Name: _____

Class: _____

Date: _____

Chemical Changes part 2 AQA Triple Chemistry

Time: **76 minutes**

Marks: **72 marks**

Comments:

1. This question is about electrolysis.

Aluminium is manufactured by electrolysing a molten mixture of aluminium oxide (Al_2O_3) and cryolite (Na_3AlF_6).

(a) Complete the half equation for the reaction occurring at the negative electrode.

$$Al^{3+} + \_\_\_\_\_e^- \rightarrow Al$$

(1)

(b) Cryolite contains Na^+ ions as well as Al^{3+} ions.

Suggest **one** reason why sodium is **not** a product of the electrolysis.

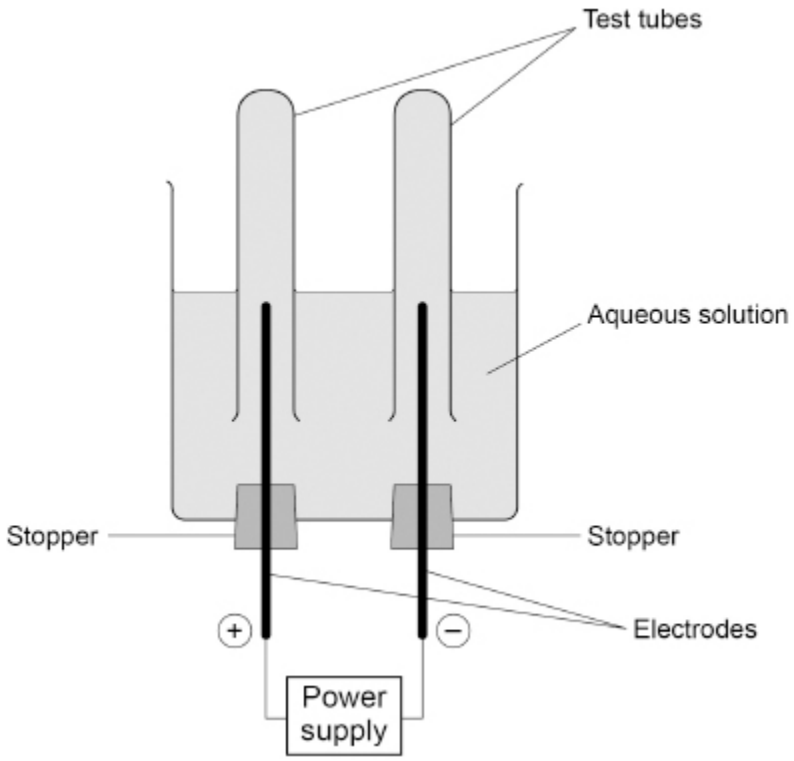
_____

_____

(1)

A student investigated the electrolysis of an aqueous solution of a different compound.

The figure below shows the apparatus.



Hydrogen was produced at the negative electrode and oxygen was produced at the positive electrode.

(c) Explain how oxygen was produced from water during the electrolysis of this aqueous solution.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(d) The student compared the volumes of the two gases collected.

How can the student change the apparatus in the figure above to compare the volumes of the two gases produced more accurately?

Give **one** reason for your answer.

Change _____

_____

Reason _____

_____

(2)

(e) The overall equation for the reaction is:

$$2\ H_2O(l) \rightarrow 2\ H_2(g) + O_2(g)$$

What is the volume of oxygen produced when 20 cm^3 of hydrogen has been produced?

Tick (✓) **one** box.

10 cm^3 ☐ 20 cm^3 ☐ 30 cm^3 ☐ 40 cm^3 ☐

(1)

(Total 9 marks)

2. This question is about displacement reactions.

Iron is extracted from iron oxide by a displacement reaction with carbon.

The equation for the reaction is:

$$Fe_2O_3 + 3\ C \rightarrow 2\ Fe + 3\ CO$$

(a) Which substance in the equation is reduced?

Give **one** reason for your answer.

Answer in terms of oxygen.

