

Name: _____

Chemical Changes part 4 AQA Triple Chemistry

Class: _____

Date: _____

Time: **95 minutes**

Marks: **91 marks**

Comments:

1.

Soluble salts are formed by reacting metal oxides with acids.

- (a) Give **one** other type of substance that can react with an acid to form a soluble salt.

(1)

- (b) Calcium nitrate contains the ions Ca^{2+} and NO_3^-

Give the formula of calcium nitrate.

(1)

(a) Suggest **one** hazard associated with **Stage 1**.

(1)

(b) Water must be kept away from the reaction in **Stage 2**.

Give **one** reason why it would be hazardous if water came into contact with sodium.

(1)

(c) Suggest why the reaction in **Stage 2** is carried out in an atmosphere of argon and **not** in air.

(2)

(d) Titanium chloride is a liquid at room temperature.

Explain why you would **not** expect titanium chloride to be a liquid at room temperature.

(3)

In **Stage 2**, sodium displaces titanium from titanium chloride.

(e) Sodium atoms are oxidised to sodium ions in this reaction.

Why is this an oxidation reaction?

(1)

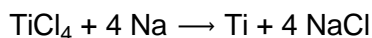
(f) Complete the half equation for the oxidation reaction.



(1)

(g) In Stage 2, 40 kg of titanium chloride was added to 20 kg of sodium.

The equation for the reaction is:



Relative atomic masses (A_r): Na = 23 Cl = 35.5 Ti = 48

Explain why titanium chloride is the limiting reactant.

You **must** show your working.

(4)

- (h) For a **Stage 2** reaction the percentage yield was 92.3%

The theoretical maximum mass of titanium produced in this batch was 13.5 kg.

Calculate the actual mass of titanium produced.

Mass of titanium = _____ kg

(2)

(Total 15 marks)

3.

This question is about acids and alkalis.

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

Explain why an acid can be described as both strong and dilute.

(2)

- (b) A 1.0×10^{-3} mol/dm³ solution of hydrochloric acid has a pH of 3.0

What is the pH of a 1.0×10^{-5} mol/dm³ solution of hydrochloric acid?

pH = _____

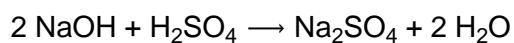
(1)

A student titrated 25.0 cm³ portions of dilute sulfuric acid with a 0.105 mol/dm³ sodium hydroxide solution.

- (c) The table below shows the student's results.

	Titration 1	Titration 2	Titration 3	Titration 4	Titration 5
Volume of sodium hydroxide solution in cm ³	23.50	21.10	22.10	22.15	22.15

The equation for the reaction is:



(e) Calculate the mass of sodium hydroxide in 30.0 cm³ of a 0.105 mol/dm³ solution.

Relative formula mass (M_r): NaOH = 40

Mass of sodium hydroxide = _____ g

(2)

(Total 12 marks)

4.

A student makes a hypothesis:

'When different salt solutions are electrolysed with inert electrodes, the product at the negative electrode is always a metal'.

(a) Describe how you would test this hypothesis in the laboratory.

You should:

- draw a labelled diagram of the apparatus
- give the independent variable
- describe what you would see at the negative electrode if the hypothesis is true.

Diagram

Independent variable _____

Observation _____

(5)

(b) The student's hypothesis is only partially correct.

Explain why the product at the negative electrode is not always a metal.

(2)

(c) Predict the product at the positive electrode in the electrolysis of:

- sodium chloride solution
- copper sulfate solution.

Sodium chloride solution _____

Copper sulfate solution _____

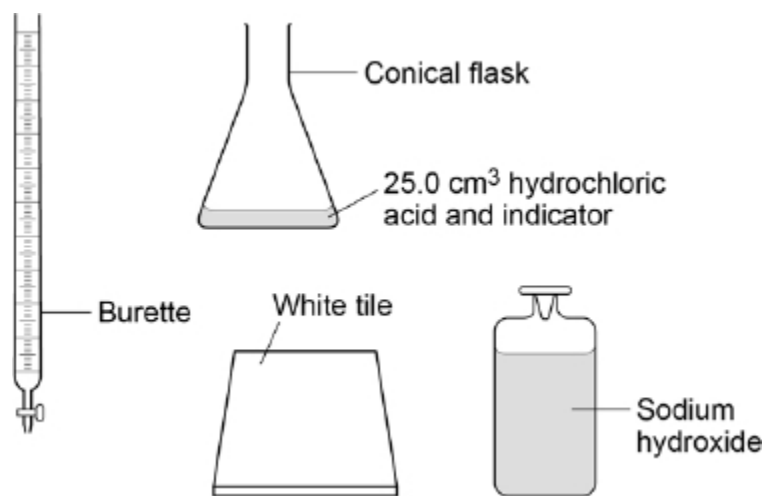
(2)

(Total 9 marks)

5.

