(ii)	Stir the mixtures with the thermometer	(1)

Question number	Answer	Mark
4(b)(iii)	An explanation that combines identification via a judgement (1 mark) to reach a conclusion via justification/reasoning (1 mark): <ul style="list-style-type: none"> • order of reactivity from most reactive to least reactive magnesium, zinc, (iron), copper (1) • because the most reactive shows biggest temperature rise/least reactive shows lowest temperature rise (1) 	(2)

Question number	Answer	Additional guidance	Mark
4(b)(iv)	An explanation that combines identification – improvement of the experimental procedure (1 mark) and justification/reasoning which must be linked to the improvement (1 mark): <ul style="list-style-type: none"> • use magnesium, zinc and copper as powders (1) • so they have the same/similar size particles/surface area/shape (1) 	allow other acceptable answers, e.g. use same mass / no moles of each	(2)

Question number	Answer	Additional guidance	Mark
4(b)(v)	1000 cm ³ contain $\frac{6.2 \times 1000}{50}$ (1) 1 dm ³ contains 124 (g dm ⁻³) (1)	Award full marks for correct numerical answer without working.	(2)

Question number	Answer	Mark
5(a)	Measuring cylinder/burette/pipette	(1)

Question number	Answer	Additional guidance	Mark
5(b)	<ul style="list-style-type: none"> axes with linear scale that use more than half of each edge of the grid and labelled with units from the table (1). all points correctly plotted to \pm half a square (1). single straight line passing through all points and the origin (1). 	7 points plotted correctly (i.e. one error) (1) allow ecf from plotting error.	(3)

Question number	Answer	Mark
5(c)	A	(1)

Question number	Answer	Mark
5(d)	Line A on graph: <ul style="list-style-type: none"> steeper curve/curve drawn to left of original (1) levelling off at 82 cm^3 (1) 	(2)

Question number	Answer	Mark
5(e)	An answer that combines the following points to provide a method: <ul style="list-style-type: none"> suitable method of warming the solutions, e.g. water bath, Bunsen burner with tripod and gauze and measure the temperature of each solution using a thermometer (1) use the same volumes of the solutions in each experiment (1) measure the time for the precipitate to form (and obscure a cross placed under the reaction vessel) using a stop watch/clock (1) 	(3)

Question number	Answer	Mark
6(a)	$\text{C}_5\text{H}_{11}\text{OH}$	(1)

Question number	Answer	Additional guidance	Mark
6(b)	$(2 \times 12) + (5 \times 1) + 16 + 1$ (1) $= 46$ (1)	Award full marks for correct numerical answer without working.	(2)

Question	Answers	Extra Information	Mark	AO / Spec. Ref
6(a)(i)	tick (✓) by: the initial temperature reading was too low		1	AO3 2.5
6(a)(ii)	the reaction is exothermic	allow energy is given out	1	AO3 2.5.1b
6(b)(i)	(positive/hydrogen) ions gain electrons hydrogen is below sodium in the reactivity series so hydrogen / H ₂ is produced	accept (positive/hydrogen) ions are reduced accept reference to high reactivity of sodium If no other mark awarded allow hydrogen (and sodium) ions or positive ions are attracted to negative electrode for 1 mark	1 1 1	AO1 AO2 2.7.1c,f,i
6(b)(ii)	$2 \text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$	must be completely correct allow multiples	1	AO1 2.7.1g
6(b)(iii)	solution is alkaline because sodium hydroxide / NaOH is produced or sodium hydroxide / NaOH is left over	accept hydroxide (ions) / OH ⁻ is produced or hydroxide (ions) / OH ⁻ is left over	1 1	AO1 AO2 2.7.1i; 2.6.2d
Total			8	

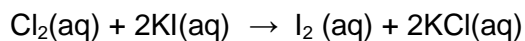
Question		Answer	Marks	AO element	Guidance
11	(a)	$Al^{3+} + 3e \rightarrow Al \checkmark$ $2O^{2-} \rightarrow O_2 + 4e \checkmark$	2	2 x 1.2	<p>ALLOW equations with electrons on the right (eg $Al^{3+} \rightarrow Al - 3e$)</p> <p>ALLOW $O^{2-} \rightarrow \frac{1}{2}O_2 + 2e$</p> <p>ALLOW (1) mark if number of electrons are correct for both equations but on incorrect sides of both equations (even if oxygen is shown as O)</p>
	(b)	<p>ions / charged particles \checkmark</p> <p>can't move in solid / held in lattice / do not move / in fixed positions \checkmark</p> <p>can move in liquid/when molten \checkmark</p>	3	3 x 1.1	DO NOT ALLOW electrons/'particles' alone
	(c)	<p>FIRST CHECK ANSWER ON ANSWER LINE If answer = 667etc (dm³) award 4 marks</p> <p>$4 \times 27(g) (=108) \checkmark$</p> <p>$=1000 \div 108 \text{ ECF } (= 9.259) \checkmark$</p> <p>$3 \times 24 \text{ (dm}^3\text{)} (=72) \checkmark$</p> <p>$= (x 72 \text{ ECF } =) 667 \text{ (dm}^3\text{)} \checkmark$</p> <p>OR</p> <p>No moles Al = $1000/27 (=37.04) \checkmark$</p> <p>Uses ratio 4:3 in calculation \checkmark</p> <p>No moles O₂ = ANS x $\frac{3}{4} (=27.77\dots) \checkmark$</p> <p>(x 24=) $667 \text{ (dm}^3\text{)} \checkmark$</p>	4	4 x 2.2	<p>9.259 = (2) for MP1 and MP2</p> <p>0.667 = (3) for MP1 MP3 and MP4</p> <p>222 = (3) for MP1 MP2 and MP4</p> <p>0.222 = (2) for MP1 and MP4</p> <p>ALLOW 666 (Rounding already assessed in earlier Q)</p> <p>ALLOW any number of sig figs</p> <p>27.7 = (3) for MP1, MP2 and MP3</p>