Substance reduced _____

Reason _____

_____

(2)

(b) Which expression shows how to calculate the mass of carbon needed to produce 1 mole of iron from iron oxide?

Relative atomic mass (A_r): C = 12

Tick (✓) **one** box.

$\frac{1}{3} \times 12\ g$ ☐

$\frac{3}{2} \times 12\ g$ ☐

$1 \times 12\ g$ ☐

$3 \times 12\ g$ ☐

(1)

A student investigated displacement reactions of four different metals represented by **A**, **B**, **C** and **D**.

A, **B**, **C** and **D** are **not** the actual chemical symbols for the metals.

The student:

- added each metal to aqueous solutions of the metal nitrates
- observed whether a reaction took place.

The table below shows information about three of the reaction mixtures.

Reaction	Metal	Metal nitrate solution	Equation
1	**A**	**B**NO_3	**A** + 2**B**NO_3 → 2**B** + **A**$(NO_3)_2$
2	**C**	**A**$(NO_3)_2$	2**C** + 3**A**$(NO_3)_2$ → 3**A** + 2**C**$(NO_3)_3$
3	**C**	**D**$(NO_3)_2$	no reaction

(c) The ionic equation for **Reaction 1** is:

$$\mathbf{A} + 2\ \mathbf{B}^{+} \rightarrow 2\ \mathbf{B} + \mathbf{A}^{2+}$$

Why is this a redox reaction?

Tick (✓) **one** box.

A gains electrons and $\mathbf{B}^{+}$ loses electrons. ☐

A loses electrons and $\mathbf{B}^{+}$ gains electrons. ☐

Both **A** and $\mathbf{B}^{+}$ gain electrons. ☐

Both **A** and $\mathbf{B}^{+}$ lose electrons. ☐

(1)

(d) Which of the four metals has the greatest tendency to form positive ions?

Use the table above.

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

(e) The nitrate ion has the formula NO_3^-

Which of the four metals could be aluminium?

Explain your answer.

Use the table above.

Metal _____

Explanation _____

_____

_____

_____

(3)

(f) Metal **X** is extracted from an oxide of metal **X** by reaction with hydrogen.

The equation for the reaction is:

$$\mathbf{X}O_3 + 3\ H_2 \rightarrow \mathbf{X} + 3\ H_2O$$

The percentage atom economy for obtaining metal **X** by this method is 77.3%.

Calculate the relative atomic mass (*A*r) of metal **X**.

Relative atomic masses (A_r): H = 1 O = 16

_____

_____

_____

_____

_____

_____

_____

_____

Relative atomic mass (A_r) = _____

(4)

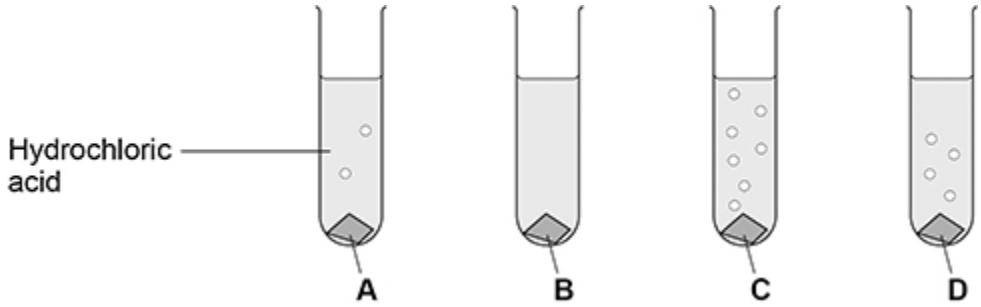
(Total 12 marks)

3. This question is about acids.

A student added four metals, **A**, **B**, **C** and **D** to hydrochloric acid.

Figure 1 shows the rate of bubbling in each tube.

Figure 1



Use **Figure 1** to answer parts (a) and (b).

(a) Which metal is copper?

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

(b) Which metal is the most reactive?

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

(c) A metal oxide reacts with an acid to produce zinc sulfate and water.

