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EDEXCEL GCSE CHEMISTRY: QUESTIONS BY TOPIC

Chemical Changes (3)

GCSE Chemistry (Higher) Topic 3

18 questions · 177 marks · Mark schemes included

Pearson Edexcel GCSE (9-1) Chemistry 1CH0, Higher Tier, June 2018 - June 2025

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HOW TO USE THIS BOOKLET

Questions run from the lowest mark tariff to the highest, so similar questions sit together.

Click any row below to jump straight to that question.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme.

Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

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QUESTIONS

18 questions · 177 marks · lowest tariff first



9-MARK QUESTIONS

10 questions in this booklet



- 2 (a) Salts of metals can be prepared by reacting the metal with an acid to produce the salt and hydrogen.

(i) Describe the test to show the gas is hydrogen.

(2)

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(ii) Nickel is a metal.

Explain how the structure of a nickel atom, Ni, changes when it forms a nickel ion, Ni^{2+} .

(2)

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- (b) A nickel sulfate solution is made by dissolving 23.5 g of nickel sulfate to make 250 cm^3 of solution.

Calculate the concentration of the solution in g dm^{-3} .

(2)

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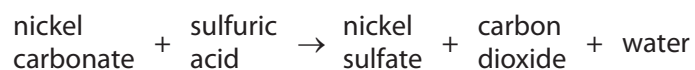
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concentration = ... g dm^{-3}



(c) Excess solid nickel carbonate is added to dilute sulfuric acid in a beaker.



Nickel sulfate is formed in solution.

Describe how a sample of pure, dry nickel sulfate crystals can be obtained from the mixture of nickel sulfate solution and excess solid nickel carbonate in the beaker.

(3)

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(Total for Question 2 = 9 marks)



- 2 Figure 3 shows the apparatus that can be used to electrolyse sodium sulfate solution using inert electrodes.

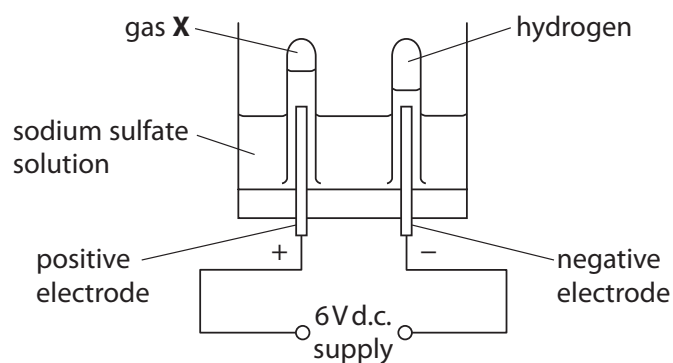


Figure 3

- (a) Hydrogen is produced at the negative electrode during electrolysis.

(i) Describe the test to show the gas is hydrogen.

(2)

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.....

(ii) What is the name of gas **X** that forms at the positive electrode?

(1)

- ☐ **A** ammonia
- ☐ **B** oxygen
- ☐ **C** nitrogen
- ☐ **D** sulfur dioxide

(iii) State what is meant by the term **electrolysis**.

(2)

.....

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- (b) The sodium sulfate solution was made by dissolving 28.4 g of sodium sulfate in water to make 250 cm³ of solution.

Calculate the concentration of this solution in g dm⁻³.

Give your answer to three significant figures.

(3)

.....

.....

.....

.....

concentration = ... g dm⁻³

- (c) The ions present in sodium sulfate are

sodium	Na ⁺
sulfate	SO ₄ ²⁻

Write the formula of sodium sulfate using this information.

(1)

.....

(Total for Question 2 = 9 marks)



6 (a) Copper carbonate reacts with dilute nitric acid.

(i) During the reaction the copper carbonate powder completely disappears.

State what can be deduced about the amount of acid used.

(1)

.....

.....

(ii) During the reaction, the pH of the mixture changed from 2 to 6.

By what factor has the concentration of the hydrogen ions in the mixture changed?

(1)

☐ A $\times 10\,000$

☐ B $\times 4$

☐ C $\times \frac{1}{4}$

☐ D $\times \frac{1}{10\,000}$

(b) Using different reactants, a solution of copper sulfate was prepared.

Describe what should be done to obtain copper sulfate crystals from this copper sulfate solution.

(2)

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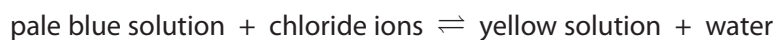
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- (c) When chloride ions are added to a pale blue solution containing copper ions, the mixture turns yellow.

This is a reversible reaction.



What effect does the removal of chloride ions have on the colour of the yellow mixture?

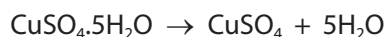
(1)

- ☐ **A** does not change colour
- ☐ **B** turns blue
- ☐ **C** turns colourless
- ☐ **D** turns darker yellow

- (d) Hydrated copper sulfate has the formula $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$.

The formula tells us that each mole of copper sulfate contains 5 moles of water.

A sample of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ was heated gently until all the water was removed to form anhydrous copper sulfate, CuSO_4 .



The mass of water formed was 4.5 g.

Calculate the mass of hydrated copper sulfate that was heated.

(relative atomic masses: H = 1.0, O = 16.0;

relative formula mass: $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ = 249.5)

(4)

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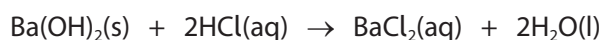
mass of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ = ... g

(Total for Question 6 = 9 marks)



- 2 Barium hydroxide reacts with dilute hydrochloric acid to form barium chloride and water.

(a) The equation for the reaction is



Which row of the table shows the correct state of each of the substances in the equation for the reaction?

(1)

		barium hydroxide	hydrochloric acid	barium chloride	water
☐	A	solid	aqueous	aqueous	liquid
☐	B	solid	liquid	solid	aqueous
☐	C	aqueous	aqueous	solid	liquid
☐	D	aqueous	liquid	aqueous	aqueous

- (b) A student wanted to investigate how the pH of the mixture changes as barium hydroxide is added to dilute hydrochloric acid.

They followed this method.

step 1 measure out 50.0 cm^3 of dilute hydrochloric acid into a beaker using a measuring cylinder

step 2 use a glass rod to place a drop of the acid onto a piece of universal indicator paper and record the pH

step 3 add 0.2 g of barium hydroxide to the acid in the beaker and stir

step 4 use the glass rod to place a drop of the mixture onto a new piece of universal indicator paper and record the pH again

step 5 repeat steps 3–4 until there is no further change in the pH.

- (i) Name a piece of equipment which could be used to measure out 50.0 cm^3 of dilute hydrochloric acid more accurately than the measuring cylinder.

(1)



- (ii) Describe how the pH of the mixture is determined when a drop of it is placed on the universal indicator paper.

(2)

- (iii) In the method, universal indicator paper is used to determine the pH.

Explain why litmus paper would not be a suitable indicator to use in this experiment.

(2)



(iv) Figure 2 shows the student's results.

mass of barium hydroxide in g	pH of mixture
0.0	1
0.2	1
0.4	1
0.6	1
0.8	2
1.0	7
1.2	12
1.4	13
1.6	13

Figure 2

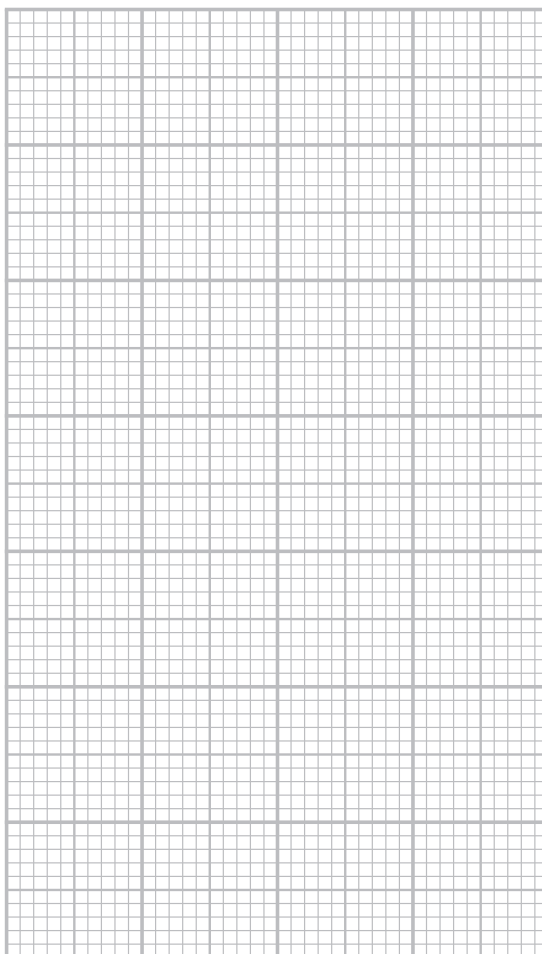
On the grid opposite:

- Add suitable scales to the vertical and horizontal axes.
- Plot a graph of the pH of the mixture against the mass of barium hydroxide.

(3)



pH of
the mixture



mass of barium hydroxide in g

(Total for Question 2 = 9 marks)



5 When copper sulfate solution is electrolysed using copper electrodes, the mass of each electrode changes.

- (a) Draw a labelled diagram to show the apparatus that can be used to electrolyse copper sulfate solution using copper electrodes.

(2)

- (b) Before the electrolysis is carried out, the mass of each electrode is determined.

Explain what should be done to the copper electrodes before their masses are determined.

(2)

- (c) Figure 4 shows the results obtained from an electrolysis experiment when copper sulfate solution was electrolysed for 10 minutes.

	electrodes	
	anode	cathode
mass of electrode before electrolysis in g	6.43	6.17
mass of electrode after electrolysis in g	5.62	6.95
change in mass in g	– 0.81	+ 0.78

Figure 4



- (i) Explain, in terms of ions, the changes in mass of the two electrodes shown in the results in Figure 4.

(3)

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- (ii) The electrolysis was repeated using another pair of copper electrodes of the same masses.

