Chemical changes – GCSE Chemistry

1. No.2

0 2 This question is about acids and alkalis.

0 2 . 1 Acids and alkalis are substances that produce ions in aqueous solution.

Draw **one** line from each substance to the ion always produced by that substance in aqueous solution.

[2 marks]

Substance	Ion always produced in aqueous solution
	Cl^-
Acid	H^+
	Na^+
Alkali	OH^-
	SO_4^{2-}

Acids give off hydrogen ions in water.

0 2 . 2 What type of aqueous solution has a pH of 11?

[1 mark]

Tick (✓) **one** box.

Acidic	
Alkaline	✓
Neutral	

0 – 6 Acids. 7 Neutral 8 – 14. Alkalis.

A student determined the reacting volumes of hydrochloric acid and sodium hydroxide solution by titration.

This is the method used.

1. Measure 25.0 cm^3 of the sodium hydroxide solution.

2. Add the sodium hydroxide solution to a conical flask.

3. Add 3 drops of indicator to the sodium hydroxide solution.

4. Add the hydrochloric acid drop by drop until the indicator changes colour.

5. Record the volume of the hydrochloric acid added.

6. Repeat steps 1 to 5 three more times.

0 2 . 3 Which piece of equipment should be used to measure 25.0 cm^3 of the sodium hydroxide solution in step 1?

[1 mark]

Tick (✓) **one** box.

Beaker	☐	A beaker is used for general holding and transferring of liquids, not precise volume measurement.
Pipette	☑	Pipette is designed for accurate measurement and transfer of small precise volume of liquids.
Ruler	☐	Ruler measures length not volume.

0 2 . 4 Which piece of equipment should be used to add the hydrochloric acid drop by drop in step 4?

[1 mark]

Tick (✓) **one** box.

Balance	☐	A balance measures mass.
Burette	☑	A burette is designed to deliver precise volume of liquids in drops.
Measuring cylinder	☐	Measuring cylinder measures volume but not suitable for dropwise addition.

Table 1 shows the results.

Table 1

Trial	1	2	3	4
Volume of hydrochloric acid added in cm^3	24.3	24.5	28.1	24.4

0 2 . 5 Which is the anomalous result in **Table 1**?

[1 mark]

Trial 1 ☐ Trial 2 ☐ Trial 3 ✓ Trial 4 ☐

0 2 . 6 Suggest **one** reason for the anomalous result in **Table 1**.

[1 mark]

The student did not rinse apparatus after the previous trial.

0 2 . 7 The student used a solution of sodium hydroxide of concentration 4.00 g/dm^3.

Calculate the mass of sodium hydroxide in 25.0 cm^3 of this solution.

1 dm^3 = 1000 cm^3

[3 marks]

Convert volume to dm^3.

$25 cm^3 = \frac{25}{1000} dm^3 = 0.025 dm^3$

Mass of sodium hydroxide.

Mass = Concentration x volume.

$= 4.00 g/dm^3 \times 0.025 dm^3$

$= 0.1 g$.

Mass = 0.1 g

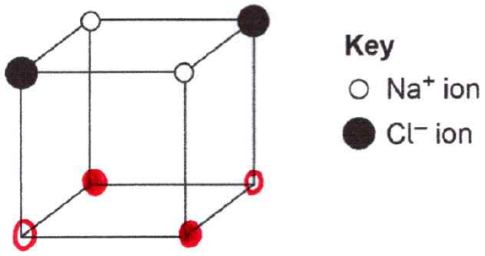
2. No.7

0 7 This question is about ionic compounds and electrolysis.

Sodium chloride is an ionic compound.

0 7 . 1 **Figure 8** represents part of the structure of solid sodium chloride.

Figure 8



Complete **Figure 8**.

[2 marks]

0 7 . 2 Give **one** reason why molten sodium chloride conducts electricity.

Refer to ions in your answer.

[1 mark]

When sodium chloride is heated to its melting point it dissociates into Na^+ and Cl^- which are mobile in liquid state; this allows conduction of electric current through molten sodium chloride.

0 7 . 3 **Table 3** shows products of the electrolysis of two molten ionic compounds.

Complete **Table 3**.