Name the metal oxide and the acid used in this reaction.

Name of metal oxide _____

Name of acid _____

(2)

(d) Universal indicator is used to measure the pH of a solution.

Draw **one** line from each pH to the colour of universal indicator in a solution with that pH.

pH	Colour of universal indicator
	Blue
1	Green
	Purple
7	Red
	Yellow

(2)

A student reacts an acid with an alkali in a titration.

(e) What is the type of reaction when an acid reacts with an alkali?

Tick (✓) **one** box.

- Combustion ☐
- Decomposition ☐
- Neutralisation ☐

(1)

(f) **Figure 2** shows a piece of equipment used to measure the volume of the acid in the titration.

Figure 2

What is the name of this piece of equipment?

Tick (✓) **one** box.

Burette ☐

Pipette ☐

Syringe ☐

Tube ☐

(1)

(Total 8 marks)

4. This question is about zinc and compounds of zinc.

A student produces pure crystals of zinc chloride by reacting zinc oxide with hydrochloric acid.

The equation for the reaction is:

$$ZnO(s) + 2\ HCl(aq) \rightarrow ZnCl_2(aq) + H_2O(l)$$

(a) The student adds zinc oxide to hydrochloric acid until the zinc oxide is in excess.

Give **one** observation that the student could make to show that the zinc oxide is in excess.

_____

_____

(1)

(b) Why is excess zinc oxide used rather than excess hydrochloric acid?

_____

_____

(1)

(c) Name **one other** compound that the student could add to hydrochloric acid to produce zinc chloride.

_____

_____

(1)

(d) Describe how the student should obtain crystals of zinc chloride from a solution of zinc chloride.

_____

_____

_____

_____

(2)

Zinc chloride is also produced in a displacement reaction between zinc and copper chloride solution.

The equation for the reaction is:

$$Zn + CuCl_2 \rightarrow ZnCl_2 + Cu$$

(e) Complete the ionic equation for this reaction.

$$Zn + \_\_\_\_\_ \rightarrow Zn^{2+} + \_\_\_\_\_$$

(1)

(f) Why is zinc described as being oxidised in this reaction?

_____

_____

(1)

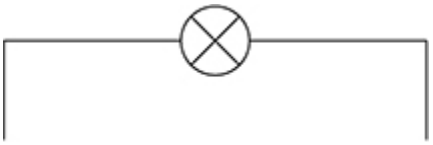
(g) Zinc and copper can be used with another substance to produce electricity.

Complete the figure below to show how zinc, copper and another substance can be used to light a lamp.

Label:

- zinc
- copper
- the other substance used.

The symbol  represents the lamp.



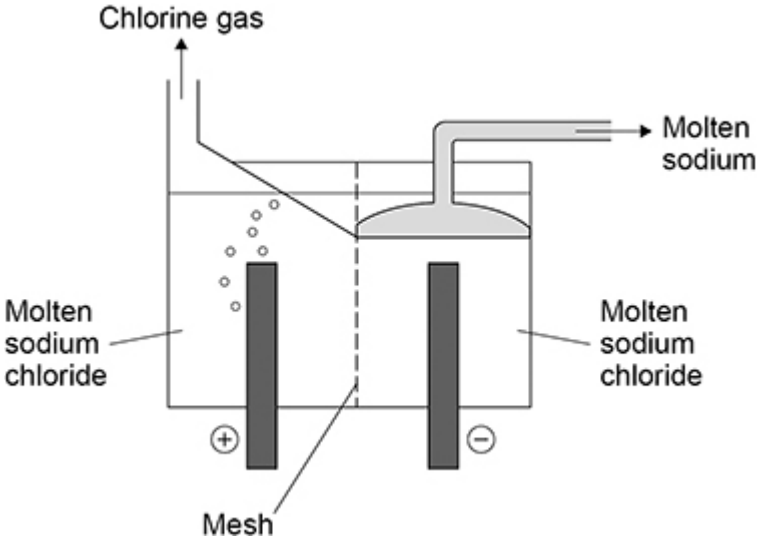
(3)

(Total 10 marks)

5. This question is about electrolysis.

Molten sodium chloride is electrolysed in an industrial process to produce sodium.