Explain a change that could be made to the electrolysis experiment to cause the mass of the cathode to increase by 2.34 g in 10 minutes.

(2)

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(Total for Question 5 = 9 marks)



- 2 In an experiment, powdered calcium hydroxide was added to dilute hydrochloric acid and the pH was measured.

The method used was

step 1 measure 200 cm³ dilute hydrochloric acid into a beaker

step 2 add 0.1 g of powdered calcium hydroxide to the beaker

step 3 find the pH of the mixture

step 4 repeat steps 2 and 3 until the pH stops changing.

- (a) State what should be done after **step 2** to make sure that any reaction is complete.

(1)

.....

.....

- (b) Complete the word equation for the reaction.

(2)

calcium hydroxide + hydrochloric acid →

- (c) Which row of the table shows the state symbols for powdered calcium hydroxide and dilute hydrochloric acid in the balanced chemical equation?

(1)

	calcium hydroxide	hydrochloric acid
☐ A	aq	l
☐ B	l	aq
☐ C	s	aq
☐ D	s	l

(d) The results of the experiment are shown in Figure 4.

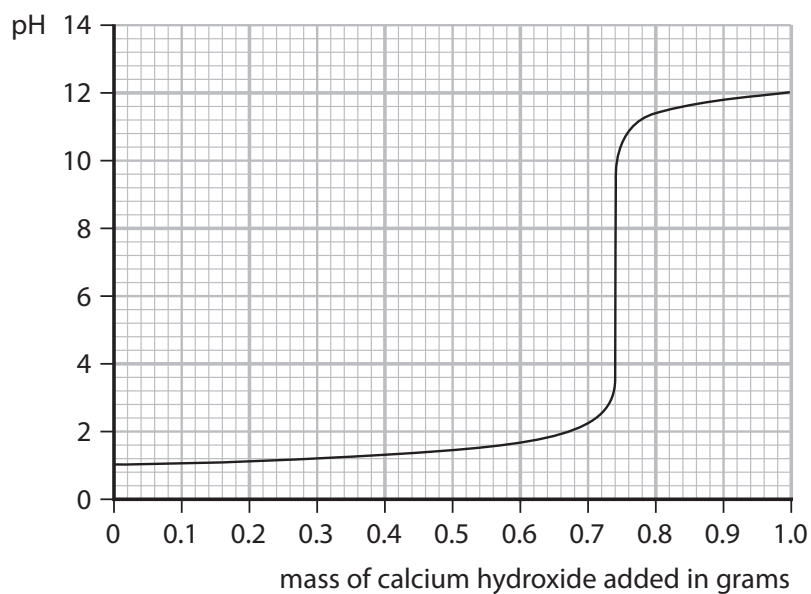


Figure 4

(i) Using Figure 4, give the pH of the acid at the start of the experiment.

(1)

pH = ...

(ii) Using Figure 4, give the mass of calcium hydroxide required to make a neutral mixture.

(1)

mass of calcium hydroxide = ... g

(iii) Explain why the pH starts at a low value and ends at a higher value.

(3)

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(Total for Question 2 = 9 marks)



- 6 A student investigates the mass of copper produced when copper chloride solution in a beaker is electrolysed using inert electrodes.

(a) Where is copper formed during the electrolysis?

(1)

- ☐ A at the anode
- ☐ B at the bottom of the beaker
- ☐ C at the cathode
- ☐ D on the surface of the electrolyte

- (b) The student investigated the change in the mass of copper formed when the current was altered.

The results are shown in Figure 7.

current in A	mass of copper formed in g
0.0	0.000
0.2	0.040
0.4	0.080
0.6	0.118
0.8	0.158
1.0	0.196

Figure 7

- (i) State and explain the trend shown in these results.

(3)

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- (ii) Describe how, after the power supply has been switched off, the mass of copper formed can be measured.

(2)

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- (c) In another experiment, 74 mg of copper is formed.

Calculate the number of copper atoms in 74 mg of copper.

(relative atomic mass Cu = 63.5; Avogadro constant = 6.02×10^{23})

(3)

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number of atoms = ...

(Total for Question 6 = 9 marks)



- 2 Barium hydroxide reacts with dilute hydrochloric acid to form barium chloride solution and water.

- (a) (i) Complete the balanced equation for the reaction by adding a **number** in front of HCl(aq).

(1)



- (ii) State what you would **see** during the reaction.

(1)

- (b) A student investigated how the pH of the mixture changed as barium hydroxide was added to dilute hydrochloric acid.

The student used this method.

step 1 measure out 50 cm³ of dilute hydrochloric acid into a beaker using a measuring cylinder

step 2 use a glass rod to place a drop of the acid onto a piece of universal indicator paper and record the pH

step 3 add one spatula measure of barium hydroxide to the acid in the beaker and stir

step 4 use the glass rod to place a drop of the mixture onto a new piece of universal indicator paper and record the pH again

step 5 repeat steps 3 and 4 until there is no further change in the pH.



- (i) Name a piece of equipment that could be used to measure the pH of a substance more accurately than universal indicator paper.

(1)

- (ii) Explain why, in step 3, the mixture was stirred after adding the barium hydroxide.

(2)

- (iii) Figure 3 shows the student's results.

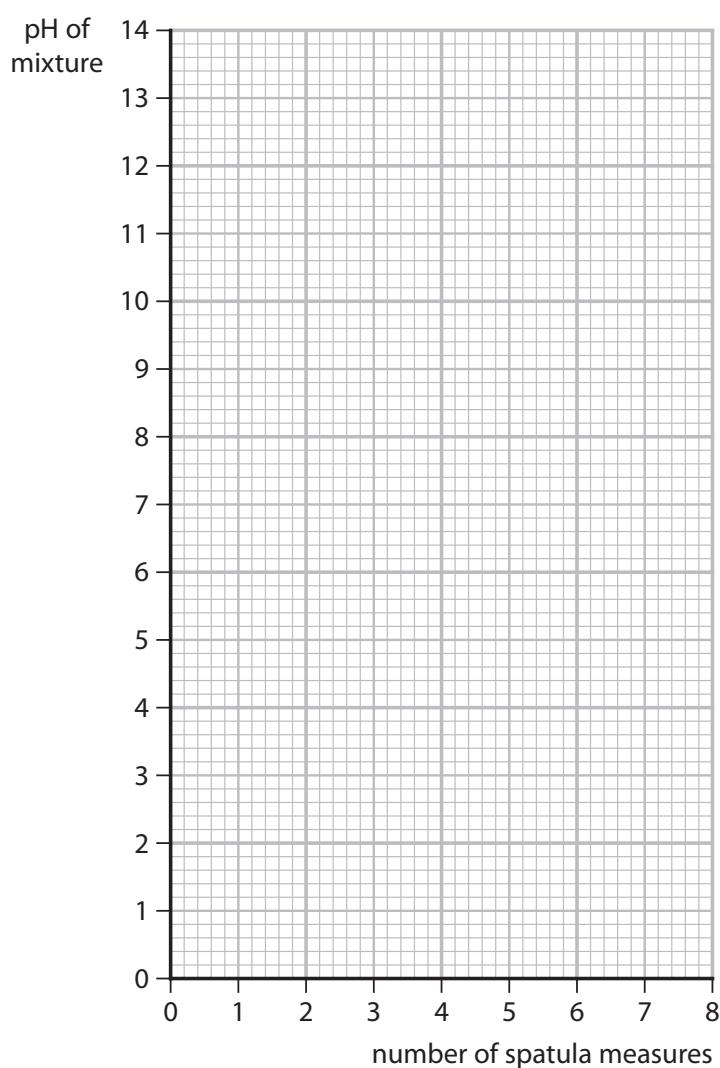
number of spatula measures of barium hydroxide	pH of mixture
0	1
1	1
2	1
3	1
4	3
5	8
6	12
7	13
8	13

Figure 3



Plot a graph of the pH of the mixture against the number of spatula measures of barium hydroxide.

(3)



- (iv) Use the graph to find the pH of the mixture when 4.5 spatula measures of barium hydroxide are added.

(1)

pH of the mixture = ...

(Total for Question 2 = 9 marks)



3 Silver nitrate and potassium chloride are ionic compounds that are soluble in water.

(a) When potassium chloride solution is added to a solution of silver nitrate, a white precipitate forms.

(i) Complete the equation for this reaction, including the missing state symbol.

(2)



(ii) Give the name of the white precipitate that forms.

(1)

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(iii) State and explain how the white precipitate can be separated from the reaction mixture.

(3)

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(b) Silver nitrate solution conducts electricity.
Solid silver also conducts electricity.

Describe how silver nitrate solution conducts electricity and how solid silver conducts electricity.

