OCR
Oxford Cambridge and RSA

Friday 13 June 2025 – Morning

GCSE (9–1) Chemistry B (Twenty First Century Science)

J258/04 Depth in Chemistry (Higher Tier)

Time allowed: 1 hour 45 minutes

You must have:
- a ruler (cm/mm)
- the Data Sheet for GCSE (9–1) Chemistry B (inside this document)

You can use:
- a scientific or graphical calculator
- an HB pencil

H

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION
- The total mark for this paper is **90**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **32** pages.

ADVICE
- Read each question carefully before you start your answer.

© OCR 2025 [601/8605/7]
DC (SL/FC) 354030/3
OCR is an exempt Charity

BLANK PAGE

DO NOT WRITE ON THIS PAGE

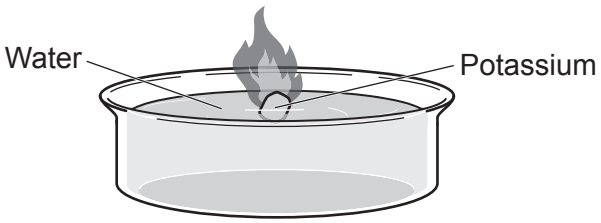
© OCR 2025

1 Potassium, sodium and lithium are metals in Group 1 of the Periodic Table.

A student watches a video of the reaction of potassium with water.

Fig. 1.1 shows a diagram of the experiment.

Fig. 1.1



The table shows information about this reaction.

Metal	**Products of the reaction**	**Observations**
Potassium	Potassium hydroxide Hydrogen gas	Potassium moves quickly on the surface of the water and fizzes violently. Potassium burns with a pale purple flame.

(a) The student then watches a video of the reaction of **sodium** with water.

Predict the products of the reaction of sodium with water and describe the observations you expect.

Products ..... and .....

Observations .....

.....

.....

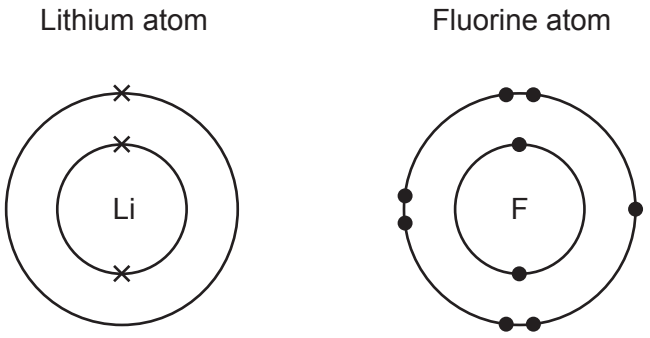
.....

[3]

© OCR 2025

(b) **Fig. 1.2** shows the arrangement of electrons in a lithium atom and a fluorine atom.

Fig. 1.2



(i) Lithium and fluorine belong to different groups of the Periodic Table.

Explain how the arrangement of electrons in lithium and fluorine is related to their **groups** in the Periodic Table.

.....

.....

.....

..... **[2]**

(ii) Explain how **Fig. 1.2** shows that lithium and fluorine are in the same **period** of the Periodic Table.

.....

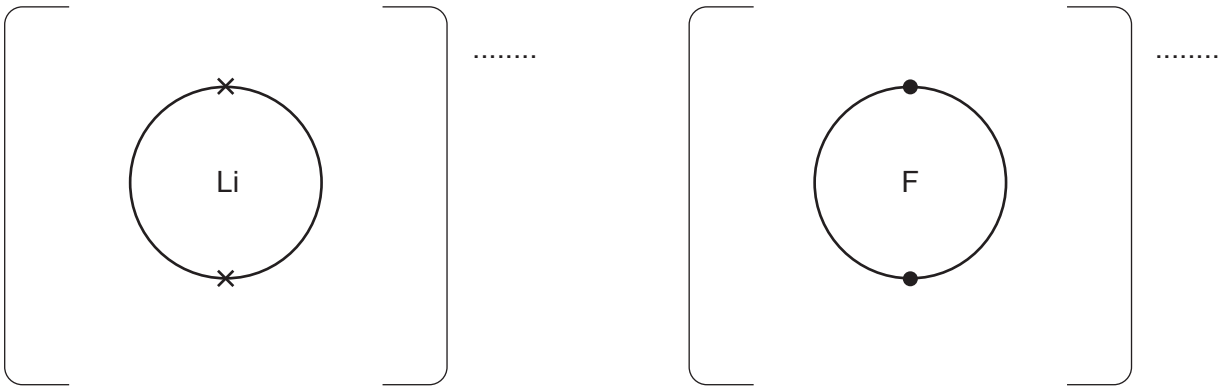
..... **[1]**

© OCR 2025

(iii) Lithium fluoride is an ionic compound that has lithium ions and fluoride ions.