The figure below shows a simplified version of the electrolysis cell used.



(a) Which is the correct half equation for the production of sodium?

Tick (✓) **one** box.

$Na + e^- \rightarrow Na^+$ ☐

$Na \rightarrow Na^+ + e^-$ ☐

$Na^+ + e^- \rightarrow Na$ ☐

$Na^+ \rightarrow Na + e^-$ ☐

(1)

A mesh is used to keep the products of the electrolysis apart.

(b) Suggest **one** reason why the products of the electrolysis must be kept apart.

_____

_____

(1)

(c) Which type of particle passes through the mesh in the electrolysis of molten sodium chloride?

Tick (✓) **one** box.

Atom ☐

Electron ☐

Ion ☐

Molecule ☐

(1)

Aqueous sodium chloride solution is electrolysed in a different industrial process.

Two gases and an alkaline solution are produced.

(d) Which **two** ions are present in aqueous sodium chloride solution in addition to sodium ions and chloride ions?

1 _____

2 _____

(2)

(e) Name the alkaline solution produced.

_____

(1)

(f) Explain how the alkaline solution is produced.

You should refer to the processes at the electrodes.

_____

_____

_____

_____

_____

_____

(3)

(Total 9 marks)

6. This question is about acids and alkalis.

(a) Which ion do acids produce in aqueous solution?

Tick (✓) **one** box.

H^+ ☐ OH^- ☐ O^{2-} ☐

(1)

(b) Acids react with alkalis.

What is the name of this type of reaction?

Tick (✓) **one** box.

Decomposition ☐

Electrolysis ☐

Neutralisation ☐

Redox ☐

(1)

(c) Balance the equation for the reaction between sulfuric acid and potassium hydroxide.

$$H_2SO_4 + \_\_\_\_ KOH \rightarrow K_2SO_4 + \_\_\_\_ H_2O$$

(1)

(d) Universal indicator turns purple in potassium hydroxide solution.

What is the pH of the solution?

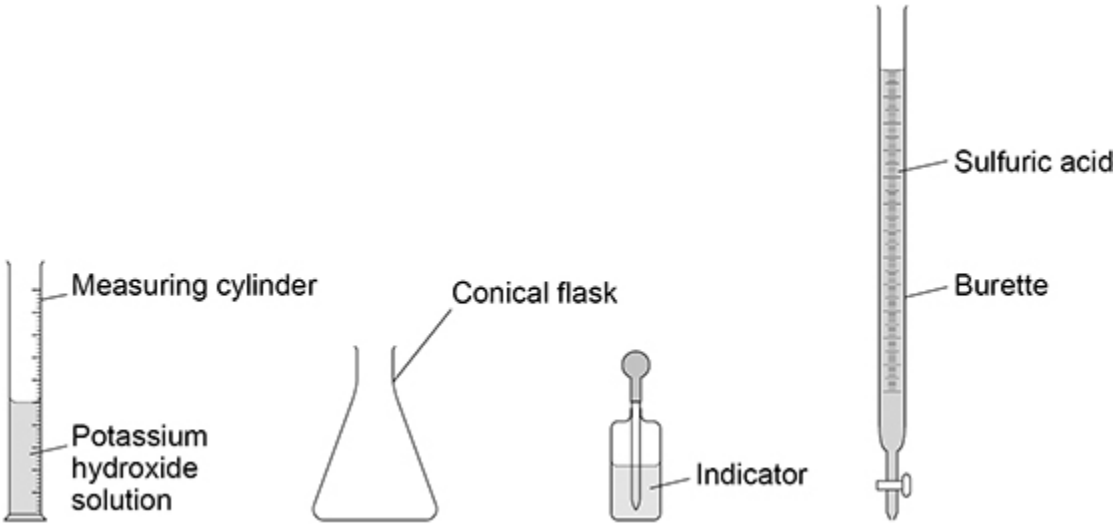
Tick (✓) **one** box.