Sodium hydroxide reacts with hydrochloric acid.

The diagram shows apparatus that can be used to find the volume of sodium hydroxide reacting with 25.0 cm³ hydrochloric acid.



(a) Describe a method to find the exact volume of sodium hydroxide that reacts with 25.0 cm³ of hydrochloric acid.

(6)

The reaction produces a solution of sodium chloride.

A student wants to obtain sodium chloride crystals from the sodium chloride solution.

This is the method used.

1. Add solid charcoal to the sodium chloride solution to remove the indicator colour.
2. Remove the solid charcoal.
3. Evaporate the solution to dryness over a Bunsen burner.

(b) Charcoal is not soluble in water.

Suggest a method the student could use to remove the solid charcoal in **Step 2**.

(1)

(c) The student obtains a powdery white solid.

Suggest how the student could improve **Step 3** of the method to obtain larger crystals instead of powder.

(1)

(Total 8 marks)

6.

This question is about metal oxides.

When sodium is heated in oxygen, sodium oxide is produced.

(a) Balance the equation for the reaction.



(1)

(b) Why is this an oxidation reaction?

(1)

- (c) Sodium oxide is added to water and shaken.
Universal indicator is added.
The pH of the solution is 14

What is the colour of the universal indicator?

Tick (✓) **one** box.

Green

Purple

Red

Yellow

(1)

- (d) Aluminium oxide reacts with hydrochloric acid to produce a salt.

What is the name of the salt produced?

Tick (✓) **one** box.

Aluminium chloride

Aluminium nitrate

Aluminium sulfate

Aluminium sulfide

(1)

A student investigates the solubility of four metal oxides and four non-metal oxides in water.

The student tests the pH of the solutions formed.

The table shows the student's results.

Type of oxide	Oxide	Solubility in water	pH of solution
Metal oxides	Sodium oxide	Soluble	14
	Calcium oxide	Soluble	10
	Magnesium oxide	Slightly soluble	9
	Zinc oxide	Insoluble	No solution formed
Non-metal oxides	Carbon dioxide	Soluble	5
	Sulfur dioxide	Soluble	2
	Phosphorus oxide	Soluble	1
	Silicon dioxide	Insoluble	No solution formed

The student makes two conclusions.

Conclusion 1: 'All metal oxides produce alkaline solutions.'

Conclusion 2: 'All non-metal oxides produce acidic solutions.'

(e) Explain why the student's conclusions are only partly correct.

Use information from the table above.

(4)

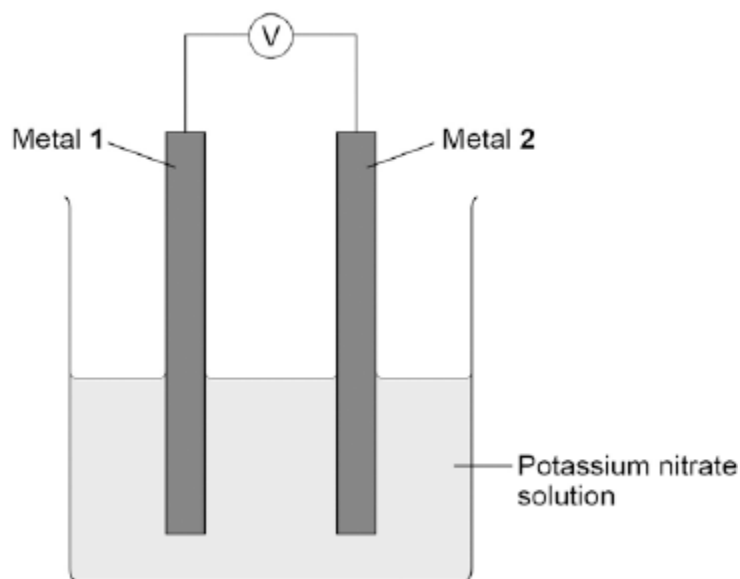
(f) Give an improved conclusion for metal oxides.