Fig. 1.3 shows a dot and cross diagram of these ions.
The diagram is **not** complete.

Fig. 1.3



Complete **Fig. 1.3**.

You need to:
- show the arrangement of electrons in the **fluoride** ion
- show the charges on **both** ions. **[3]**

(iv) Which statement gives a correct limitation of using a complete dot and cross diagram to represent ionic bonding?

Tick (✓) **one** box.

It does **not** show that the ions are different sizes. ☐

It does **not** show the correct ratio of numbers of ions. ☐

It does **not** show the total number of electrons. ☐

It only shows shared electrons. ☐

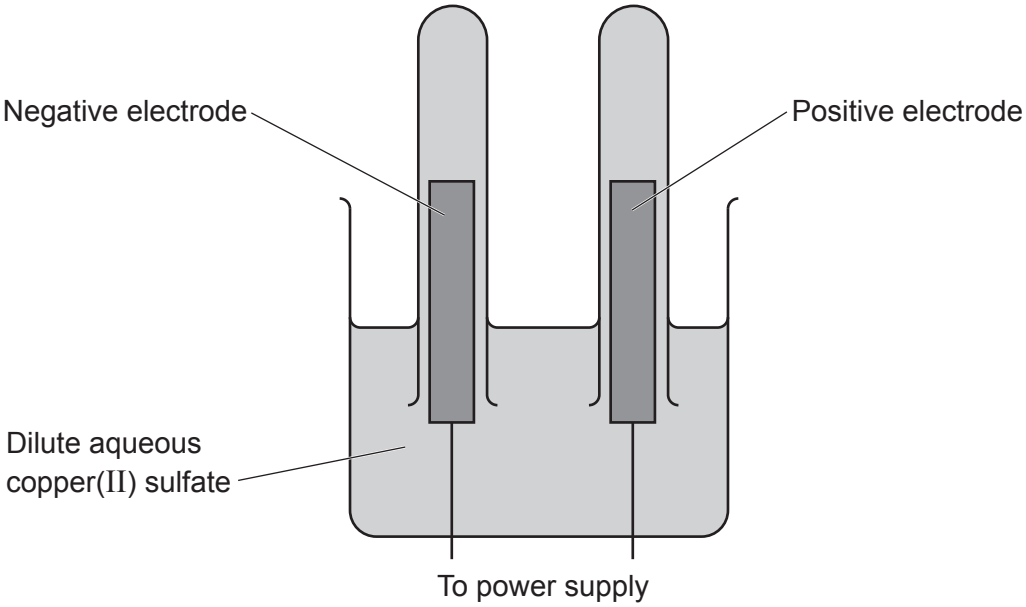
[1]

© OCR 2025

2 A student does an electrolysis experiment.

They pass electricity through dilute aqueous copper(II) sulfate using inert electrodes.

The diagram shows the apparatus they set up.



(a) Oxygen gas forms at the positive electrode.

Which **two** statements give correct reasons why oxygen forms at the positive electrode?

Tick (✓) **two** boxes.

Copper reacts with water to form oxygen. ☐

Hydroxide ions from water react to form oxygen. ☐

Non-metals usually form at the positive electrode. ☐

The electricity causes water to evaporate around the electrode. ☐

[2]

© OCR 2025

(b) The student wants to find the rate that oxygen gas forms by measuring the volume of gas produced.

(i) Suggest **one** change to the apparatus so that the volume of oxygen gas can be measured.

.....

..... **[1]**

(ii) Describe how the student uses the new apparatus and a stop watch to find the rate that oxygen gas forms.

Include in your answer:
- what results they need to collect
- how they use their results to find the rate.

.....

.....

.....

.....

.....

..... **[2]**

(c) The student measures the mass of the electrodes before and after the electrolysis.

The table shows their results.

	Negative electrode	**Positive electrode**
Mass before electrolysis (g)	10.2	10.4
Mass after electrolysis (g)	10.9	10.4

Explain what happens to the mass of each electrode during the experiment.