1 ☐ 4 ☐ 7 ☐ 14 ☐

(1)

A student does a titration to find the volume of sulfuric acid that reacts with 25 cm^3 of potassium hydroxide solution.

The figure below shows the equipment used.



(e) The 25 cm^3 of potassium hydroxide solution is measured with the measuring cylinder.

Which piece of equipment could the student use to measure the 25 cm^3 of potassium hydroxide solution more accurately?

Tick (✓) **one** box.

Beaker ☐

Evaporating basin ☐

Pipette ☐

Test tube ☐

(1)

(f) Describe how the student would use the equipment in the figure above to complete the titration.

(5)

(Total 10 marks)

7. This question is about acids and alkalis.

(a) Explain why the pH of an acid depends on:

- the strength of the acid
- the concentration of the acid.

(4)

(b) A student titrated 25.00 cm^3 of hydrochloric acid with 0.100 mol/dm^3 barium hydroxide solution.

The table below shows the results.

Titration number	1	2	3	4	5
Volume of barium hydroxide solution used in cm^3	23.90	23.45	23.55	23.55	23.45

The student calculated the volume of barium hydroxide solution to be used in the titration calculation as 23.50 cm^3.

Explain why the student used a volume of 23.50 cm^3 of barium hydroxide solution in the titration calculation.

_____

_____

_____

_____

(2)

(c) 25.00 cm^3 of the hydrochloric acid reacted with 23.50 cm^3 of the 0.100 mol/dm^3 barium hydroxide solution.

The equation for the reaction is:

$$2\ HCl(aq) + Ba(OH)_2(aq) \rightarrow BaCl_2(aq) + 2\ H_2O(l)$$

Calculate the concentration of the hydrochloric acid in mol/dm^3.

_____

_____

_____

_____

_____

_____

_____

_____

Concentration of the hydrochloric acid = _____ mol/dm^3

(4)

Another student titrated sulfuric acid with barium hydroxide solution.

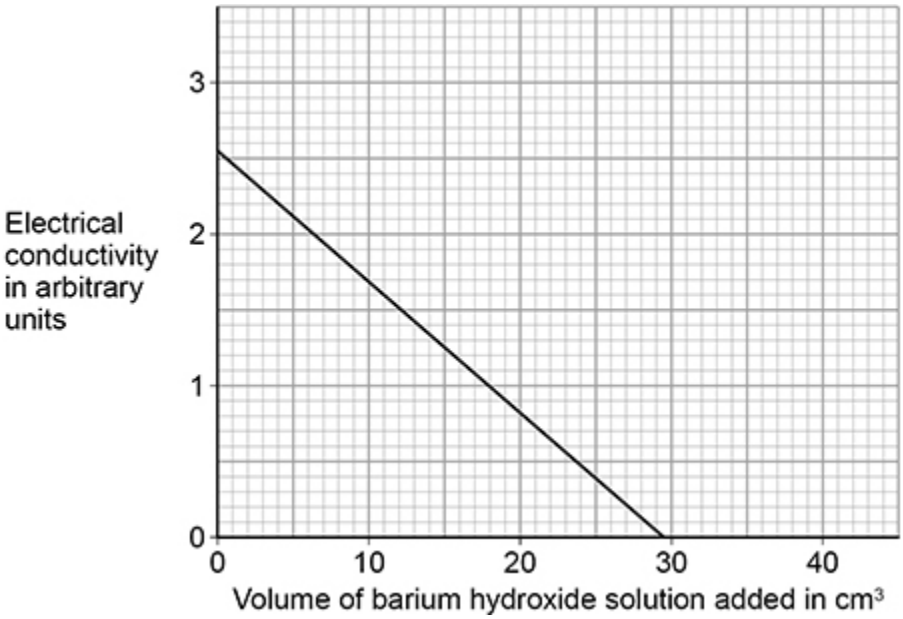
The equation for the reaction is:

$$H_2SO_4(aq) + Ba(OH)_2(aq) \rightarrow BaSO_4(s) + 2\ H_2O(l)$$

The student measured the electrical conductivity of the mixture during the titration.