(3)

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(Total for Question 3 = 9 marks)

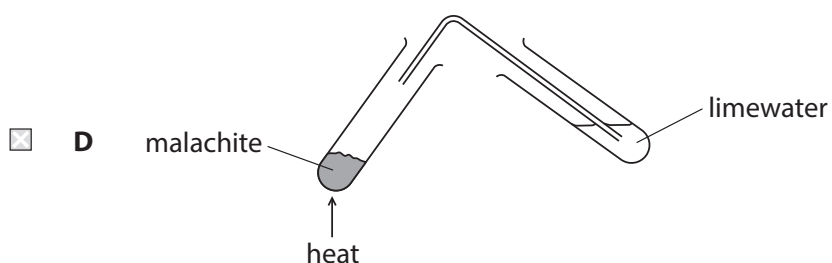
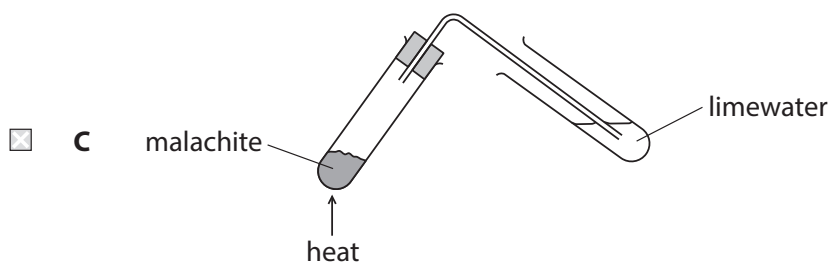
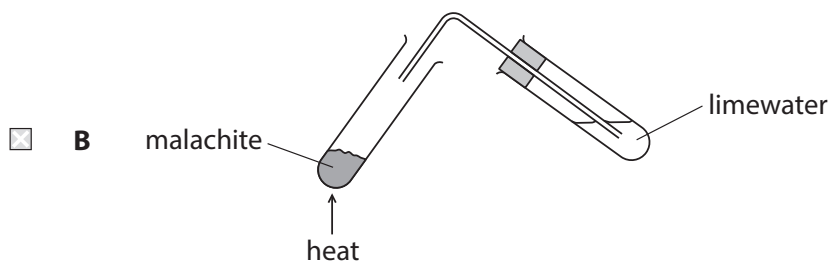
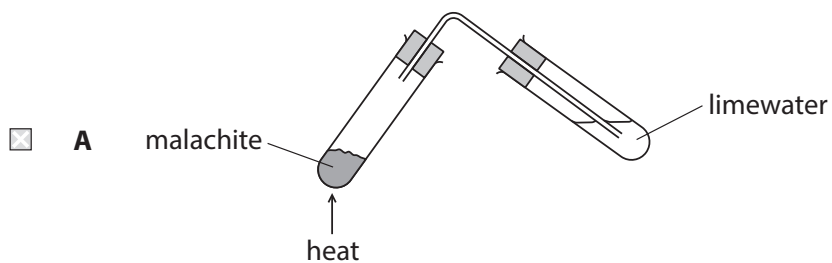


6 Malachite, $\text{Cu}_2\text{CO}_3(\text{OH})_2$, is a mineral containing copper.

(a) When heated, malachite decomposes to form copper oxide, carbon dioxide and water.

(i) Which apparatus should be used to heat the malachite and test for carbon dioxide?

(1)



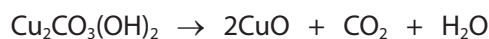
- (ii) When carbon dioxide is bubbled through limewater, a precipitate forms. This precipitate solid makes the limewater cloudy.

Name the precipitate that makes the limewater cloudy.

(1)

.....

- (iii) The equation for the decomposition of malachite when it is heated is



Calculate the maximum mass of copper oxide that can be formed when 22.1 g of malachite is decomposed completely.

(relative atomic masses: Cu = 63.5, O = 16.0, C = 12.0, H = 1.0)

(4)

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maximum mass of CuO = ... g



- (b) Copper can be extracted from copper oxide by heating the copper oxide with carbon.

A student investigated two methods to extract the maximum mass of copper from copper oxide.

Figure 3 shows the two methods.

method 1	method 2
step 1 place one spatula measure of copper oxide into a beaker	step 1 place one spatula measure of copper oxide into a glass test tube
step 2 mix the copper oxide thoroughly with carbon powder	step 2 carefully add carbon powder on top of the copper oxide
step 3 place the mixture into a metal crucible and heat the mixture with a roaring Bunsen flame	step 3 heat the two layers with a roaring Bunsen flame

Figure 3

Comment on the strengths and weaknesses of these two methods.

(3)

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(Total for Question 6 = 9 marks)

10-MARK QUESTIONS

1 question in this booklet



6 (a) Molten zinc chloride is an electrolyte.

- (i) Which row shows the products formed at the anode and at the cathode when molten zinc chloride is electrolysed?

(1)

	product at anode	product at cathode
☐ A	oxygen	zinc
☐ B	chlorine	hydrogen
☐ C	chlorine	zinc
☐ D	oxygen	hydrogen

- (ii) Which of the following is the reason why molten zinc chloride is an electrolyte?

(1)

- ☐ A it contains molecules that can move
- ☐ B it has a giant structure
- ☐ C it contains delocalised electrons
- ☐ D it contains ions that can move

(b) Copper sulfate solution was electrolysed using copper electrodes.

- (i) Draw a labelled diagram to show the apparatus that is used to carry out this electrolysis in the laboratory.

(2)



- (ii) Before the electrolysis, the masses of the electrodes were determined. After the electrolysis, the electrodes were washed and dried and their masses re-determined.

Figure 6 shows these masses and the resulting changes in masses of the electrodes.

	mass of electrode before electrolysis in g	mass of electrode after electrolysis in g	change in mass of electrode in g
anode	11.27	10.42	−0.85
cathode	11.32	12.17	+0.85

Figure 6

Explain these results.

(4)

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- (c) When sodium sulfate solution is electrolysed, using inert electrodes, hydrogen is formed at the cathode.

Write the half equation for the formation of hydrogen gas, H_2 , from hydrogen ions, H^+ .

(2)

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(Total for Question 6 = 10 marks)

11-MARK QUESTIONS

7 questions in this booklet



9 (a) Dilute hydrochloric acid is a strong acid.

(i) Explain why dilute hydrochloric acid is described as a strong acid.

(2)

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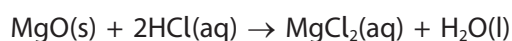
(ii) 1 cm³ of hydrochloric acid of pH 2 is made up to a volume of 10 cm³ with distilled water.

State the pH of the new solution.

(1)

pH = ...

(b) Magnesium oxide reacts with dilute hydrochloric acid to produce magnesium chloride solution and water.



Write the ionic equation for this reaction.

(3)

.....

(c) In an experiment magnesium hydroxide powder is added in 0.1 g portions to 25 cm³ of dilute hydrochloric acid until the magnesium hydroxide is just in excess.

Universal indicator paper can be used to test the pH of the solution after each addition of magnesium hydroxide.

(i) Give the name of an alternative piece of equipment that can be used to measure pH.

(1)

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- (ii) State and explain how the pH changes as the magnesium hydroxide is added to the dilute hydrochloric acid.

(4)

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(Total for Question 9 = 11 marks)



5 This question is about electrolysis.

(a) A sample of molten potassium bromide is electrolysed.

What are the two products formed?

(1)

- ☐ A hydrogen and oxygen
- ☐ B hydrogen and bromine
- ☐ C potassium and oxygen
- ☐ D potassium and bromine

(b) Zinc chloride and zinc carbonate contain ions.

Zinc chloride mixed with water can be electrolysed.

Zinc carbonate mixed with water cannot be electrolysed.

Explain this difference.

(2)

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(c) In the electrolysis of sodium chloride solution, bubbles of a colourless gas form at the cathode.

This gas, when mixed with air, burns with a squeaky pop.

(i) Identify this gas.

(1)

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(ii) Explain how this gas is formed at the cathode.

(2)

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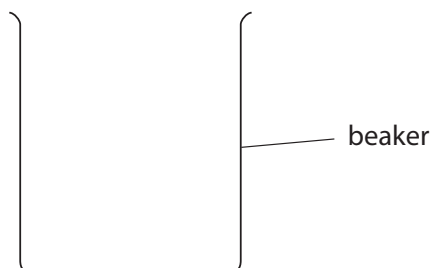


(d) A solution of copper sulfate in a beaker is electrolysed using copper electrodes.

(i) Draw a labelled diagram to show how this experiment would be set up.

The beaker has been drawn for you.

(2)



(ii) During the electrolysis, the anode gets smaller, the cathode gets larger and the solution remains the same shade of blue.

Give the reason for each of these observations.

(3)

the anode gets smaller

.....

.....

the cathode gets larger

.....

.....

the solution remains the same shade of blue

.....

.....

(Total for Question 5 = 11 marks)



7 Titration is used to carry out some neutralisation reactions.

(a) Ammonium nitrate can be made by neutralisation.

- (i) State the name of the two reactants that are neutralised to make the salt ammonium nitrate.

(2)

..... and

- (ii) Ammonium nitrate is a fertiliser.
Another fertiliser is ammonium phosphate.

Which elements are combined in ammonium phosphate?

(1)

- ☐ **A** nitrogen, oxygen and phosphorus only
- ☐ **B** hydrogen, oxygen and phosphorus only
- ☐ **C** hydrogen, nitrogen and phosphorus only
- ☐ **D** hydrogen, nitrogen, oxygen and phosphorus only

(b) Titrations involve aqueous solutions and the use of burettes.

- (i) Figure 8 shows readings on part of a burette at the start and at the end of a titration.

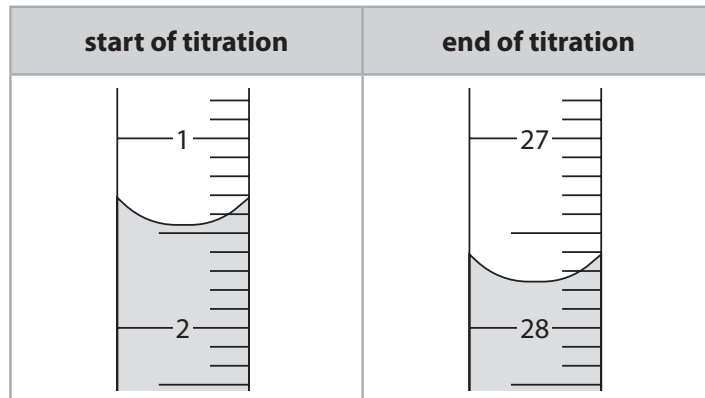


Figure 8

Calculate the volume of solution added from this burette.

Give your answer to a suitable number of decimal places.

(2)

.....
.....

volume = ... cm³

- (ii) A student carries out a titration four times.

The volumes from the student's results table are shown in Figure 9.

	rough	titration 1	titration 2	titration 3
volume in cm ³	25.90	24.90	24.60	25.00
used to calculate mean volume				

Figure 9

Tick the volumes that should be used to calculate the mean volume.

(1)

- (iii) Figure 10 shows the burette and flask prepared for use by the student. The burette is supported vertically by a clamp that is not shown in the diagram.