Positive electrode .....

.....

.....

Negative electrode .....

.....

.....
[3]

© OCR 2025

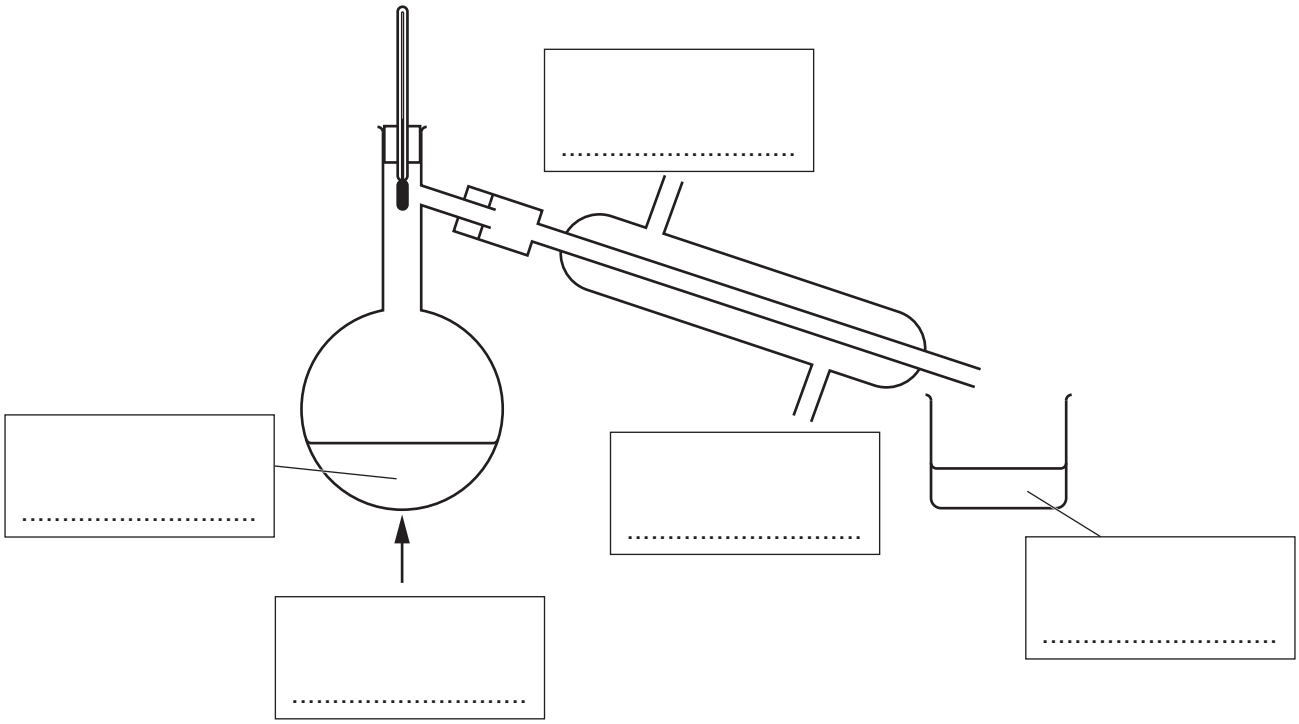
3 Water for drinking can be separated from sea water by distillation.

(a) The diagram shows a laboratory apparatus that can be used for the distillation of sea water.

(i) Complete the labels on the diagram.

Use all of the words from the list.

Heat	**Pure water**	**Sea water**	**Water in**	**Water out**



[2]

© OCR 2025

(ii) Sea water contains dissolved sodium chloride.

A student adds dilute acidified silver nitrate to the sea water before distillation and to the water collected after distillation.

Complete the table to show the observations that the student makes.

Explain your answer.

Observations when acidified silver nitrate is added	
Sea water before distillation	**Water collected after distillation**

Explanation .....

.....

.....

.....