The better a conductor, the higher the electrical conductivity value.

The figure below shows the results.



(d) Explain why the electrical conductivity of the mixture was zero when the sulfuric acid had just been neutralised.

Use the equation for the reaction.

Refer to ions in your answer.

_____

_____

_____

_____

_____

_____

(3)

(e) The student then added a further 10 cm^3 of barium hydroxide solution.

The electrical conductivity of the mixture increased.

Give **one** reason why.

_____

_____

(1)

(Total 14 marks)

1.

(a) Al^{3+} + **3** e^- → Al

allow multiples

1

(b) sodium is more reactive than aluminium

1

(c) water (molecules) break down

1

(to) produce (H^+ and) OH^- (ions)

1

(so) OH^- (ions) are attracted / move to the positive electrode

1

(where) OH^- (ions) are discharged / oxidised to give oxygen (molecules)

allow (where) OH^- (ions) lose electrons to give oxygen (molecules)

1

allow hydroxide ions for OH^- throughout

(d) (change)
use measuring cylinders (instead of test tubes)

allow (inverted) burettes for measuring cylinders

allow gas syringes for measuring cylinders

1

(reason)
because there is a scale (on the measuring cylinders)

allow measuring cylinder(s) measure volume

1

(e) 10 cm^3

1

[9]

2.

(a) (substance reduced) Fe_2O_3

allow iron oxide

1

(reason)
(Fe_2O_3) loses oxygen

MP2 is dependent upon MP1 being awarded

ignore Fe^{3+} gains electrons

1

(b) $\frac{3}{2} \times 12g$

1

(c) **A** loses electrons and $\mathbf{B}^{+}$ gains electrons

1

(d) **D**

1

(e) (metal) **C**

1

(explanation) aluminium forms ions with a charge 3+

allow aluminium forms Al^{3+} (ions)

1

(so) 3 nitrate ions are needed for 1 aluminium ion

allow (so) 3 nitrate ions are needed to balance the 3+ charge on 1 aluminium (ion)

1

(f) (percentage atom economy =)

$$\frac{A_r\mathbf{X}}{A_r\mathbf{X} + 54} \times 100 = 77.3$$

1

100 $A_r\mathbf{X}$ = 77.3 ($A_r\mathbf{X}$ + 54)

allow $A_r\boldsymbol{X}$ = 0.773 ($A_r\boldsymbol{X}$ + 54)

allow correct use of an incorrectly determined value of the M_r of the non-useful reactant atoms

1

22.7 $A_r\mathbf{X}$ = 4174.2

allow 0.227 $A_r\boldsymbol{X}$ = 41.742

1

$A_r\mathbf{X}$ = 184

allow 183.8854626 correctly rounded to at least three significant figures

1

alternative approach 1:

($3M_r$ H_2O = (3 × 16) + (6 × 1) =) 54
and (percentage = 100 - 77.3 =) 22.7% (1)

(total M_r of reactants =)
$\frac{100}{22.7} \times 54$ (1)

allow correct use of an incorrectly determined value for $3M_r$ H_2O and/or percentage of unwanted products

= 238 (1)

(A_r**X** = 238 - 54)
or
$\left(A_r\mathbf{X} = 238 \times \frac{77.3}{100}\right)$
= 184 (1)

allow correct use of an incorrectly determined value of total M_r of reactants and/or value for $3M_r$ H_2O

allow 183.8854626 correctly rounded to at least three significant figures

alternative approach 2:

($3M_r$ H_2O = (3 × 16) + (6 × 1) =) 54
and (percentage = 100 - 77.3 =) 22.7% (1)

$\left(\frac{1}{22.7} \times 54 =\right)$ 2.3788546 (1)

allow correct use of an incorrectly determined value for $3M_r$ H_2O and/or percentage of unwanted products