Use the table above.

(2)
(Total 9 marks)

7.

A student investigated simple cells using the apparatus shown in the figure below.

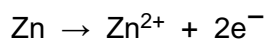


- If metal 2 is more reactive than metal 1 then the voltage measured is positive.
- If metal 1 is more reactive than metal 2 then the voltage measured is negative.
- The bigger the difference in reactivity of the two metals, the larger the voltage produced.

The student's results are shown in the table below.

Metal 1 \ Metal 2	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

- (a) 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)

(b) Look at the table above.

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

Give a reason for your answer.

Metal _____

Reason _____

(2)

(c) 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)

(d) 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)

- (e) Write the **two** half equations for the reactions that occur at the electrodes in a hydrogen fuel cell.

(2)

(Total 9 marks)

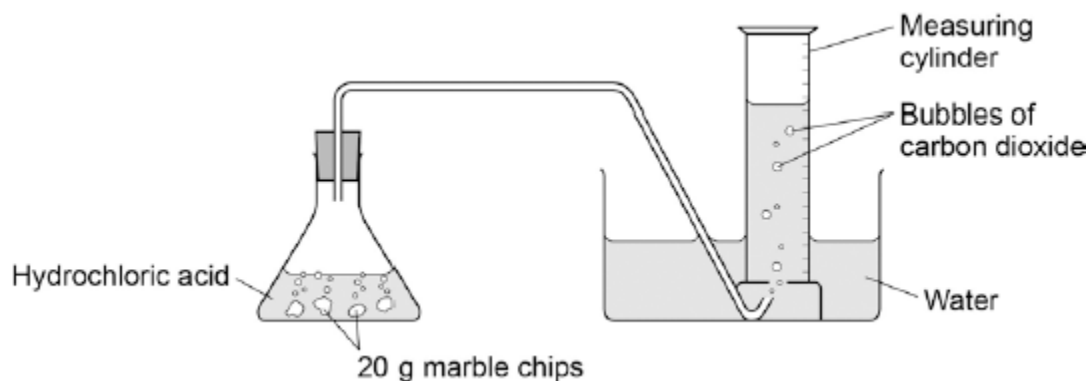
8.

Marble chips are mainly calcium carbonate (CaCO_3).

A student investigated the rate of reaction between marble chips and hydrochloric acid (HCl).

Figure 1 shows the apparatus the student used.

Figure 1



- (a) Complete and balance the equation for the reaction between marble chips and hydrochloric acid.



(2)