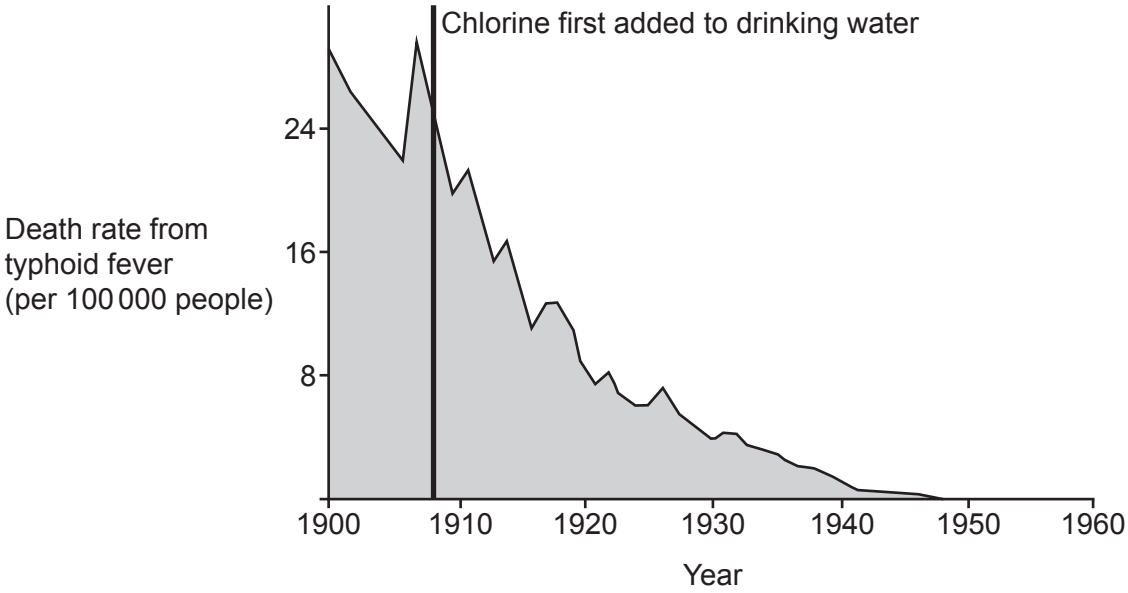
[3]

© OCR 2025

(b) Typhoid fever is a disease that causes death. It is caused by harmful microorganisms in water.

Chlorine was added to drinking water in the United States in 1908.

The graph shows the death rate from typhoid fever in the United States before and after chlorine was first added to drinking water.



(i) Chlorine was **not** added to water in all areas of the United States at the same time.

A student says that the time taken for all areas to have chlorine added to their drinking water was ~40 years.

Explain why the student is **correct**.

Include data from the graph in your answer.

.....

.....

.....

..... **[2]**

© OCR 2025

(ii) Some people think that chlorine should **not** be added to drinking water because it causes other health issues such as allergies in some people.

Suggest why chlorine **should** be added to drinking water.

Include in your answer:
- ideas about risk and benefit
- data from the graph.

.....

.....

.....

.....

.....

..... **[3]**

(c) The effect of adding chlorine to drinking water was an important scientific discovery.

Today, information about important scientific discoveries is published for peer review.

Information about important scientific discoveries is also published in newspapers.

Explain the differences between publishing information for peer review and in newspapers.

.....

.....

.....

.....

.....

..... **[3]**

© OCR 2025

4 Pure iron corrodes easily and is too weak for some uses.

(a) When iron corrodes it reacts with oxygen to make iron(III) oxide.

Complete the **balanced symbol** equation for the reaction.

Include state symbols.

iron	+	oxygen	→	iron(III) oxide
..... (....)	+	..... (....)	→	$2Fe_2O_3$ (....)

[3]

(b) Steel is a mixture of iron and other elements.

Table 4.1 shows the effect of different elements on the properties of steel.

Table 4.1

Element	Effect on properties of steel	Percentage in steel
Chromium	Increases corrosion resistance, especially at high temperatures.	~18%
Nickel	Increases corrosion resistance and can be bent without breaking.	>8 <10%
Carbon	Increases hardness but also makes steel more easy to break. No effect on corrosion resistance.	⩽ 2%
Copper	Increases electrical conductivity. Increases corrosion resistance in sea water.	~4%
Manganese	Increases hardness but can make steel more easy to break when bent.	⩽ 15%

(i) A type of steel contains 2% carbon and 98% iron.

Explain why this steel has a limited range of uses.

Use **Table 4.1** to help you answer.

.....

.....

.....

..... **[2]**

© OCR 2025

(ii) Another type of steel is used to make electrical wires for use in the engine of a ship.

The engine gets very hot.

This steel contains iron mixed with three other metals and a small amount of carbon.