[2 marks]

Table 3

Molten compound	Product at the negative electrode	Product at the positive electrode
Magnesium bromide	Magnesium	Bromine
Potassium chloride	Potassium	Chlorine

0 7 . 4 Aluminium is extracted by electrolysis.

The electrolyte is a molten mixture of aluminium oxide and cryolite.

Why is a mixture used instead of pure aluminium oxide as the electrolyte?

[1 mark]

Tick (✓) **one** box.

- The mixture has a lower melting point than pure aluminium oxide. ✓
- The mixture has the same melting point as pure aluminium oxide.
- The mixture has a higher melting point than pure aluminium oxide.

lower melting point is essential for the electrolysis process to occur efficiently and at lower energy cost.

0 7 . 5 Electrolysis of an aqueous solution of sodium sulfate produces hydrogen and oxygen.

What is the source of the hydrogen and the oxygen produced during the electrolysis of aqueous sodium sulfate solution?

[1 mark]

Tick (✓) **one** box.

- Air
- Sulfate ions
- Water ✓

water is reduced to produce hydrogen gas at the cathode and at the anode, water is oxidized to produce oxygen gas.

Electrolysis of an aqueous solution of sodium sulfate produces hydrogen and oxygen.

0 7 . 6 Why is hydrogen produced instead of sodium in the electrolysis of aqueous sodium sulfate solution?

[1 mark]

Tick (✓) **one** box.

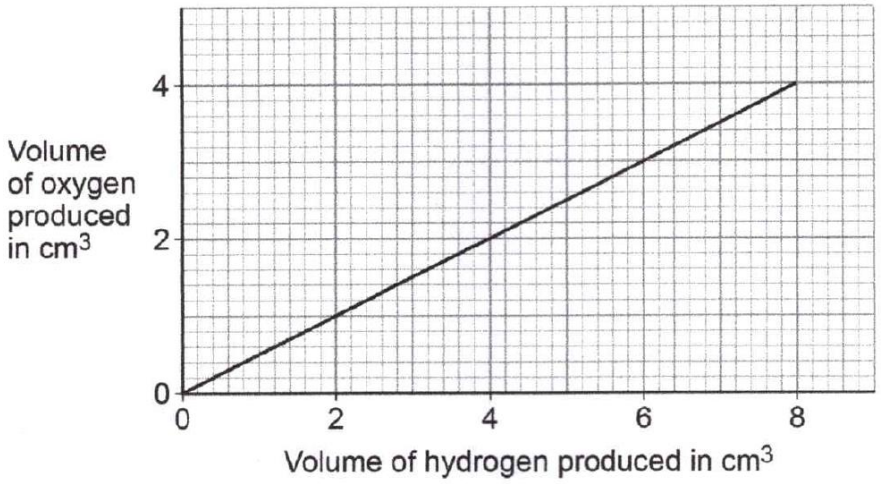
Hydrogen is less reactive than sodium. ✓

Hydrogen has the same reactivity as sodium.

Hydrogen is more reactive than sodium.

0 7 . 7 **Figure 9** shows the relationship between the volume of hydrogen and the volume of oxygen produced during the electrolysis.

Figure 9



Give **one** conclusion that can be made about the volume of hydrogen produced compared to the volume of oxygen produced.

[1 mark]

The volume of hydrogen is twice the volume of oxygen.

3. No.8

0 8 This question is about displacement reactions.

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

0 8 . 1 Balance the equation for the reaction.

[2 marks]

$$Fe_2O_3 + 3C \rightarrow \underline{2}\ Fe + \underline{3}\ CO$$

0 8 . 2 Iron oxide is reduced in this reaction.

How does the equation show that iron oxide is reduced?

[1 mark]

Fe_2O_3 loses oxygen atoms and is converted to iron Fe. This indicates reduction of iron oxide.

0 8 . 3 Calculate the relative formula mass (M_r) of Fe_2O_3

Relative atomic masses (A_r): O = 16 Fe = 56

[2 marks]

Total mass of Fe: $2 \times 56 = 112$.

Total mass of Oxygen $3 \times 16 = 48$.

M_r = Mass from Fe + Mass from O_2.