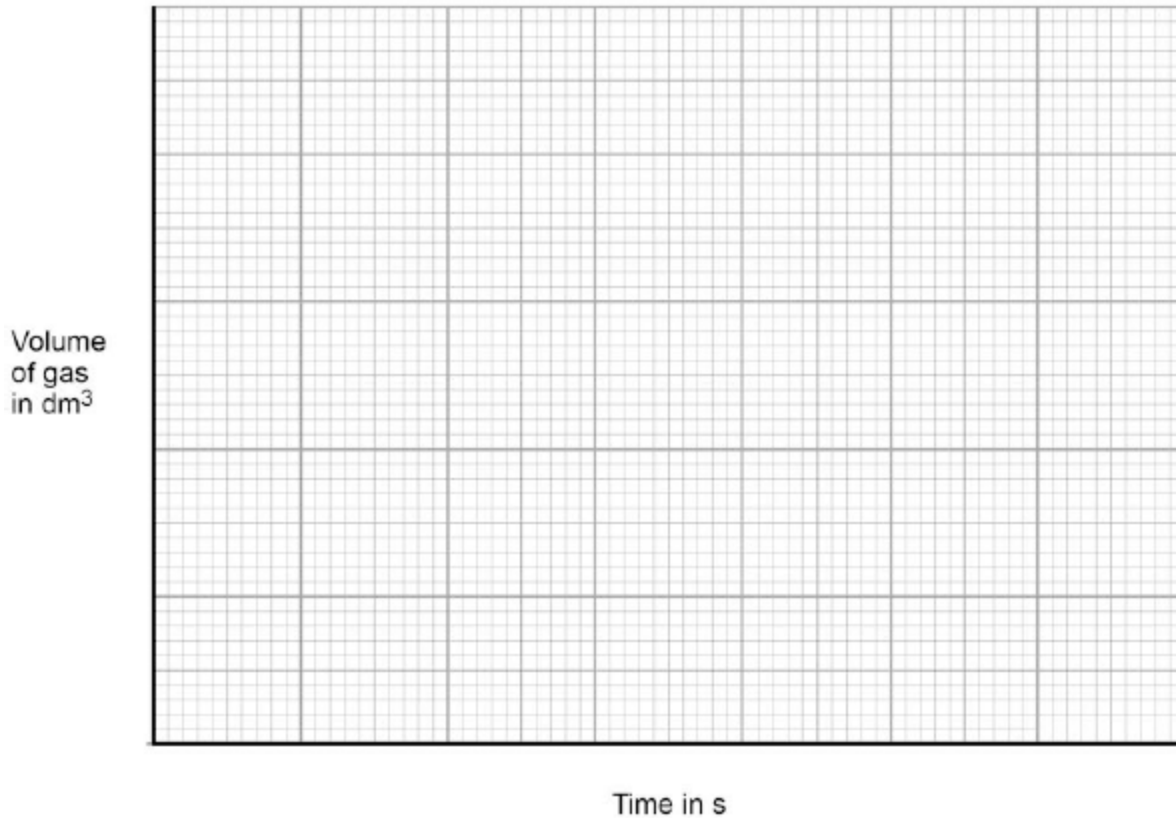
(b) The table below shows the student's results.

Time in s	Volume of gas in dm ³
0	0.000
30	0.030
60	0.046
90	0.052
120	0.065
150	0.070
180	0.076
210	0.079
240	0.080
270	0.080

On **Figure 2**:

- Plot these results on the grid.
- Draw a line of best fit.

Figure 2



(4)

- (c) Sketch a line on the grid in **Figure 2** to show the results you would expect if the experiment was repeated using 20 g of smaller marble chips.

Label this line **A**.

(2)

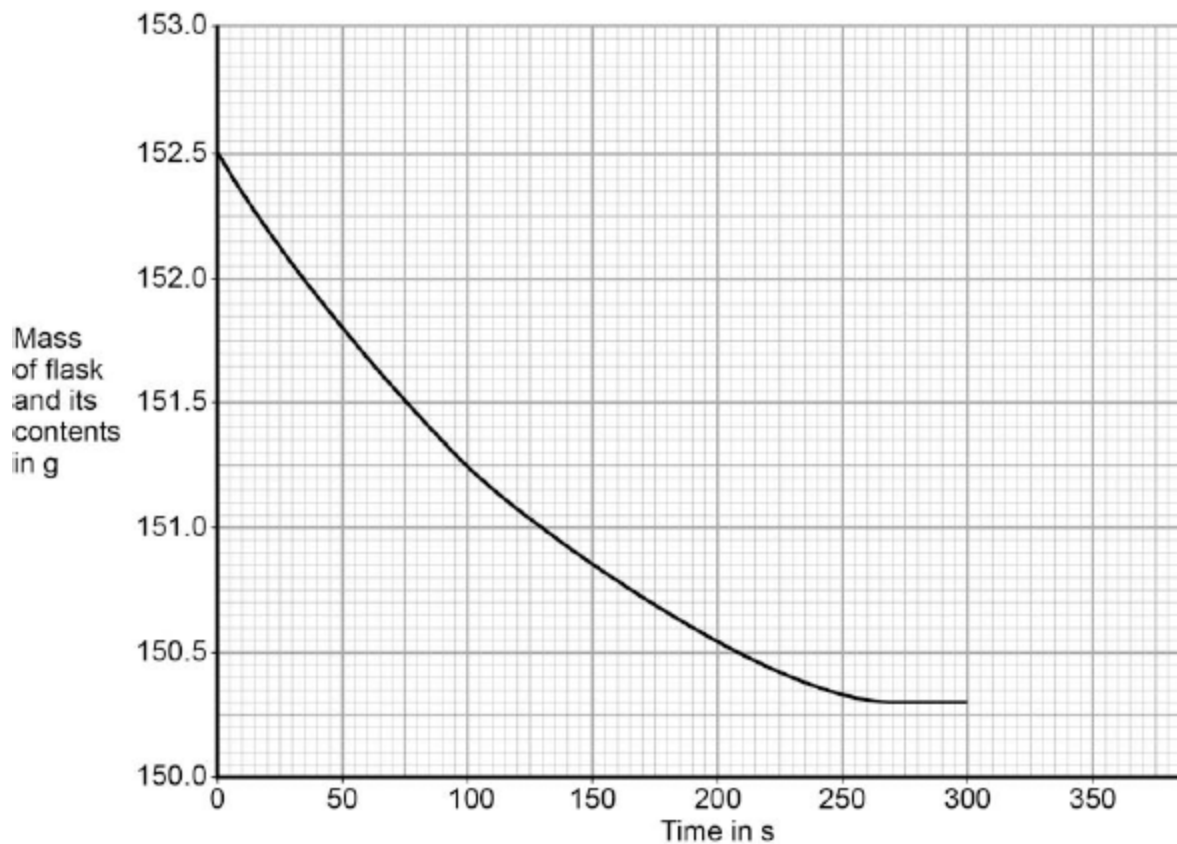
- (d) Explain, in terms of particles, how and why the rate of reaction changes during the reaction of calcium carbonate with hydrochloric acid.