Complete **Table 4.2** by:
- suggesting which **three** metals have been added to this steel to make it most suitable for this use
- predicting a value for the percentage of each metal in this steel.

Use **Table 4.1** to help you answer.

Table 4.2

Element	**Percentage of element in this steel (%)**
Carbon	0.1
.....	.....
.....	.....
.....	.....
Iron	.....

[3]

© OCR 2025

5 Nitrogen and hydrogen react together to make ammonia in the Haber process.

Ammonia is used in fertilisers.

(a) Which statements about fertilisers are **true** and which are **false**?

Tick (✓) **one** box in each row.

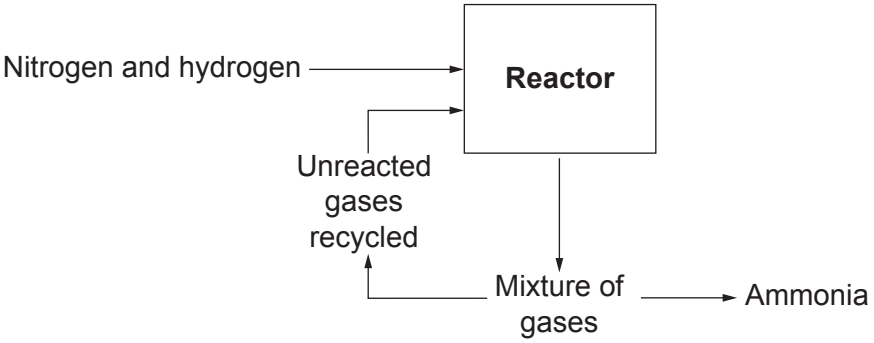
	True	**False**
Ammonia is added to fertilisers to provide potassium and phosphorus for plant growth.		
Fertilisers made from ammonia are needed to balance supply and demand of food.		
Industrial processes used to make fertilisers are usually on a large scale in batches.		

[2]

© OCR 2025

(b)* The diagram shows a flow chart for the substances that enter and leave the reactor in the Haber process.

The table shows the main conditions used.



Conditions used
450 °C
200 atm
catalyst
unreacted gases recycled

Explain why the conditions in the table are chosen for this process.

Include in your answer:
- the effect each condition has on the rate of reaction and on the yield
- why higher or lower values of temperature and pressure are **not** used.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... **[6]**

© OCR 2025

6 Methanol (CH_3OH) and hydrogen can both be used as fuels.

(a) Burning hydrogen has a different impact on the Earth's climate to burning methanol.

Explain why.

.....

.....

.....

.....

.....

..... **[3]**

(b) **Equation 1** shows the reaction of methane with steam which is used in industry to manufacture hydrogen.

Equation 1

$$CH_4 + 2H_2O \rightleftharpoons 4H_2 + CO_2$$

The carbon dioxide produced in the reaction is used to make methanol, CH_3OH.

In the process shown in **Equation 1**, carbon dioxide is considered a by-product and **not** a waste product.

Explain the difference between a by-product and a waste product.

.....

.....

.....

..... **[2]**

© OCR 2025

(c) **Table 6.1** shows the relative formula masses for the reactants and products in the reaction of methane with steam.

Table 6.1

	Relative formula mass
CH_4	16
H_2O	18
H_2	2
CO_2	.....

(i) Complete **Table 6.1** by calculating the relative formula mass for carbon dioxide.

Use the Periodic Table. **[1]**

(ii) Calculate the atom economy of the reaction of methane with steam to make hydrogen.

Use:
- **Equation 1**: $CH_4 + 2H_2O \rightleftharpoons 4H_2 + CO_2$
- the data from **Table 6.1**.

Give your answer to **1** decimal place.

Atom economy = ... % **[4]**

© OCR 2025

(d) Scientists did some experiments and collected data about the yield of the products made when 1000 kg of methane reacts with steam.

Table 6.2 shows the data they collected.

Table 6.2

Mass of methane used (kg)	1000
Theoretical yield of hydrogen (kg)	500
Actual mass of hydrogen formed (kg)	370
Actual mass of carbon dioxide formed (kg)	2035

Calculate the percentage yield of hydrogen.

Use data from **Table 6.2**.

Percentage yield of hydrogen = ... % **[2]**

(e) Methanol can be made by reacting carbon dioxide with hydrogen.

Equation 2 shows this reaction.