$= 112 + 48 = 160$.

M_r = 160.

0 8 . 4 Copper oxide reacts with hydrogen to produce copper.

The equation for the reaction is:

$$CuO + H_2 \rightarrow Cu + H_2O$$

Calculate the percentage atom economy for obtaining copper from this reaction.

Use the equation:

$$\text{Percentage atom economy} = \frac{A_r \text{ of Cu}}{M_r \text{ of } H_2 + M_r \text{ of CuO}} \times 100$$

Relative atomic mass (A_r): Cu = 63.5
Relative formula masses (M_r): H_2 = 2 CuO = 79.5

[2 marks]

$\frac{63.5}{2+79.5} \times 100 = 77.91\%$

Percentage atom economy = 77.9 %

A student investigated the reactivity of four different metals, **A**, **B**, **C** and **D**.

The student:

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

0 8 . 5 Give **one** observation that would show a reaction took place.

[1 mark]

There was colour change in solution.

0 8 . 6 **Table 4** shows the results.

Table 4

	Metal sulfate solution			
Metal	**A sulfate**	**B sulfate**	**C sulfate**	**D sulfate**
A	×	×	✓	×
B	✓	×	✓	×
C	×	×	×	×
D	✓	✓	✓	×

✓ shows that a displacement reaction took place.
× shows that a displacement reaction did not take place.

Write metals **A**, **B**, **C** and **D** in order of reactivity.

Give a reason for your order of reactivity.

[2 marks]

Most reactive D

B

A

Least reactive C

Reason A more reactive metal displaces a less reactive metal.

4. No.3

0 3 This question is about making a soluble salt.

0 3 . 1 Plan a method to make pure, dry crystals of zinc chloride from zinc carbonate and a dilute acid.

[6 marks]

Add excess zinc carbonate to a beaker containing dilute HCl
The reaction will produce bubbles of carbon dioxide gas.
Once the reaction has stopped, filter the mixture to remove
any undissolved zinc carbonate.
Carefully heat the filtrate in an evaporating dish. As the water
evaporates, the solution will become more concentrated.
Continue heating until crystals of zinc chloride start to
form. Allow the solution to cool slowly to encourage larger
crystals growth. Once crystals have formed, remove them from
the evaporating dish and dry them thoroughly, using filter
paper.
Crystals should be dried thoroughly to remove any
remaining water using a filter paper.

0 3 . 2 Name **two** other substances that can each be reacted with a dilute acid to make zinc chloride.

Do **not** refer to zinc carbonate in your answer.

[2 marks]

1 Zinc oxide.

2 Zinc hydroxide.

5. No.5

0 5 This question is about acids and alkalis.

0 5 . 1 Ethanoic acid is a weak acid.

What is meant by 'weak acid'?

Answer in terms of ionisation.

[1 mark]

A substance that partially ionises in aqueous solution / water.

0 5 . 2 The concentration of an acid can be measured in mol/dm^3.

Which combination of changes **increases** the concentration of an acid?

[1 mark]

Tick (✓) **one** box.

The mass of acid dissolved is halved and the volume of the solution is halved.	☐
The mass of acid dissolved is halved and the volume of the solution is doubled.	☐
The mass of acid dissolved is doubled and the volume of the solution is halved.	✓
The mass of acid dissolved is doubled and the volume of the solution is doubled.	☐

0 5 . 3 The concentration of an acid can be determined by titration.

An indicator is added to an alkali in a flask.

Name an indicator that can be used in this titration.

Give the colour change of the indicator when acid from a burette is added to the alkali in the flask.

[2 marks]

Name of indicator Phenolphthalein.

Colour change from Pink to colourless to Colourless.

0 5 . 4 Sodium carbonate dissolves in water to produce an alkaline solution.

Give the formula of the ion that makes a solution alkaline.

[1 mark]

OH^-

0 5 . 5 A student does a titration using sodium carbonate solution and nitric acid.

The equation for the reaction is:

$$Na_2CO_3 + 2HNO_3 \rightarrow 2NaNO_3 + CO_2 + H_2O$$

25.0 cm^3 of 0.124 mol/dm^3 sodium carbonate solution is neutralised by 23.6 cm^3 of nitric acid.