(4)

(e) Another student investigated the rate of reaction by measuring the change in mass.

Figure 3 shows the graph plotted from this student's results.

Figure 3



Use **Figure 3** to calculate the mean rate of the reaction up to the time the reaction is complete.

Give your answer to three significant figures.

Mean rate of reaction = _____ g / s

(4)

(f) Use **Figure 3** to determine the rate of reaction at 150 seconds.

Show your working on **Figure 3**.

Give your answer in standard form.

Rate of reaction at 150 s = _____ g / s

(4)

(Total 20 marks)

Mark schemes

1.

(a) any **one** from:

- metal
- (metal) hydroxide
allow ammonium hydroxide
- (metal) carbonate
allow ammonium carbonate
- alkali
allow soluble base
allow ammonia

1

allow named example
allow correct formula
ignore base

(b) $\text{Ca}(\text{NO}_3)_2$

allow $\text{Ca}^{2+}(\text{NO}_3^-)_2$

1

(c) **Level 3:** The method would lead to the production of a valid outcome. All key steps are identified and logically sequenced.

5–6

Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced.

3–4

Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.

1–2

No relevant content

0

Indicative content

- use magnesium oxide and sulfuric acid
- add sulfuric acid to a beaker
- warm sulfuric acid
- add magnesium oxide
- stir
- continue adding until magnesium oxide is in excess

- filter
- using a filter paper and funnel
- to remove excess magnesium oxide

- heat solution in an evaporating basin
- to crystallisation point
- leave to crystallise
- pat dry with filter paper

credit may be given for diagrams

[8]

2.

(a) chlorine is toxic

- allow carbon monoxide is toxic*
- allow poisonous for toxic*
- ignore harmful / deadly / dangerous*
- allow a poisonous gas is used / produced*
- allow titanium chloride is corrosive*

1

(b) any **one** from:

- very exothermic reaction
 - allow explosive*
 - allow violent reaction*
 - ignore vigorous reaction*
 - ignore sodium is very reactive*
- produces a corrosive solution
 - allow caustic for corrosive*
 - ignore alkaline*
- produces hydrogen, which is explosive / flammable
 - allow flames produced*
 - ignore sodium burns*

1

- (c) argon is unreactive / inert
allow argon will not react (with reactants / products / elements)
 1
- oxygen (from air) would react with sodium / titanium
or
 water vapour (from air) would react with sodium / titanium
allow elements / reactants / products for sodium / titanium
 1
- (d) metal chlorides are usually ionic
allow titanium chloride is ionic
 1
- (so)(metal chlorides) are solid at room temperature
or
 (so)(metal chlorides) have high melting points
allow titanium chloride for metal chlorides
 1
- (because) they have strong (electrostatic) forces between the ions
ignore strong ionic bonds
- or**
 (but) must be a small molecule or covalent
allow molecular
 1
- allow alternative approach:
 titanium chloride must be covalent **or** has small molecules (1)
 with weak forces between molecules
 do **not** accept bonds unless intermolecular bonds(1)
 (but) metal chlorides are usually ionic (1)*
- (e) sodium (atoms) lose electrons
*do **not** accept references to oxygen*
 1
- (f) $\text{Na} \rightarrow \text{Na}^+ + \text{e}^-$
*do **not** accept e for e⁻*
 1