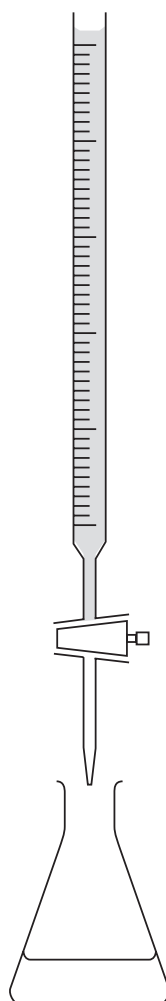


Figure 10

The student wrote a description of how they used the burette.

I took the burette from the cupboard. I closed the tap and filled the burette with the correct solution. I added the solution from the burette drop by drop to the flask until the indicator changed colour.

Give **three** improvements to the way that the student used the **burette**.

(3)

- 1
- 2
- 3

(c) In a titration a student placed alkali in the flask.

By mistake a few drops of litmus **and** a few drops of phenolphthalein were added to the flask.

The student added acid to the flask until the mixture was acidic.

Predict the colour change that would be seen.

(1)

from to

(d) In a titration a student rinsed out the flask with distilled water and did not dry it.

They used the flask for titration, adding the solution from the burette until the indicator changed colour.

State the effect, if any, on the titre volume of using the wet flask rather than a dry flask.

(1)

(Total for Question 7 = 11 marks)



8 Crystals of copper sulfate are prepared by reacting copper oxide, a base, with dilute sulfuric acid.

(a) Name the other product of this reaction.

(1)

(b) During the experiment, a spatula measure of copper oxide, a black powder, is added to warm, dilute sulfuric acid in a beaker.

When the mixture is stirred, the black powder disappears and the mixture turns pale blue.

The student then adds more copper oxide until the maximum amount of copper sulfate is formed without wasting copper oxide.

Explain how the student knows when to stop adding copper oxide.

(3)

(c) The reaction produces an aqueous solution of copper sulfate.

What is the best way to obtain crystals of copper sulfate from an aqueous solution?

(1)

- ☐ **A** pour the solution through filter paper in a funnel
- ☐ **B** heat the solution with a Bunsen burner until dry
- ☐ **C** heat the solution using a water bath
- ☐ **D** leave the solution in a cold, damp place

- (d) When some water is removed from the aqueous solution of copper sulfate, crystals of copper sulfate are made.

Describe how the arrangement and movement of the particles change as crystals are formed from a solution.

(3)

- (e) In this reaction, copper oxide, CuO , forms copper sulfate, CuSO_4 .

Explain, in terms of electrons, whether the copper in copper oxide has been oxidised, has been reduced, or has not been oxidised or reduced.

(2)

- (f) In another experiment, a copper sulfate solution with a concentration of 39.875 g dm^{-3} is used.

Calculate the mass of copper sulfate dissolved in 0.300 dm^3 of this solution.

(1)

mass = ... g

(Total for Question 8 = 11 marks)



- 7 (a) Water, acidified with dilute sulfuric acid, was electrolysed for 10 minutes using inert electrodes.

Figure 5 shows the apparatus used.

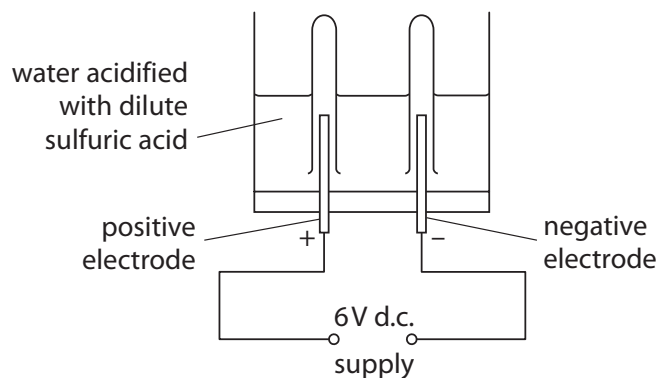


Figure 5

- (i) In this electrolysis, the acidified water is an electrolyte.

Explain why acidified water is an electrolyte.

(2)

.....

.....

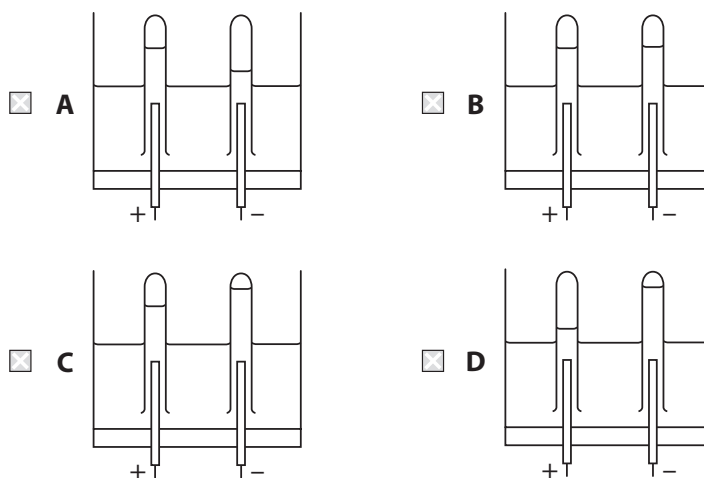
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- (ii) Hydrogen collects at the negative electrode and oxygen collects at the positive electrode.

Which of these shows the results after 10 minutes of this electrolysis?

(1)



- (iii) Complete and balance the half equation for the formation of oxygen at the positive electrode in this electrolysis.

(2)



- (b) Copper sulfate solution was electrolysed for 10 minutes using copper electrodes.

Figure 6 shows the mass of the cathode and the appearance of the copper sulfate solution before electrolysis and after electrolysis.

	mass of cathode in g	appearance of copper sulfate solution
before electrolysis	5.32	pale blue solution
after electrolysis	5.87	pale blue solution

Figure 6

- (i) Describe what should be done to the copper cathode, after it has been removed from the copper sulfate solution, before its final mass is determined.

(2)

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.....

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.....

- (ii) Explain, in terms of ions, the change in mass of the cathode shown in Figure 6.

(2)

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.....



- (iii) Explain why the appearance of the copper sulfate solution did not change during the electrolysis.

(2)

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.....

(Total for Question 7 = 11 marks)



4 Phosphoric acid is important in the production of fertilisers.

- (a) (i) A few drops of litmus solution are added to a sample of dilute phosphoric acid.

What is the colour of the mixture formed?

(1)

- ☐ A colourless
- ☐ B green
- ☐ C purple
- ☐ D red

- (ii) State why litmus cannot be used to measure pH.

(1)

.....

.....

- (b) Phosphoric acid can react to form phosphate salts which are used in fertilisers.

Give **two** reasons why farmers use fertilisers on their fields.

(2)

1

.....

2

.....

(c) An experiment was carried out to produce phosphoric acid.

(i) The actual yield for the experiment was 18.62 g.

The theoretical yield for the experiment is 24.50 g.

$$\text{percentage yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

Calculate the percentage yield of this experiment.

(2)

.....

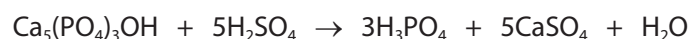
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.....

percentage yield = ...

(ii) The equation for a reaction to make phosphoric acid, H_3PO_4 , is



Calculate the atom economy for the production of phosphoric acid in this reaction.

$$\text{atom economy (\%)} = \frac{\text{total formula mass of desired product}}{\text{total formula mass of all reactants or products}} \times 100$$

(relative formula masses: $\text{Ca}_5(\text{PO}_4)_3\text{OH} = 502$, $\text{H}_2\text{SO}_4 = 98$, $\text{H}_3\text{PO}_4 = 98$, $\text{CaSO}_4 = 136$, $\text{H}_2\text{O} = 18$)

(3)

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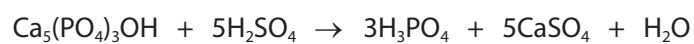
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atom economy = ... %



(iii) The equation for a reaction to produce phosphoric acid is



Explain how the atom economy of the reaction can be increased.

(2)

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.....

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.....

(Total for Question 4 = 11 marks)



10 A student is asked to carry out a titration to find the concentration of a sodium hydroxide solution.

(a) A teacher dilutes some sulfuric acid with distilled water to make a solution with a concentration of $0.250 \text{ mol dm}^{-3}$ for the student to use.

(i) What effect does diluting the sulfuric acid with distilled water have on the pH of the solution and the concentration of the H^+ ions?

(1)

	concentration of the H^+ ions	pH of the solution
☐ A	decreased	decreased
☐ B	increased	increased
☐ C	increased	decreased
☐ D	decreased	increased

(ii) What is the concentration, in g dm^{-3} , of a $0.250 \text{ mol dm}^{-3}$ solution of H_2SO_4 ?

(relative formula mass: $\text{H}_2\text{SO}_4 = 98.0$)

(1)

- ☐ A 0.00245
- ☐ B 0.394
- ☐ C 24.5
- ☐ D 394

(b) The student uses the apparatus shown in Figure 10 to carry out the titration.

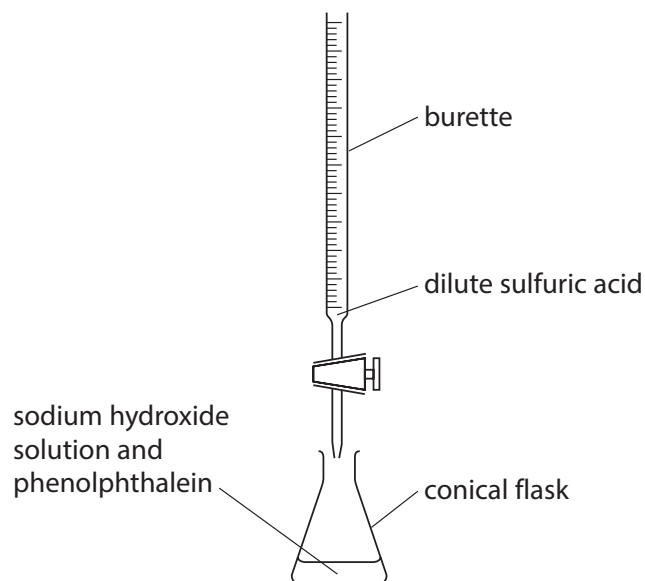


Figure 10

Before using the apparatus, the student rinses the burette with distilled water.