Equation 2

$CO_2 + 3H_2 \rightleftharpoons CH_3OH + H_2O$

(i) Explain how **Equation 2** shows that the percentage yield of methanol is **not** 100%.

.....

.....

.....

..... **[2]**

(ii) Explain how **Equation 2** shows that the atom economy of the reaction to make methanol is **not** 100%.

.....

..... **[1]**

© OCR 2025

BLANK PAGE

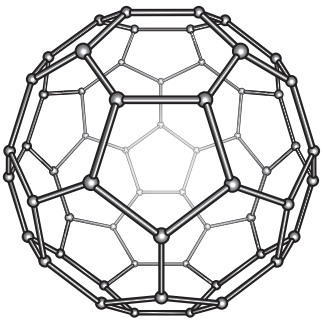
DO NOT WRITE ON THIS PAGE

Turn over for the next question

© OCR 2025

7 Buckyballs are a type of nanoparticle.
They consist of carbon atoms joined in a ball with a hollow centre.

The diagram shows the structure of a buckyball.



A buckyball has a diameter of 1 nm.

1 nm = 1×10^{-9} m

(a) Which of these is the best estimate for the diameter of a carbon atom?

Tick (✓) **one** box.

1×10^{-8} m ☐

1×10^{-10} m ☐

10 nm ☐

1×10^{10} nm ☐

[1]

(b) The radius of a buckyball is half its diameter.

The surface area to volume ratio of a buckyball can be calculated using this formula:

surface area to volume ratio = $\frac{3}{r}$ (r is the radius of the buckyball **in nm**).

Calculate the surface area to volume ratio of a buckyball that has a **diameter** of 1 nm.

Surface area to volume ratio = ... **[3]**

© OCR 2025

(c) Scientists are developing ways of using nanoparticles such as buckyballs to carry medicines into the human body.

(i) Describe **two** reasons why buckyballs are suitable to carry medicines into the human body.

1 .....

.....

2 .....

.....

[2]

(ii) Explain **one** possible risk of using nanoparticles to carry medicines into the human body.

.....

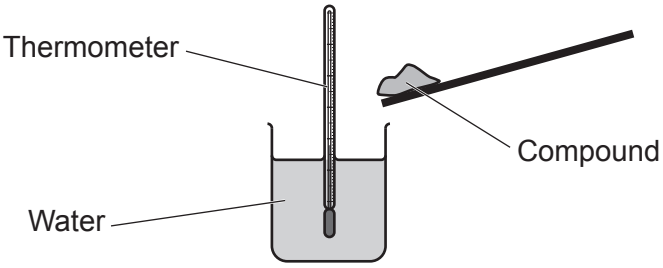
..... **[1]**

© OCR 2025

8

(a)* A student does some experiments to investigate the trends in energy changes when ionic compounds dissolve in water.

The diagram shows the apparatus the student uses.



The student follows this method:

- Add the same amount of each compound to the same volume of water.
- Stir until the compound is fully dissolved.
- Record the change in temperature.

The table shows their results.

Group 1 ion in compound	Group 7 ion in compound	Change in temperature when compound dissolved (°C)
lithium	chloride	+8
sodium	chloride	–2
potassium	chloride	–5
lithium	bromide	+12
sodium	bromide	+1
potassium	bromide	–8
lithium	iodide	+14
sodium	iodide	+3
potassium	iodide	–9

© OCR 2025

What conclusions can you make about the trends in energy changes when compounds containing Group 1 ions and Group 7 ions dissolve in water?

Use the information in the table.

In your answer you should:
- identify exothermic and endothermic changes
- discuss trends for ions down Group 1 and Group 7.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