Question		Answer		Marks	AO element	Guidance									
24	(a)	<table border="1"> <thead> <tr> <th>Experiment</th> <th>What happens at cathode (-)</th> <th>What happens at anode (+)</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>copper deposited / formed ✓</td> <td>oxygen made</td> </tr> <tr> <td>2</td> <td>copper deposited</td> <td>(copper) anode dissolves ✓</td> </tr> </tbody> </table>		Experiment	What happens at cathode (-)	What happens at anode (+)	1	copper deposited / formed ✓	oxygen made	2	copper deposited	(copper) anode dissolves ✓	2	2 x 1.2	<p>ALLOW copper atoms form (at cathode) IGNORE copper purified (at cathode)</p> <p>ALLOW (anode) loses mass / copper loses electrons / copper ions made / copper is lost (at anode) DO NOT ALLOW copper ions lose electrons</p>
		Experiment	What happens at cathode (-)	What happens at anode (+)											
1	copper deposited / formed ✓	oxygen made													
2	copper deposited	(copper) anode dissolves ✓													
(b)	Non-inert electrodes are changed during electrolysis ✓	1	1.2	ALLOW idea that non-inert electrodes can react (with the solution or the electrode products)											
	(c)	$\text{Cu}^{2+} + 2\text{e}^{-} \rightarrow \text{Cu}$ <p>formulae ✓ balancing ✓</p>		2	2 x 2.2	<p>balancing mark is conditional on correct formulae ALLOW = or \rightleftharpoons instead of arrow</p> <p>DO NOT ALLOW and or & instead of +</p> <p>ALLOW $\text{Cu}^{2+} \rightarrow \text{Cu} - 2\text{e}^{-}$</p> <p>ALLOW any correct multiples including fractions e.g. $2\text{Cu}^{2+} + 4\text{e}^{-} \rightarrow 2\text{Cu}$</p> <p>ALLOW one mark for correct equation with minor errors in case, subscript or superscript e.g. $\text{Cu}^{2+} + 2\text{e}^{-} \rightarrow \text{CU}$</p> <p>IGNORE state symbols</p>									

Question		Answer	Marks	AO element	Guidance
	(d)	Idea that hydrogen is less reactive than sodium / ORA ✓ So is discharged before sodium / ORA ✓	2	2 x 1.2	ALLOW idea that hydrogen gains electrons more easily (than sodium) / idea that hydrogen is reduced more easily (than sodium) IGNORE hydrogen is made

A redox reaction takes place when aqueous chlorine is added to potassium iodide solution.

The equation for this reaction is:



0 1 . **3** Look at **Table 1**.

What is the colour of the final solution in this reaction?

[1 mark]

Tick **one** box.

- | | |
|------------|--------------------------|
| Brown | <input type="checkbox"/> |
| Orange | <input type="checkbox"/> |
| Pale green | <input type="checkbox"/> |
| Colourless | <input type="checkbox"/> |

0 1 . **4** What is the ionic equation for the reaction of chlorine with potassium iodide?

[1 mark]

Tick **one** box.

- | | |
|---|--------------------------|
| $\text{Cl}_2 + 2\text{K} \rightarrow 2\text{KCl}$ | <input type="checkbox"/> |
| $2\text{I}^- + \text{Cl}_2 \rightarrow \text{I}_2 + 2\text{Cl}^-$ | <input type="checkbox"/> |
| $\text{I}^- + \text{Cl} \rightarrow \text{I} + \text{Cl}^-$ | <input type="checkbox"/> |
| $\text{I}^- + \text{K}^+ \rightarrow \text{KI}$ | <input type="checkbox"/> |

Question 1 continues on the next page

0 1 . **5** Why does potassium iodide solution conduct electricity?

[1 mark]

Tick **one** box.

- It contains a metal
- It contains electrons which can move
- It contains ions which can move
- It contains water

0 1 . **6** What are the products of electrolysis of potassium iodide solution?