This is an error.

(i) Explain what effect this error has on the result of the titration.

(2)

.....

.....

.....

.....

.....

.....

(ii) State what the student should do to correct the error.

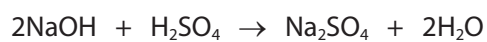
(1)

.....

.....

.....

*(c) The equation for the reaction in the titration is



Explain how the equation for the reaction and the apparatus in Figure 10 can be used to find the concentration of 25.0 cm^3 of sodium hydroxide solution using the 0.250 mol dm^{-3} sulfuric acid.

(6)



(Total for Question 10 = 11 marks)



MARK SCHEMES

official Pearson Edexcel mark schemes



Question Number	Answer	Additional guidance	Mark
2(a)(i)	A description including • apply lighted splint (1) • (squeaky) pop (1)	allow flame / ignite gas / fire ignore 'squeaky pop test' / glowing splint second mark is dependent on first	(2) AO 2 2

Question Number	Answer		Mark
2(a)(ii)	An explanation linking • loss of electron(s) (1) • two electrons (1)	allow gains two electrons for 1 mark zero marks overall if sharing of electrons / gain or loss of protons / positive electrons marks can be awarded for suitably drawn diagram / half equation	(2) AO 1 1

Question Number	Answer	Additional guidance	Mark
2(b)	final answer of 94 (g dm ⁻³) with or without working (2) OR $\frac{23.5}{250}$ (1) (= 0.094) 0.094 x 1000 (1) OR $\frac{250}{1000}$ (dm ³) (1) (= 0.25 (dm ³)) $\frac{23.5}{0.25}$ (1) OR $\frac{1000}{250}$ (1) = 4 4 x 23.5 (1)	allow ECF (error carried forward) throughout other final answers: 0.094 / 9.4 (1) 0.000094 or 9.4 x 10 ⁻⁵ (1) 0.25 (dm ³) (1) allow $\frac{250}{23.5}$ x 1000 or 10638(.3) (1)	(2) AO 2 1

Question Number	Answer	Additional guidance	Mark
2(c)	A description to include • filter (1) and two in a logical order from • crystallisation (1) • heat solution (to concentrate) (1) • allow to cool (1) • dry crystals between filter papers (1)	if filtration not first stage, ignore it and give maximum 2 marks allow description of filtration ignore filtration to obtain nickel sulfate (crystals) allow 'leave until water evaporates' / use of water bath / evaporate {water/the solution} allow leave {until crystals form / for a few hours / in a warm place / on a window sill} allow 'dry crystals in (warm) oven' if alternative methods of making nickel sulfate solution described, max 1 mark from last four marking points	(3) AO 2 2

Total for question 2 = 9 marks



Question number	Answer	Additional guidance	Mark
2(a)(i)	A description including • apply lighted splint (1) • gas burns / (squeaky) pop (1)	allow flame / ignite gas ignore 'squeaky pop test' / glowing splint second mark is dependent on first	(2)

Question number	Answer	Mark
2(a)(ii)	B oxygen The only correct answer is B A, C & D these gases are not produced in the electrolysis of sodium sulfate solution	(1)

Question number	Answer	Additional guidance	Mark
2(a)(iii)	• electrical energy / electricity (1) • {decomposes / breaks down / splits} {electrolytes / (ionic) compounds / substances} (1)	allow electric current allow separates ions reject decomposing elements for MP2	(2)

Question number	Answer	Additional guidance	Mark
2(b)	final answer of 114 (g dm ⁻³) with or without working (3) OR <u>28.4</u> (1) (= 0.1136) 250 0.1136 x 1000 (1) (= 113.6) = 114 (g dm ⁻³) (1)	allow ECF throughout <u>250</u> (dm ³) (1) (= 0.250 (dm ³)) 1000 <u>28.4</u> (1) (= 113.6) 0.250 OR <u>1000</u> (1) = 4 250 4 x 28.4 (1) (= 113.6) Must have 3sf for MP3 0.114 scores 2 Lose MP1 if rounded incorrectly e.g, to 0.11 or 0.113 but mark on	(3)

Question number	Answer	Additional guidance	Mark
2(c)	Na_2SO_4	allow SO_4Na_2 allow upper case A ignore any charges on ions reject non-subscript 2 & 4	(1)

Question number	Answer	Additional guidance	Mark
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Question number	Answer	Additional guidance	Mark
6(a)(i)	the acid is in excess	allow exact quantity of acid used to react with the carbonate	(1) AO3

Question number	Answer	Mark
6(a)(ii)	D 1/10 000 is the only correct answer. A, B and C are factually incorrect	(1) AO1

Question number	Answer	Additional guidance	Mark
6(b)	A description to include - heat solution (to evaporate water and concentrate the salt solution) (1) - leave to cool (1)	evaporating all water loses MP1 allow leave {in warm place/on window sill} (for water to evaporate slowly) (1) for several days (1)	(2) AO1

Question number	Answer	Mark
6(c)	B turns blue is the only correct answer. A, C and D are incorrect because the position of equilibrium will shift to the left-hand side	(1) AO2



Question number	Answer	Additional guidance	Mark
6(d)	$M_r \text{ H}_2\text{O} = 18.0$ (1) then moles of $\text{H}_2\text{O} = 4.5 / 18.0$ (= 0.25) (1) moles $\text{CuSO}_4 \cdot 5\text{H}_2\text{O} = 1/5 \times 0.25$ (= 0.05) (1) mass $\text{CuSO}_4 \cdot 5\text{H}_2\text{O} = 0.05 \times 249.5$ (= 12.475 g) (1) OR $5 \text{ H}_2\text{O} : 1 \text{ CuSO}_4 \cdot 5\text{H}_2\text{O}$ (1) $5 \times 18 : 249.5$ (1) mass $\text{CuSO}_4 \cdot 5\text{H}_2\text{O} = 249.5 / 90 \times 4.5$ (= 12.475 g) (1)	12.475 / 12.48 (g) with or without working scores 4 Allow TE throughout Answer must be to 2 or more sig figs	(4) AO2

(Total for question 6 = 9 marks)



Question number	Answer	Mark
2(a)	A solid aqueous aqueous liquid is the only correct answer B is incorrect because hydrochloric acid is aqueous C and D are incorrect as barium hydroxide is a solid	(1) AO1-1

Question number	Answer	Additional guidance	Mark
2(b)(i)	burette / (volumetric/graduated) pipette	allow syringe ignore any form of measuring cylinder / volumetric flask / dropping pipette	(1) AO3-3b

Question number	Answer	Additional guidance	Mark
2(b)(ii)	A description to include (observe / look at) colour produced on (universal indicator) paper (1) - compare to pH {chart / scale} (1)	allow (paper/solution/mixture) changes colour / specific colours given of UI ignore incorrect linking colour to acidity ignore reference to other indicators ignore reference to pH meters	(2) AO2-2



Question number	Answer	Additional guidance	Mark
2(b)(iii)	An explanation linking - litmus paper only shows if the solution is {acidic / alkaline} (1) - does not show <u>how</u> acidic or alkaline the solution is (1)	allow litmus goes red in acid, blue in alkali / litmus only has 2 colours / only UI gives a wide range of colours / litmus paper does not have a gradual change in colour ignore references to purple and neutral ignore litmus is not {precise / accurate} allow does not give the pH / litmus does not give accurate pH allow litmus paper does not show a gradual change in pH / ORA allow litmus does not give 'strength' of acid/alkali allow litmus paper is qualitative not quantitative (1) reject answers referring to use in test for chlorine	(2) AO3- 2a 2b

Question number	Answer	Additional Guidance	Mark
2(b)(iv)	- linear scales on both axes (1) {plotted points / best fit line} must cover at least half graph paper in both directions (1) 7 or more points plotted correctly ($\pm$ half a square) (1)	axes must be numbered (pH can start at 1) allow MP2 and MP3 if axes reversed must have numbered scale to score MP3 allow MP1 only for bar chart / histogram reject plotting on scale that uses the values from the table on Y axis (1, 1, 1, 1, 2, 7, 12, 13, 13)	(3) AO2-1

Total for Question 02 = 9 marks



Question number	Answer	Additional guidance	Mark
5(a)	Diagram showing - two (copper) electrodes in {beaker / suitable container} of {copper sulfate / solution / electrolyte} (1) - connected to {power supply / battery / cell} (1)	diagram needs to be labelled to score full marks electrodes must go into solution for MP1 reject AC / mains supply	(2) AO1-2

Question number	Answer	Additional guidance	Mark
5(b)	An explanation linking (electrodes) cleaned (using emery paper) (or similar) (1) - to remove {surface oxide / grease / impurities} (1)	allow scrubbed allow dip / wash into named organic solvent allow dirt / other substances reject rust	(2) AO1-2

Question number	Answer	Additional guidance	Mark
5(c)(i)	An explanation linking - at anode copper / atoms {lose electrons / oxidised} / (copper) ions leave anode (– cause mass loss) (1) (copper) ions (in solution) move to cathode (1) - At cathode (copper) ions {gain electrons / reduced} (– cause mass increase) (1)	allow $\text{Cu} \rightarrow \text{Cu}^{2+} + 2\text{e}^{(-)}$ reject mass loss is due to loss of electrons ignore copper dissolves allow $\text{Cu}^{2+} + 2\text{e}^{(-)} \rightarrow \text{Cu}$ reject mass gain is due to gain of electrons if no other mark scored allow oxidation at anode and reduction at cathode (1)	(3) AO3-2