(g) (M_r of TiCl_4 =) 190

$$\text{(moles Na} = \frac{20\,000}{23} \text{ =) } 870 \text{ (mol) } *$$

1

$$\text{(moles TiCl}_4 \text{ =} \frac{40\,000}{190} \text{ =) } 211 \text{ (mol) } *$$

1

allow 1 mark for 0.870 mol Na **and 0.211 mol TiCl_4*

allow use of incorrectly calculated M_r from step 1

either

(sodium is in excess because) 870 mol Na is more than the 844 mol needed

or

(because) 211 mol TiCl_4 is less than the 217.5 mol needed

the mark is for correct application of the factor of 4

other correct reasoning showing, with values of moles

or mass, an excess of sodium or insufficient TiCl_4 is

acceptable

allow use of incorrect number of moles from steps 2 and

/ or 3

1

alternative approaches:

approach 1:

(M_r of TiCl_4 =) 190(1)

(40 kg TiCl_4 needs)

$$\frac{40}{190} \times 4 \times 23 \text{ (kg Na) (1)}$$

(=) 19.4 (kg) (1)

so 20 kg is an excess (1)

approach 2:

(M_r of TiCl_4 =) 190(1)

(20 kg Na needs)

$$\frac{20}{4 \times 23} \times 190 \text{ (kg TiCl}_4 \text{) (1)}$$

(=) 41.3 (kg) (1)

so 40 kg is not enough (1)

(h) (actual mass \Rightarrow) $\frac{92.3}{100} \times 13.5$

or

(actual mass \Rightarrow) 0.923×13.5

1

$= 12.5$ (kg)

allow 12 / 12.46 / 12.461 / 12.4605 (kg)

1

an answer 12.5 (kg) scores 2 marks

[15]

3.

(a) (strong because) completely ionised (in aqueous solution)

ignore pH

allow dissociated for ionised

*do **not** accept hydrogen is ionising*

*do **not** accept H^+ are ionised*

1

(dilute because) small amount of acid per unit volume

ignore low concentration

1

(b) 5.0

allow 5

1

(c) (titre):
chooses titrations 3, 4, 5 1

average titre = 22.13 (cm³)

*allow average titre = 22.13(3...) (cm³)
allow a correctly calculated average from an incorrect
choice of titrations*

1

(calculation):

(moles NaOH =

$$\frac{22.13}{1000} \times 0.105 = 0.002324)$$

allow use of incorrect average titre from step 2

1

(moles H₂SO₄ =

$$\frac{1}{2} \times 0.002324 = 0.001162$$

allow use of incorrect number of moles from step 3

1

(concentration =

$$\frac{0.001162}{25} \times 1000)$$

$$= 0.0465 \text{ (mol/dm}^3\text{)}$$

allow use of incorrect number of moles from step 4

1

alternative approach for step 3, step 4 and step 5

$$\frac{2}{1} = \frac{22.13 \times 0.105}{25.0 \times \text{conc. H}_2\text{SO}_4} \quad (1)$$

(concentration H₂SO₄ =)

$$\frac{22.13 \times 0.105}{25.0 \times 2}$$

$$= 0.0465 \text{ (mol/dm}^3\text{)} \quad (1)$$

*an answer of 0.046473 or 0.04648 correctly rounded to
at least 2 sig figs scores marking points 3, 4 and 5*

*an answer of 0.092946 or 0.09296 or 0.185892 or
0.18592 correctly rounded to at least 2 sig figs scores
marking points 3 and 5*

*an incorrect answer for one step does **not** prevent
allocation of marks for subsequent steps*

(d) pipette measures a fixed volume (accurately) 1

(but) burette measures variable volume

allow can measure drop by drop

1

(e) $(\text{moles} =) \frac{30}{1000} \times 0.105$

or 0.00315 (mol)

or

(mass per $\text{dm}^3 =$) 0.105×40

or 4.2 (g)

1

$(\text{mass} = \frac{30}{1000} \times 0.105 \times 40)$

= 0.126 (g)

1

an answer of 0.126 (g) scores 2 marks

an answer of 126(g) scores 1 mark

*an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps*

[12]

4.