[1 mark]

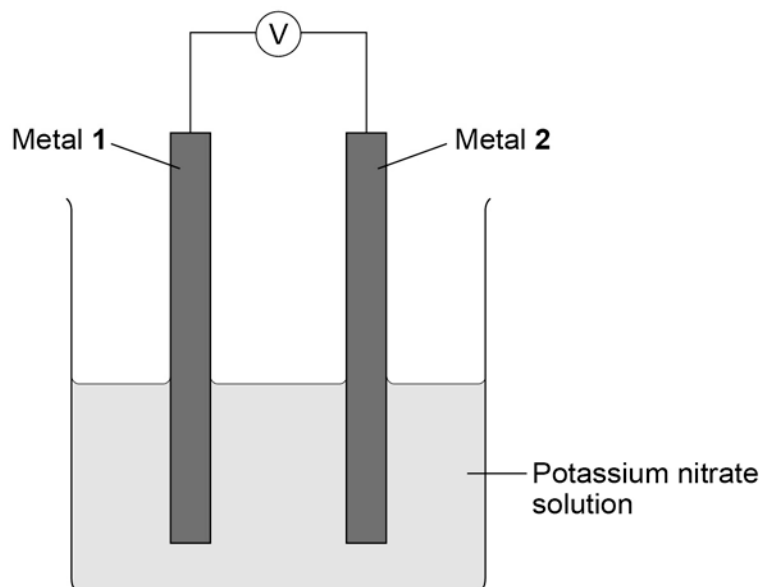
Tick **one** box.

Product at cathode	Product at anode	
hydrogen	iodine	<input type="checkbox"/>
hydrogen	oxygen	<input type="checkbox"/>
potassium	iodine	<input type="checkbox"/>
potassium	oxygen	<input type="checkbox"/>

0 6

A student investigated simple cells using the apparatus shown in **Figure 4**.

Figure 4



- If metal 2 is more reactive than metal 1 then the voltage measured is positive.
- If metal 1 is more reactive than metal 2 then the voltage measured is negative.
- The bigger the difference in reactivity of the two metals, the larger the voltage produced.

The student's results are shown in **Table 3**.

Table 3

Metal 2 \ Metal 1	Chromium	Copper	Iron	Tin	Zinc
Chromium	0.0 V				
Copper	1.2 V	0.0 V			
Iron	0.5 V	not measured	0.0 V		
Tin	0.8 V	-0.4 V	0.3 V	0.0 V	
Zinc	0.2 V	-1.0 V	-0.3 V	-0.6 V	0.0 V

0 6 . **1**

The ionic equation for the reaction occurring at the zinc electrode in the simple cell made using copper and zinc electrodes is:



Zinc is oxidised in this reaction.

Give a reason why this is oxidation.

[1 mark]

0 6 . **2**

Look at **Table 3**.

Which **one** of the metals used was the least reactive?

Give a reason for your answer.

[2 marks]

Metal _____

Reason _____

Question 6 continues on the next page

-
- 0 6** . **3** Predict the voltage that would be obtained for a simple cell that has iron as metal **1** and copper as metal **2**.

Explain your answer.

[3 marks]

- 0 6** . **4** Hydrogen fuel cells have been developed for cars.

Write a word equation for the overall reaction that takes place in a hydrogen fuel cell.
[1 mark]

- 0 6** . **5** Write the **two** half equations for the reactions that occur at the electrodes in a hydrogen fuel cell.

[2 marks]

Question 1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	The forces between iodine molecules are stronger		1	AO1/1 4.2.2.4
01.2	anything in range +30 to +120		1	AO3/2a 4.1.2.6
01.3	Brown		1	AO2/1 4.1.2.6
01.4	$2 \text{I}^- + \text{Cl}_2 \rightarrow \text{I}_2 + 2 \text{Cl}^-$		1	AO2 /1 4.1.2.6 4.1.1.1
01.5	It contains ions which can move		1	AO1/1 4.2.2.3
01.6	hydrogen iodine		1	AO2/1 4.4.3.4
Total			6	

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	(zinc has) lost electron(s)	accept loss of electrons	1	AO1/1 4.4.1.4
06.2	copper is the least reactive		1	AO3/1a
	because it gave the most negative voltage when it was metal 2		1	AO3/2a
	or it gave the biggest voltage with chromium or it gave the most positive voltage when it was metal 1			4.5.2.1
06.3	-0.7 V	accept use of other cell pairings such as tin with copper and tin with iron	1	AO3/2a
	The voltage with chromium and copper is 1.2		1	AO3/2b
	The voltage with chromium and iron is 0.5 and copper is less reactive (than iron)		1	AO3/2b 4.5.2.1
06.4	hydrogen + oxygen = water		1	AO1/1 4.5.2.2
06.5	$H_2 \rightarrow 2H^+ + 2e^-$		1	AO1/1 4.5.2.2
	$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$		1	
Total			9	