Calculate the concentration of the nitric acid.

Give your answer to 3 significant figures.

You should calculate:

- the number of moles of sodium carbonate in 25.0 cm^3 of the solution
- the number of moles of nitric acid in 23.6 cm^3 of the nitric acid
- the concentration of the nitric acid in mol/dm^3.

[5 marks]

Moles of Na_2CO_3 =

Concentration x volume.

$0.124\ mol/dm^3 \times 0.0250\ dm$.

$= 0.00310\ mol$.

$Na_2CO_3 + 2HNO_3 \rightarrow NaNO_3 + CO_2 + H_2O$.

1 : 2.

Moles of HNO_3 = 2 x moles of Na_2CO_3.

$0.00310 \times 2 = 0.00620$

Concentration of HNO_3 = Moles of HNO_3 / Conc Volume.

$= \frac{0.00620\ mol}{0.0236\ dm^3}$

$= 0.2627118644$

$= 0.263$.

Concentration (3 significant figures) = 0.263. mol/dm^3

When hydrochloric acid dissolves in water, hydrogen ions (H^+) and chloride ions (Cl^-) are produced.

0 5 . 6 A solution of hydrochloric acid with pH 4.5 has a concentration of H^+ ions of 3.16×10^{-5} mol/dm^3.

What is the concentration of H^+ ions in a solution of hydrochloric acid with pH 2.5?

[1 mark]

$2.5 = -\log [H^+]$. $= 10^{-3} \times 10^{0.5} = 0.001 \times 3.6$.

$[H^+] = 10^{-2.5} = 10^{-3+0.5}$ $= 0.00316$.

Concentration of H^+ ions = 3.6×10^{-3} mol/dm^3

0 5 . 7 Which element has atoms that have the same electronic structure as the chloride ion?

Use the periodic table.

[1 mark]

Argon.

6. No.7

0 7 This question is about electrolysis.

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

0 7 . 1 Complete the half equation for the reaction occurring at the negative electrode.

[1 mark]

$$Al^{3+} + \underline{3}\ e^- \rightarrow Al$$

0 7 . 2 Cryolite contains Na^+ ions as well as Al^{3+} ions.

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

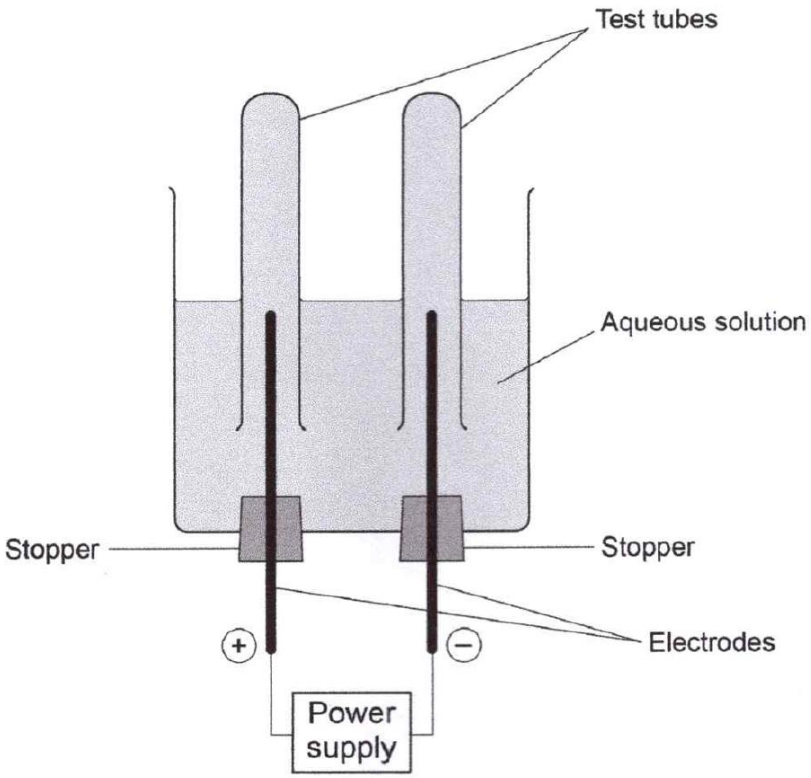
[1 mark]

Sodium is more reactive than aluminium, therefore they are less reduced than aluminium ions.