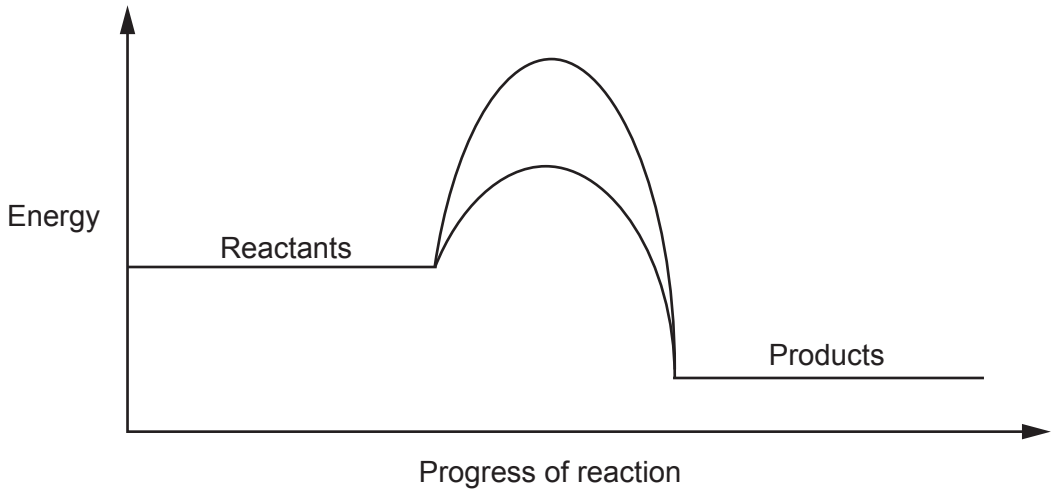
.....

..... **[6]**

© OCR 2025

(b) **Fig. 8.1** shows a reaction profile diagram for a catalysed and an uncatalysed reaction.

Fig. 8.1



Complete Fig. 8.1 by drawing labelled arrows to show:

- the activation energy for the uncatalysed reaction, E_a
- the activation energy for the catalysed reaction, E_{acat}
- the energy change of reaction, ΔE.

[3]

© OCR 2025

BLANK PAGE

DO NOT WRITE ON THIS PAGE

Turn over for the next question

© OCR 2025

9 Aqueous sodium hydroxide reacts with dilute nitric acid in a neutralisation reaction.

$NaOH(aq) + HNO_3(aq) \longrightarrow NaNO_3(aq) + H_2O(l)$

(a) **Table 9.1** shows the relative formula masses for the compounds in the equation.

Table 9.1

Compound	Relative formula mass
NaOH	40
HNO_3	63
$NaNO_3$	85
H_2O	18

Explain how the equation and the data in **Table 9.1** show that this reaction obeys the principle of conservation of mass.

Include data from **Table 9.1** in your answer.

.....

.....

.....

..... **[2]**

(b) In the reaction, hydrogen ions from the acid react with hydroxide ions from the sodium hydroxide.

Write the ionic equation for this reaction.

..... **[2]**

© OCR 2025

(c) **Table 9.2** shows information about some solutions of dilute acids.

Table 9.2

Dilute acid	Formula	Number of moles of acid in solution	Volume of solution (dm^3)	Concentration of dilute acid (mol/dm^3)	Concentration of hydrogen ions (mol/dm^3)
1	HCl	0.1	0.5	.....	.....
2	HCl	.....	2.0	0.3	0.3
3	HNO_3	1.0	……..	0.5	0.5
4	H_2SO_4	0.5	0.5	1.0	2.0

(i) Complete **Table 9.2** by working out the missing information. **[3]**

(ii) 25.0 cm^3 samples of each dilute acid are used in a titration with aqueous sodium hydroxide. The concentration of the aqueous sodium hydroxide was the same for each titration.

Which dilute acid, **1**, **2**, **3** or **4**, needs the largest volume of aqueous sodium hydroxide for neutralisation?

Explain your answer.

Dilute acid .....

Explanation .....

.....

[2]

(iii) The concentration of hydrogen ions is the same as the concentration of acid for some dilute acids but different for others.

Explain why.

Use examples from **Table 9.2** in your answer.

.....

.....

.....

.....

.....

..... **[3]**

END OF QUESTION PAPER

© OCR 2025

EXTRA ANSWER SPACE

If you need extra space use these lined pages. You must write the question numbers clearly in the margin.

© OCR 2025

© OCR 2025

© OCR 2025

© OCR 2025

OCR
Oxford Cambridge and RSA

Copyright Information

OCR is committed to seeking permission to reproduce all third-party content that it uses in its assessment materials. OCR has attempted to identify and contact all copyright holders whose work is used in this paper. To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced in the OCR Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download from our public website (www.ocr.org.uk) after the live examination series.

If OCR has unwittingly failed to correctly acknowledge or clear any third-party content in this assessment material, OCR will be happy to correct its mistake at the earliest possible opportunity.

For queries or further information please contact The OCR Copyright Team, The Triangle Building, Shaftesbury Road, Cambridge CB2 8EA.

OCR is part of Cambridge University Press & Assessment, which is itself a department of the University of Cambridge.

© OCR 2025