(a) **(diagram)**

complete circuit with power supply

1

test solution in beaker or other appropriate apparatus

1

electrodes

allow carbon, platinum or inert electrodes

1

(independent variable)

salt solutions (with different metal ions)

1

(observation)

solid / metal deposit on the negative electrode

1

(b) (sometimes) hydrogen is produced

1

(because) the metal is more reactive than hydrogen

1

(c) chlorine

1

oxygen

1

[9]

5.	(a) fill burette with sodium hydroxide	1
	add sodium hydroxide from the burette to the hydrochloric acid and indicator	1
	stop when colour changes	1
	measure volume used from burette	1
	plus any two from:	
	• stand flask on white tile	
	• swirl	
	• add dropwise near the endpoint	
	• repeat	2
	(b) filtration	1
	(c) evaporate some of the solution and leave to cool	
	or	
	<i>heat with an electric heater</i>	1
		[8]
6.	(a) $4 \text{ Na} + \text{O}_2 \rightarrow 2\text{Na}_2\text{O}$	
	<i>allow multiples</i>	1
	(b) (sodium) gains oxygen	1
	(c) purple	1
	(d) aluminium chloride	1

- (e) **Level 2 (3-4 marks):**
Relevant reasons are identified, given in detail and logically linked to form a clear account.

Level 1 (1-2 marks):

Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.

Level 0

No relevant content

Indicative content

conclusion 1

- pH values above 7 are alkaline
- sodium oxide, calcium oxide and magnesium oxide do form alkaline solutions (so correct for those)
- not all metal oxides form solutions (so incorrect for zinc oxide)

conclusion 2

- pH values below 7 are acidic
- carbon dioxide, sulfur dioxide and phosphorus oxide do form acidic solutions (so correct for those)
- not all non-metal oxides form solutions (so incorrect for silicon oxide)]

4

- (f) metal oxides produce alkaline solutions if they dissolve in water

allow 1 mark for most metal oxides produce alkaline solutions

2

[10]

7.

- (a) (zinc has) lost electron(s)

accept loss of electrons

1

- (b) copper is the least reactive

1

because it gave the most negative voltage when it was metal 2

or

it gave the biggest voltage with chromium

or

it gave the most positive voltage when it was metal 1

1

- (c) -0.7 V

1

The voltage with chromium and copper is 1.2

accept use of other cell pairings such as tin with copper and tin with iron

1

The voltage with chromium and iron is 0.5 and copper is less reactive (than iron)

1

(d) hydrogen + oxygen = water

1

(e) $\text{H}_2 \rightarrow 2\text{H}^+ + 2\text{e}^-$

1

$\text{O}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}$

1

[9]

8.

(a) $\text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O} + \text{CO}_2$

2

allow 1 mark for correct formulae

(b) sensible scales, using at least half the grid for the points

1

all points correct

± ½ small square

allow 1 mark if 8 or 9 of the points are correct

2

best fit line

1

(c) steeper line to left of original

1

line finishes at same overall volume of gas collected

1

(d) acid particles used up

allow marble / reactant used up

1

so concentration decreases

allow surface area of marble decreases

1

so less frequent collisions / fewer collisions per second

do not accept fewer collisions unqualified

1

so rate decreases / reaction slows down

1

(e) mass lost of 2.2 (g)

1

time taken of

270 s

allow values in range 265 – 270

1

$$\frac{2.2}{270} = 0.00814814$$

allow ecf for values given for mass and time

1

0.00815 (g / s)

or

8.15×10^{-3}

allow 1 mark for correct calculation of value to 3 sig figs

accept 0.00815 or 8.15×10^{-3} with no working shown for 4 marks

1

(f) correct tangent

1

eg 0.35 / 50

1

0.007

allow values in range of 0.0065 – 0.0075

1

7×10^{-3}

1

accept 7×10^{-3} with no working shown for 4 marks

[20]