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

Figure 7 shows the apparatus.

Figure 7



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

0 7 . 3 Explain how oxygen was produced from water during the electrolysis of this aqueous solution.

[4 marks]

Electric current passed through water cause it to dissociate to H^+ and OH^-. At the cathode reduction occurs; H^+ gain electrons to form hydrogen gas. $2H^+ + 2e^- \longrightarrow H_{2(g)}$.
At the anode oxidation occurs. The OH^- lose electrons to form oxygen gas and water
$4OH^- \longrightarrow O_{2(g)} + 2H_2O + 4e^-$
Therefore oxygen is produced at anode from oxidation of hydroxide ions during electrolysis of water.

0 7 . 4 The student compared the volumes of the two gases collected.

How can the student change the apparatus in **Figure 7** to compare the volumes of the two gases produced more accurately?

Give **one** reason for your answer.

[2 marks]

Change Use a measuring cylinder.

Reason A measuring cylinder is graduated / has a scale.

0 7 . 5 The overall equation for the reaction is:

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

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

[1 mark]

Tick (✓) **one** box.

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

7. No.9

0 9 This question is about displacement reactions.

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

The equation for the reaction is:

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

0 9 . 1 Which substance in the equation is reduced?

Give **one** reason for your answer.

Answer in terms of oxygen.

[2 marks]

Substance reduced Fe_2O_3.

Reason It loses oxygen.

0 9 . 2 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

[1 mark]

Tick (✓) **one** box.

- $\frac{1}{3} \times 12$ g ☐
- $\frac{3}{2} \times 12$ g ☑
- 1×12 g ☐
- 3×12 g ☐

Mole ration.

3C : 2Fe.

mole of carbon needed to form 1 mole of iron.

$\frac{3C}{2Fe} \times 1$ mol Fe.

$= 3/2$ moles.

Mass of C.

$= 3/2 \times 12$ g.

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.

Table 6 shows information about three of the reaction mixtures.

Table 6

Reaction	Metal	Metal nitrate solution	Equation
1	**A**	$\mathbf{B}NO_3$	$\mathbf{A} + 2\mathbf{B}NO_3 \rightarrow 2\mathbf{B} + \mathbf{A}(NO_3)_2$
2	**C**	$\mathbf{A}(NO_3)_2$	$2\mathbf{C} + 3\mathbf{A}(NO_3)_2 \rightarrow 3\mathbf{A} + 2\mathbf{C}(NO_3)_3$
3	**C**	$\mathbf{D}(NO_3)_2$	no reaction

0 9 . 3 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?

[1 mark]

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. ☐

$A \rightarrow A^{2+} + 2e^-$ (oxidation)

$2B^+ + 2e^- \rightarrow 2B$ (reduction).

0 9 . 4 Which of the four metals has the greatest tendency to form positive ions?

Use **Table 6**.

[1 mark]

Tick (✓) **one** box.

A ☐ B ☐ C ☐ D ☑

0 9 . 5 The nitrate ion has the formula NO_3^-

Which of the four metals could be aluminium?

Explain your answer.

Use **Table 6**.

[3 marks]

Metal C

Explanation Aluminium form ions with a charge of (+3) 3+ So three nitrates are needed to form one aluminium ion because nitrates have a charge of -1. 1-

0 9 . 6 Metal **X** is extracted from an oxide of metal **X** by reaction with hydrogen.

The equation for the reaction is:

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

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

[4 marks]

Mass (molecular) of XO_3

$A + 3 \times 16 \rightarrow X = Ar$.

Molecular mass of $H_2O = 18$

$\frac{Ar\ X}{Ar + 3 \times 18}$ Ratio of Molecular mass of X.

$77.3 = \frac{Ar}{Ar + 54} \times 100$.

$77.3(Ar + 54) = 100Ar$.

$77.3Ar + 4174.2 = 100Ar$

$22.7Ar = 4174.2$

$Ar = 183.9$

$= 184$.

Relative atomic mass (A_r) = 184.