Question number	Answer	Additional guidance	Mark
5(c)(ii)	An explanation linking - mass of copper increased by {3x / calculated 2.34/0.78} (=3) (1) (so) need (3x) / more {current / voltage} passing through solution (1)	allow need (3 x) {greater surface area of electrode / larger electrode / greater concentration (of copper sulfate solution)} / reduce distance between electrodes allow power in place current or voltage 3x { current / voltage / power } = 2 marks	(2) AO2-2

Total for Question 05 = 9 marks



Question number	Answer	Additional guidance	Mark
2(a)	stir/ swirl/ shake (the beaker)	allow mix, warm/ heat ignore wait (until reaction over/ until powder disappears)	A01 2 (1)

Question number	Answer	Additional guidance	Mark
2(b)	in either order: calcium chloride (1) water (1)	allow phonetic spellings but reject calcium chlorine allow CaCl ₂ but formula must be correct for the mark ignore 'solution'/ any state symbols allow H ₂ O but formula must be correct for the mark if three products given, allow (1) only if both correct products are given. four or more products scores (0)	A02 1 (2)

Question number	Answer	Mark
2(c)	C s aq is the only correct answer A, B and D are not correct because the calcium hydroxide is a solid and the acid is an aqueous solution.	A02 1 (1)

Question number	Answer	Additional Guidance	Mark
2(d)(i)	1	allow 0.9 or 1.1	A03 2 (1)

Question number	Answer	Mark
2(d)(ii)	0.74 (g)	A03 2 (1)



Question number	Answer	Additional guidance	Mark
2(d)(iii)	An explanation linking: START - solution is acidic / acids have low pH / high {concentration/ amount} of H^+ ions/ excess H^+ ions (1) REACTION - neutralisation/ $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$/ {the hydroxide/ alkali} <u>reacts</u> with the {acid/ H^+} (1) END {amount/ concentration} of H^+ ions has reduced/ {amount/ concentration} of OH^- ions has increased / excess OH^- ions/ (excess of) hydroxide ions have $\text{pH} > 7$ (1)	allow for low pH: pH less than 7 / pH 1-6 / pH =1 ignore there is no alkali ignore references to 'strong' or weak' allow acid $\rightarrow$ neutral $\rightarrow$ alkali (2) allow calcium hydroxide is {an alkali/a base} ignore description of pattern – as calcium hydroxide added pH increases (0) ignore 'becomes alkaline'/ is alkaline/ is less acidic	A02 1 (3)

Question number		Mark
6(a)	C at the cathode is the only correct answer A, B and D are incorrect because the copper ions are positive so are reduced at the cathode.	A02 2 (1)

Question number	Answer	Additional Guidance	Mark
6(b)(i)	An explanation including: - as current increases mass increases / the mass is proportional to the current (1) - because the higher the current the more electrons (per second) (1) - so more copper ions {are reduced/ gain electrons/ are discharged} (1)	ignore names of electrodes overall trend required e.g. more mass at 0.4A than 0.2A (0), as current up by 0.2 mass up 0.04 (1), more current, more copper(1) allow positive correlation (between current and mass) allow 'amps' for 'current', 'amount' for mass allow 'greater flow of electrons' allow higher rate of electron transfer allow electrons move faster allow higher (amount of) charge allow $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$ allow more copper ions react if give copper ion symbol, allow any positive charge ignore more copper (atoms) form	A02 1 (3)

Question number	Answer	Additional Guidance	Mark
6(b)(ii)	A description including: • (rinse and) dry {electrode / cathode} (1) • measure mass of {<u>electrode/ cathode</u>} (on a balance) (and subtract original mass) (1)	MP1 and MP2 independent allow anode/ electrodes allow rinse electrode with solvent/ propanone (and leave for solvent to evaporate) ignore clean/ wipe electrode allow weigh electrode at start and end allow subtract original mass from final mass allow 'find increase in mass of electrode' ignore measure mass of copper before and after scrape off copper and weigh scores 0 marks	A02 2 (2)



Question number	Answer	Additional Guidance	Mark
6(c)	7.015×10^{20} with or without working scores 3 - mass copper in g = $\frac{74}{1000}$ = $0.074 / 7.4 \times 10^{-2}$ g (1) - amount of copper = $\frac{0.074}{63.5}$ = $0.001165\ldots / 1.165\ldots \times 10^{-3}$ mol (1) - number of atoms = $0.001165\ldots \times 6.02 \times 10^{23}$ = 7.015×10^{20} (1)	allow ecf for MP2 and MP3 allow correct rounding at each stage MP2 for $\frac{\text{mass}}{63.5}$ MP3 for number using 74 and 63.5 x Avogadro correctly worked out allow 1 or more sig fig. 7.015×10^{23} scores 2 7.015×10^{26} scores 2 2.829×10^{24} scores 2 2.829×10^{27} scores 1	A02 1 (3)

Question number	Answer	Mark
2(a)(i)	$\text{Ba(OH)}_2(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow \text{BaCl}_2(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$	(1) A02-1

Question number	Answer	Additional guidance	Mark
2(a)(ii)	barium hydroxide {disappears / gets smaller} / (it) becomes clear	allow 'solid' for barium hydroxide allow barium hydroxide dissolves ignore any colours mentioned / colour change / any incorrect observations ignore becomes a {liquid/solution} reject bubbles	(1) A02-2

Question number	Answer	Additional guidance	Mark
2(b)(i)	pH meter	allow pH probe ignore pH paper / data logger / pH scale	(1) A03-3b

Question number	Answer	Additional guidance	Mark
2(b)(ii)	An explanation linking - to ensure that the mixture is evenly spread (1) - to make substances {react/ dissolve} / to speed up the {reaction / dissolving} (1)	allow to mix the reactants allow so pH (in mixture) is uniform / concentration is uniform / to get an accurate pH ignore more accurate / valid / fair test allow 'so the reaction is complete' / 'to dissociate all the hydroxide ions'	(2) AO2-2

Question number	Answer	Additional Guidance	Mark
2(b)(iii)	all points plotted correctly ($\pm$ half a small square) (2) OR 7/8 points plotted correctly (1) S-shaped line of best fit (1)	line of best fit must go through 7 points if the points are not visible a line going through all correct values scores 3 reject dot-to-dot line / line starting from origin tramlines allowed here but rejected in 2(b)(iv) bar chart scores 0	(3) AO2-1



Question number	Answer	Additional guidance	Mark
2(b)(iv)	pH reading at 4.5 spatula measures from their line on graph	allow $\pm$ half a small square on the y -axis ignore any candidate working allow ECF from 2(b)(iii) but if no graph line or multiple lines, cannot score. if bar chart has been drawn for 2(b)(iii), then mark for 2biv cannot be awarded	(1) AO3-2a

Total for question 02 = 9 marks



Question number	Answer	Additional guidance	Mark
3(a)(i)	aq (1) KNO ₃ (1)	allow AQ / Aq / aQ reject aqueous allow NO ₃ K / K(NO ₃) / (K)NO ₃ reject any other answer all letters must be capitals. The 3 must be a subscript. ignore any brackets in formula	(2) AO2 1

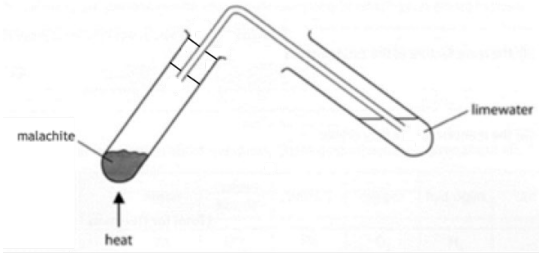
Question number	Answer	Additional guidance	Mark
3(a)(ii)	silver chloride	reject silver chlorine ignore solid / precipitate / ppt	(1) AO2 1

Question number	Answer	Additional guidance	Mark
3(a)(iii)	An explanation including any 3 from - filtration (1) <u>pour mixture through</u> {filter funnel / filter paper} (1) {precipitate / residue / solid / AgCl} stays on the paper (1) {solution / filtrate / liquid} goes through (the paper) (1)	allow to filter (mixture) allow <u>pour mixture through</u> {filter / funnel} allow precipitate is left behind (in filter / funnel) allow particles too big to go through ignore mixture goes through ignore any additional processes after filtration step if filtration occurs after any other process, e.g. heating, MP1 and MP2 do not score but MP3 and MP4 can be scored diagram can score all MPs	(3) AO3 3a

Question number	Answer	Additional guidance	Mark
3(b)	A description including {silver nitrate / solution} has ions (1) {silver / solid / metal} has delocalised electrons (1) {ions / electrons} move (1)	reject silver nitrate has electrons {that move / delocalised} for MP1 allow {free / sea of} electrons reject <u>silver</u> has ions {that move / delocalised} for MP2 allow charged particles move MP3 for idea of movement of charge (even if, for example, MP1 and/or MP2 reversed or wrong)	(3) AO2 1

Total for Question 3 = 9 marks



Question number	Answer	Mark
6(a)(i)	C  B and D are not correct as the carbon dioxide would escape A is not correct as the bung would pop out and the carbon dioxide would escape	(1) A03 3b

Question number	Answer	Additional guidance	Mark
6(a)(ii)	calcium carbonate	allow CaCO_3	(1) A02 2

Question number	Answer	Additional guidance	Mark
6(a)(iii)	formula mass of $\text{Cu}_2\text{CO}_3(\text{OH})_2$: $(63.5 \times 2) + 12 + (16 \times 3) + ((16+1) \times 2) = 221$ (1) $\frac{22.1}{221} = 0.1$ (1) $0.1 \times 2 = 0.2$ (1) $0.2 \times 79.5 = 15.9$ (1)	15.9 gains 4 marks with or without working allow ECF throughout alternative method: $(63.5 \times 2) + 12 + (16 \times 3) + ((16+1) \times 2) = 221$ (1) mole ratio 1 mole: 2 moles CuO (1) 221g malachite : $2 \times 79.5 = 159\text{g CuO}$ (1) 22.1 malachite : $159 \times 22.1/221 = 15.9\text{g}$ (1) 31.8 (g) scores 3 7.95 (g) scores 3	(4) AO2 1