2.3788546 × 77.3 (1)

allow correct use of an incorrectly determined value for 1% of the total M_r of reactants

= 184 (1)

allow 183.8854626 correctly rounded to at least three significant figures

[12]

3. (a) **B**

1

(b) **C**

1

(c) zinc (oxide)

allow ZnO

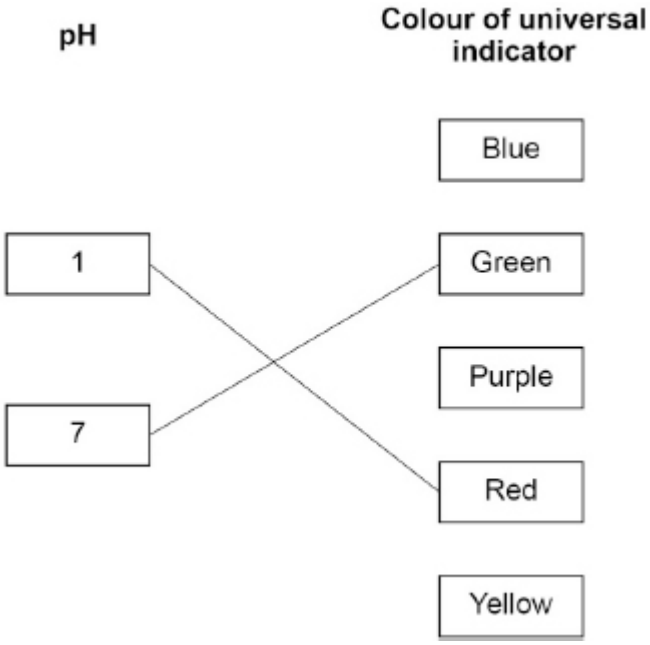
1

sulfuric (acid)

allow H_2SO_4

1

(d)



*do **not** accept more than one line from a box on the left*

2

(e) neutralisation

1

(f) burette

1

[8]

4. (a) (zinc oxide) solid remaining

allow (zinc oxide) solid no longer disappears

ignore references to colour / effervescence

1

(b) (excess) zinc oxide can be filtered off

allow converse statement for hydrochloric acid

allow separation / removal of (excess) zinc oxide is easier

ignore to ensure all the (hydrochloric) acid is used up

1

(c) any **one** from:

- zinc hydroxide

  allow $Zn(OH_2)$

- zinc carbonate

  allow $ZnCO_3$

1

(d) heat (the solution) until crystallisation point is reached

allow heat (the solution) until crystals start to form

allow heat (the solution) to reduce the volume

allow heat (the solution) to evaporate (some of the water)

1

leave the solution (to cool / crystallise)

1

*if no other mark is awarded allow **1** mark for heat the solution to dryness*

(e) $Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$

ignore state symbols

1

(f) zinc (atoms) lose (2) electrons

*do **not** accept references to oxygen*

1

(g) (a diagram showing)

solution in a container

ignore labels

1

zinc electrode
and
copper electrode
both inserted into solution

ignore polarities on electrodes

1

complete circuit that would function as an electrochemical cell including a labelled electrolyte

allow a named electrolyte in solution

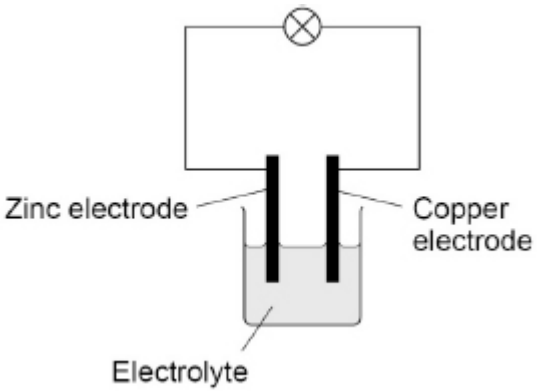
allow a named molten electrolyte

*do **not** accept cell / battery in external circuit*

*do **not** accept a wire between the electrodes*

1

an answer of



scores **3** marks

ignore voltmeter / ammeter regardless of location

[10]