Question number	Answer	Additional guidance	Mark
6(b)	comments to include three from: method 1 - mixing - strength - means more will react OR method 2 - not mixing - weakness - less will react (1) method 1 and / or method 2 - quantity of carbon not given – weakness - may not be in excess (1) method 1 - use of a metal crucible - strength - conducts more heat (1) method 1 - use of a metal crucible – weakness – metal crucible might react (1) method 1 – transfers reactants between containers – weakness – loss of reactants (1) method 1 and / or method 2 - roaring flame - strength - gives enough energy for reaction to occur (1) method 1 and / or method 2 – separation of copper – weakness - no method given (1)	Note: implication of strength/weakness and method can be obtained from the way in which the candidate gives the answer eg using the metal crucible is better as it conducts more heat Only Method 1 is using the metal crucible so the method has been identified. 'is better' would be another way of saying that it is a strength	(3) A03 1

Total for Question 6= 9 marks



Question Number	Answer	Mark
6(a)(i)	C chlorine zinc The only correct answer is C <i>A is not correct because oxygen cannot be produced by the electrolysis of this molten salt</i> <i>B is not correct because hydrogen cannot be produced by the electrolysis of this molten salt</i> <i>D is not correct because hydrogen and oxygen cannot be produced by the electrolysis of this molten salt</i>	(1) AO 2 1

Question Number	Answer	Mark
6(a)(ii)	D it contains ions that can move The only correct answer is D <i>A is not correct because molten zinc chloride does not contain molecules</i> <i>B is not correct because molten zinc chloride does not have a giant structure</i> <i>C is not correct because delocalised electrons are not present</i>	(1) AO 1 1



Question Number	Answer	Additional guidance	Mark
6(b)(i)	A diagram of a workable apparatus showing a complete circuit including - electrodes labelled in (copper sulfate) solution (1) {power supply / power pack / battery} connected (1)	max 1 if circuit not complete allow labelling as 'electrodes' or 'anode' and 'cathode' or 'copper' ignore 'connected to mains' allow symbol for cell/battery even if wrong way round	(2) AO 1 2

Question Number	Answer	Additional guidance	Mark
6(b)(ii)	An explanation linking the following point to a maximum of four - anode lost copper and cathode gained copper / reaction at cathode is reverse of reaction at anode / copper ions move into solution at anode AND copper ions move out of solution at cathode (1) and any three from - at anode copper atoms become copper ions (1) and lose two electrons (1) OR (at anode) $\text{Cu} \rightarrow \text{Cu}^{2+} + 2\text{e}^-$ (2) - at cathode copper ions become copper atoms (1) and gain two electrons (1) OR (at cathode) $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$ (2)	ignore references to zinc, chlorine and zinc chloride allow copper atoms are oxidised (1) marking points independently allow copper ions are reduced (1) marking points independently penalise wrong use of atom / ion once only penalise wrong use of reduced / oxidised once only	(4) AO 2 1

Question Number	Answer	Additional guidance	Mark
6(c)	$2\text{H}^+ + 2\text{e}^{(-)} \rightarrow \text{H}_2$ / $2\text{H}^+ \rightarrow \text{H}_2 - 2\text{e}^{(-)}$ (2) species in correct place as shown above (1) balancing of correct species in correct place (1)	allow use of = or $\rightleftharpoons$ in place of $\rightarrow$ allow multiples reject h_2 / h_2 / H_2 / H^2	(2) AO 1 1

Total for question 6 = 10 marks



Question number	Answer	Additional guidance	Mark
9(a)(i)	an explanation linking - fully dissociates (1) - to form {H⁺/hydrogen} ions (1)	allow ionises/splits up	(2)

Question number	Answer	Mark
9(a)(ii)	3 / pH 3	(1)

Question number	Answer	Additional guidance	Mark
9(b)	$\text{MgO} + 2\text{H}^+ \rightarrow \text{Mg}^{2+} + \text{H}_2\text{O}$ LHS (1) RHS (1) balancing of correct formulae (1)	allow two marks for $\text{O}^{2-} + 2\text{H}^+ \rightarrow \text{H}_2\text{O}$	(3)

Question number	Answer	Additional guidance	Mark
9(c)(i)	pH meter/ pH probe	ignore data logger alone reject litmus / phenolphthalein / universal indicator solution / pH paper	(1)

Question number	Answer	Additional guidance	Mark
9(c)(ii)	- increases pH (1) - until pH above 7 (1) and an explanation linking REACTION {magnesium hydroxide / base / alkali / OH⁻ ions} {reacts with / neutralises} {the acid / the H⁺ ions} IONS REMAINING - so the hydrogen ions concentration is reduced / all hydrogen ions reacted / there is an excess of hydroxide ions (1)	allow until pH = 7 ignore until neutral ignore there is an excess of magnesium hydroxide	(4)

Question number	Answer	Mark
5(a)	D potassium and bromine D is the only correct answer. A is incorrect since neither hydrogen nor oxygen are products of this electrolysis. B is incorrect because only bromine is a product and hydrogen is not a product of this electrolysis. C is incorrect since only potassium is a product and oxygen is not a product of this electrolysis.	(1) AO1

Question number	Answer	Additional guidance	Mark
5(b)	An explanation linking - zinc chloride soluble and zinc carbonate insoluble (1) - so ions free to move only in zinc chloride solution / comparison with zinc carbonate (1)		(2) AO1

Question number	Answer	Mark
5(c)(i)	hydrogen / H ₂	(1) AO3



Question number	Answer	Additional guidance	Mark
5(c)(ii)	An explanation linking - hydrogen ions attracted to cathode/negatively charged electrode (1) (two) hydrogen ions {gain (two) electrons / are reduced / form hydrogen molecules} / correct half equation ($2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$) (1)	allow positively charged ions attracted to cathode ignore references to sodium ions	(2) AO1

Question number	Answer	Additional guidance	Mark
5(d)(i)	Diagram to show - electrodes in solution (1) - wires and power supply connected to give a complete circuit (1)	max 1 mark if no labelling Ignore any charges on the diagram	(2) AO1

Question number	Answer	Additional guidance	Mark
5(d)(ii)	- anode: smaller because copper atoms form ions (and go into solution) / oxidation of Cu atoms (1) - cathode: larger because copper atoms are formed (from ions in the solution) / reduction of Cu^{2+} (1) - solution: the same number of ions enter and leave solution (1)		(3) AO1

(Total for question 5 = 11 marks)



Question number		Additional guidance	Mark
7(a)(i)	- ammonia (solution) (1) - nitric acid (1)	allow ammonium hydroxide for ammonia. ignore any formulae	A01 1 (2)

Question number	Answer	Mark
7(a)(ii)	D hydrogen, nitrogen, oxygen and phosphorus only is the only correct answer A, B and C are incorrect because they each lack one of the elements	A02 1 (1)

Question number	Answer	Additional guidance	Mark
7(b)(i)	- two readings: 27.75 and 1.45 (1) $27.75 - 1.45 = \mathbf{26.30}$ (1)	MP1 for these values only MP2 for correct subtraction of 2 volumes (to 1 or 2 d.p.) but answer must be 2 d.p. Any 1 d.p. answer including 26.3 does not score MP2. Answers with NO working 26.30 (2); any other answer (0) 26.30 with working may score 2 (if 2 correct values used) or score 1 (e.g. $27.78 - 1.48 = 26.30$; $27.8 - 1.5 = 26.30$)	A03 1 (2)

Question number	Answer					Mark
7(b)(ii)		25.90	24.90	24.60	25.00	A03 2 (1)
			✓		✓	



Question number	Answer	Additional Guidance	Mark
7(b)(iii)	An answer including any three from • rinse the burette with titrant (1) • fill the jet / tip (1) • do not fill burette over 0 cm^3 / overfill/ run liquid out until volume at or below 0 cm^3 (1) • add drop by drop only near {end point/ colour change} (1)	allow clean/ wash the burette / wash with water allow rinse with (named) acid or alkali ignore dry the burette allow indication of this part of apparatus e.g. below tap allow ensure no gas bubbles/ air note: diagram shows overfilled burette ignore measure start volume allow do not fill to top allow rough titration first (then add similar volume before going dropwise) ignore any remarks about taking readings ignore additional method points e.g. use funnel, clamping burette	A03 3 (3)

Question number	Answer	Additional Guidance	Mark
7(c)	from: pink-blue/ pink-purple/ blue-purple/ purple to red	in colours allow any qualifiers e.g. light/ dark etc FROM allow any type of purple alone e.g lilac allow any combination of pink/blue/purple reject blue <u>alone</u> or pink <u>alone</u> reject any red TO Reject any other colours with red	A01 2 (1)

Question number	Answer	Additional Guidance	Mark
7(d)	None / volume the same	Must be clear there is NO effect e.g. 'little to no change' (0)	A01 2 (1)



Question number	Answer	Additional Guidance	Mark
8(a)	water	allow H ₂ O 2 must be subscript H and O must be capitals ignore copper sulfate/ CuSO ₄	A01 1 (1)

Question number	Answer	Additional Guidance	Mark
8(b)	An explanation including OBSERVATION - when some powder remains in the beaker (after stirring) (1) COPPER OXIDE - there is an excess of copper oxide (1) ACID - all the acid {is neutralised/ has reacted}/ no acid remains (1)	MP1, 2 and 3 are independent allow {mixture/ solution} turns black/ copper oxide does not 'dissolve'/ copper oxide remains / solution gets no darker blue ignore fizzing stops ignore copper oxide precipitate allow acid used up allow acid is the limiting reactant ignore reaction complete	A01 2 (3)

Question number	Answer	Mark
8(c)	C heat the solution with a water bath is the only correct answer. A is incorrect because the solution will not be separated. B is incorrect because a powder forms instead of crystals. D is incorrect because the method would be very slow.	A01 2 (1)