5. (a) $Na^+ + e^- \rightarrow Na$

1

(b) so the products do not react (to reform sodium chloride)

1

(c) ion

1

(d) hydrogen / H^+ (ions)

1

hydroxide / OH^- (ions)

1

(e) sodium hydroxide

allow NaOH

1

(f) sodium ions and hydroxide ions are left (in solution)

1

(because) hydrogen ions are discharged / reduced (at the negative electrode to form hydrogen)

allow (because) hydrogen ions gain electrons (at the negative electrode to form hydrogen)

allow (because at the negative electrode) $2\ H^+ + 2\ e^- \rightarrow H_2$

1

(and because) chloride ions are discharged / oxidised (at the positive electrode to form chlorine)

allow (and because) chloride ions lose electrons (at the positive electrode to form chlorine)

allow (and because at the positive electrode) $2\ Cl^- \rightarrow Cl_2 + 2\ e^-$

1

[9]

6. (a) H^+

1

(b) neutralisation

1

(c) $H_2SO_4 + 2\ KOH \rightarrow K_2SO_4 + 2\ H_2O$

allow multiples

1

(d) 14

1

(e) pipette

1

(f) add potassium hydroxide (solution) to the (conical) flask

1

add (a few drops of) indicator

1

add the (sulfuric) acid (from the burette)

1

until the colour (of the indicator) changes

1

read the volume from the burette

1

[10]

7. (a) **Level 3:** Relevant points (reasons / causes) are identified, given in detail and logically linked to form a clear account.

3–4

Level 2: Relevant points (reasons / causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.

1–2

No relevant content

0

Indicative content

General principle

- pH depends on H^+ ion concentration
- the higher the concentration of H^+ ions the lower the pH

Strength

- the stronger an acid the greater the ionisation / dissociation (in aqueous solution)
- (so) the stronger the acid the lower the pH

Concentration

- the higher the concentration of an acid the more acid / solute in the same volume (of solution)
- (so) the higher the concentration of the acid the lower the pH

(b) the mean of titration numbers 2 to 5 values is calculated

1

(because) 23.90 (cm^3) is an anomalous result

allow (because) 23.90 (cm^3) is not concordant

allow (because) 23.90 (cm^3) is too high a value

allow (because) the first titration is a rough value

*allow for **2** marks an answer of (because) the mean is taken of the values within 0.10 (cm^3)*

*allow for **2** marks an answer of (because) the mean is taken of the concordant values*

1

allow identification of titration by titration number or volume

(c) (moles $Ba(OH)_2 = \frac{23.50}{1000} \times 0.100$) = 0.00235

1

(moles HCl = 0.00235 × 2 =) 0.00470

allow correct use of an incorrectly calculated number of moles of $Ba(OH)_2$

1

(concentration =) $0.00470 \times \frac{1000}{25.0}$

allow correct use of an incorrectly calculated number of moles of HCl

1

= 0.188 (mol/dm^3)

1

alternative approach:

$\left(\text{ratio } \frac{\text{moles HCl}}{\text{moles Ba(OH)}_2} =\right)$

allow inverted expression

$\frac{2}{1} = \frac{25.0 \times \text{concentration}}{23.50 \times 0.100}$ (**2**)

*allow **1** mark for the expression with an incorrect mole ratio*

(concentration =) $\frac{2 \times 23.50 \times 0.100}{25.00}$ (1)

allow correct use of the expression with an incorrect mole ratio

= 0.188 (mol/dm^3) (1)

(d) there are no ions that are free to move

allow there are no ions in solution

allow there are no ions free to carry the charge

1

(because) barium sulfate is solid / insoluble

1

(and) hydrogen ions have reacted with hydroxide ions to produce water

allow (and) water is a covalent / molecular substance

1

(e) the mixture (now) contains barium ions and hydroxide ions that are free to move

allow excess barium hydroxide solution contains ions

1

[14]