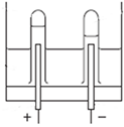
Question number	Answer	Additional guidance	Mark
8(d)	A description including any three from: SOLUTION • (the ions) are (freely) moving (1) • (the ions) are randomly arranged (1) SOLID • (the ions) are fixed/ not moving/ vibrating (1) • (the ions) are in a regular arrangement/ lattice/ giant structure (1)	allow atoms or particles for ions reject molecules once allow suitable diagrams (could score MP2, MP4) ignore any reference to bonding allow liquid for solution ignore flowing ignore have less energy allow in rows/ tightly packed/ close together	A01 1 (3)

Question number	Answer	Additional Guidance	Mark
8(e)	An explanation including: • the copper (ions are) neither oxidised nor reduced (1) • the copper (ions) do not lose or gain electrons/ Cu^{2+} present at start and end (1)	mark independently with no ecf allow copper oxide not oxidised or reduced allow 'neither' allow copper (ions) have same number of electrons/ have same charge ignore references to spectator ions	A01 1 (2)

Question number	Answer	Additional Guidance	Mark
8(f)	11.9625 with or without working scores 1 11.9625	11.963/ 11.96/ 12.0/ 12 scores 1	A02 2 (1)



Question number	Answer	Additional guidance	Mark
7(a)(i)	An explanation linking - it contains (hydrogen / sulfate) ions (1) - which can move (1)	MP2 depends on MP1 reject electrons for MP1 and MP2 allow formula for {hydrogen ion / sulfate ions} even if incorrect allow charged particles / cations / anions allow hydrogen or sulfate ions even if charge or formula is incorrect allow which are dissociated / are free / in a liquid / in a solution / go to electrodes ignore 'it conducts electricity'	(2) AO1-1

Question number	Answer	Mark
7(a)(ii)	A  B, C and D are incorrect because they show the incorrect ratio of gases that are produced	(1) AO2-2

Question number	Answer	Additional guidance	Mark
7(a)(iii)	$4\text{OH}^- \rightarrow \text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^{(-)}$ (2)	correct species (1) balancing of only correct species (1) allow incorrect cases / subscripts allow 1 mark for $\text{O}_2 + 2\text{H}_2\text{O}$ on RHS allow 1 mark for $+ 4\text{e}^{(-)}$ on RHS	(2) AO2-1



Question number	Answer	Additional guidance	Mark
7(b)(i)	A description to include - wash / rinse (1) - dry / leave to dry / allow any solvent to evaporate (1)	mark independently reject clean with sandpaper / scrape off the copper for both marks allow dip in {propanone / water} ignore wipe / clean allow water, propanone for solvent allow pat dry	(2) AO1-2

Question number	Answer	Additional guidance	Mark
7(b)(ii)	An explanation linking {copper ions / cations / positive ions} and {gain electrons/ are reduced} (1) - to form {copper / atoms} (on cathode) (1)	allow incorrect size of positive charge on copper ion half-equation (even if incorrect size of positive charge on copper ion or incorrectly balanced) can score MP1 and MP2 if no other marks awarded allow max 1 for {copper ions / cations / positive ions} go to cathode	(2) AO1-1



Question number	Answer	Additional guidance	Mark
7(b)(iii)	An explanation linking • {Cu²⁺ / cations / ions} enter solution (from anode) and leave solution (at cathode) (1) • no change in {concentration / amount / number} of {Cu²⁺/ cations / ions} (1)	allow constant / same concentration of {Cu²⁺/cations / ions} allow concentration of copper sulfate	(2) AO3-2

Total for question 07 = 11 marks



Question number	Answer	Additional guidance	Mark
4(a)(i)	D red A is incorrect as litmus does not turn colourless B is incorrect as litmus is red in acid C is incorrect as litmus is red in acid		(1) AO2 2

Question number	Answer	Additional guidance	Mark
4(a)(ii)	does not give a {number / value} / does not give a range of colours (1)	allow not precise, 'can't tell the pH value/ number , does not say how acidic/ alkaline, only says if acid or alkali, only has 2 (or 3) colours, only red or blue ignore not accurate, 'you can't tell the pH' ignore how pH should be measured	(1) AO2 2

Question number	Answer	Additional guidance	Mark
4(b)	- provides minerals / phosphorus / phosphates / potassium / nitrogen / nitrates (1) - helps crops grow / grow faster / increase crop yield (1)	allow to provide nutrients allow to prevent mineral deficiencies or specific minerals allow grow more food ignore to keep crops healthy / kills pests	(2) AO1 1

Question number	Answer	Additional guidance	Mark
4(c)(i)	76(%) with or without working scores 2 $\frac{18.62}{24.50} \times 100$ (1) = 76 (1)	No ECF on this question 0.76 scores 1	(2) AO2 1



Question number	Answer	Additional guidance	Mark
4(c)(ii)	numerator: $3 \times 98 = 294$ (1) denominator: $502 + (5 \times 98) = 992$ / $(3 \times 98) + (5 \times 136) + 18 = 992$ (1) $\frac{294}{992} \times 100 = 29.63709677$ (1)	29.64/ 29.6/ 30 shown with no working, scores 1 only If working shown mark as indicated For MP3: allow 2 or more s.f., answer must be correctly rounded allow ecf for MP3 only if all Mr values from either reactants or products have been used and answer <100%	(3) A02 1

Question number	Answer	Additional guidance	Mark
4(c)(iii)	an explanation linking - find a use for calcium sulfate / water / waste product(s) / all products (1) - so the formula mass of the <u>desired product</u> increases (1) OR - find a use for all products / calcium sulfate and water (1) - so atom economy is 100% (1)	MP2 dependent on MP1 in both options ignore find an alternative reaction allow specified use, even if incorrect allow 'amount' ignore references to increasing yield	(2) A03 2

Total for Question 4 = 11 marks



Question number	Answer	Mark
10(a)(i)	D A , B and C are incorrect because hydrogen ions concentration decreases and the pH increases	(1) AO2 1

Question number	Answer	Mark
10(a)(ii)	C 24.5 A , B and D are incorrect as the concentration g dm ⁻³ is 24.5 g dm ⁻³	(1) AO2 1

Question number	Answer	Additional guidance	Mark
10(b)(i)	an explanation linking (left over water will) decrease the concentration of the sulfuric acid (1) - so more acid would be needed / concentration of sodium hydroxide will appear higher (1)	allow dilute the acid (more) ignore references to changing pH allow H ⁺ (ions) for acid	(2) AO3 2

Question number	Answer	Additional guidance	Mark
10(b)(ii)	rinse (inside of burette) with (sulfuric) acid	ignore any reference to drying ignore use a different burette	(1) AO3 3b



Question number	Indicative content	Mark
*10(c)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material that is indicated as relevant. Additional content included in the response must be scientific and relevant. AO1 6 marks • add white tile under apparatus • so that colour change can be seen clearly • run sulfuric acid into sodium hydroxide • swirl the mixture in the flask • to ensure all the reactants react • phenolphthalein is pink in alkali but colourless in acid • add acid dropwise towards the end point • so the exact amount of acid can be obtained • rinse the end of the burette and the inside of the conical flask • to ensure all the acid is in the mixture • repeat until results are concordant • average concordant results • the exact volume of acid is now known, so with concentration of acid no of mols can be found • no of mols = concentration x volume • H_2SO_4 reacts in a 1:2 ratio with NaOH / ORA • so number of mols of alkali = 2 x number of mols of acid / ORA • volume of sodium hydroxide is known so with no of mols of alkali, concentration can be determined • concentration = number of moles divided by volume	(6) AO1 2

Level	Mark	Descriptor
	0	• No rewardable material.
Level 1	1-2	• Demonstrates elements of chemical understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) • Presents an explanation with some structure and coherence. (AO1)
Level 2	3-4	• Demonstrates chemical understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5-6	• Demonstrates accurate and relevant chemical understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)



Level	Mark	Descriptor	Additional Guidance
	0	No rewardable material	Read whole answer and ignore all incorrect material and any references to other metals / discard any contradictory material then:
Level 1	1–2	<u>Additional Guidance</u> Gives simple statements about the titration or the calculation OR Gives a simple description of the titration or the calculation	<u>Possible candidate response: (examples)</u> phenolphthalein will go from pink to colourless (1) moles = concentration x volume (1) Add sulfuric acid to sodium hydroxide. Stop when the phenolphthalein loses its colour (2) The acid will neutralise the alkali. The number of moles of acid can be calculated knowing the volume used (2)
Level 2	3–4	<u>Additional Guidance</u> Gives a simple explanation of the titration AND the calculation with at least 1 linked statement OR Gives a detailed explanation of the titration OR the calculation with at least 1 linked statement plus other simple statements	<u>Possible candidate response:</u> The acid will react with the alkali in a neutralisation reaction, the phenolphthalein will change colour when all alkali has been neutralised, we can then read off the exact amount of acid needed to neutralise the sodium hydroxide. (3) Calculate the number of moles of sulfuric acid. Then multiply by 2 to calculate moles of sodium hydroxide (3) Acid reacts with alkali to form salt + water in neutralisation reaction. The indicator has a sharp end point which will change colour at equivalence point, so the volume of acid is now known so with the concentration of acid the number of mols of sodium hydroxide can be found (4)
Level 3	5–6	<u>Additional Guidance</u> Gives a explanation of the titration AND the calculation with at least 3 linked statements	<u>Possible candidate response:</u> The acid will react with the alkali in a neutralisation reaction, the phenolphthalein will go from pink to colourless when all alkali has been neutralised, we can then read off the exact amount of acid needed to neutralise the sodium hydroxide. the number of mols of acid used = concentration x volume (5) Acid reacts with alkali to form salt + water in neutralisation reaction, $H^+ + OH^- \rightarrow H_2O$, the indicator has a sharp end-point which will change colour at equivalence point, so the volume of acid is now known this along with the concentration of acid, the no of mols of sodium hydroxide can be found. When the volume of sodium hydroxide is known and the number of mols of alkali known, concentration can be determined using concentration = number of moles divided by volume (6)

Total for Question 10 = 11 marks

