

**GCSE (9-1)**

**Examiners' report**

**GATEWAY SCIENCE  
COMBINED  
SCIENCE A**

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**J250**

For first teaching in 2016

**J250/04 Summer 2022 series**

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## Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. A selection of candidate answers are also provided. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

A full copy of the question paper and the mark scheme can be downloaded from OCR.

### Advance Information for Summer 2022 assessments

To support student revision, advance information was published about the focus of exams for Summer 2022 assessments. Advance information was available for most GCSE, AS and A Level subjects, Core Maths, FSMQ, and Cambridge Nationals Information Technologies. You can find more information on our [website](#).

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## Paper 4 series overview

Candidates were well prepared for this examination. Most questions were attempted by the majority of candidates.

Questions on metals and the Earth's early atmosphere were particularly well answered. Questions on water treatment and organic chemistry were more challenging. More successful candidates interpreted data in questions and applied knowledge and understanding to question contexts.

Calculations were generally performed well. It is advisable for candidates to structure their working out so that where a final answer is incorrect it may be possible for working and error carried forward marks to be given; this also helps the candidate to process their thoughts clearly and logically.

After completing an answer it is advisable for candidates to read the question again to make sure they have answered all of what is being asked, this will help make sure that numerical answers are given to an appropriate number of significant figures and that written responses cover all aspects of the question.

Writing an answer in pencil and then overwriting in ink should be discouraged as it makes answers difficult to decipher.

| Candidates who did well on this paper generally did the following:   | Candidates who did less well on this paper generally did the following:  |
|--|--|
| <ul style="list-style-type: none"> <li>• Produced a clear well-structured answer to the Level of Response Question 15, which included pertinent own knowledge not included in the question data.</li> <li>• Performed calculations showing working steps in Questions 11 (d) (i) and 13 (d).</li> <li>• Identified the products of a reaction in Question 12 (a) (i).</li> <li>• Showed understanding and use of the reactivity series of metals in Question 12.</li> <li>• Put linear scales on the axis, plotted points correctly, drew a suitable line of best fit and estimated a value from the line in Questions 16 (d) (i) and 16 (d) (ii).</li> <li>• Interpreted data in Questions 12, 13 (b), 14 (c) (i), 14 (c) (ii), 16 (a), 16 (c) and 16 (e).</li> </ul> | <ul style="list-style-type: none"> <li>• Used only the data provided as their answer to the Level of Response Question 15.</li> <li>• Showed imprecise use of scientific terminology in Questions 1, 4 and 14 (a).</li> <li>• Struggled to recall knowledge in Questions 11 (b), 11 (c), 13 (a) and 13 (b).</li> <li>• Produced answers to numerical questions without showing working steps in Question 13 (d).</li> <li>• Found it difficult to interpret data given in Questions 14 (c) (ii) and 14 (d).</li> </ul> |

## Section A overview

Most candidates attempted every question.

Questions on deriving an order of reactivity of metals (2), naming apparatus (3) and calculating the number of trees to offset carbon dioxide output (10) were particularly well answered.

Questions on alkanes (6), catalysts (7) and interpreting rate of reaction graphs (9) proved more challenging.

### Question 1

1 Supplies of crude oil are running out.

Which word describes crude oil?

- A Finite
- B Renewable
- C Reusable
- D Sustainable

Your answer

[1]

Finite was quite well known, B was a popular selection.

## Question 2

2 A student heats **four** different metals using a Bunsen burner.

The table shows their observations.

| Metal | Observation when metal is heated |
|-------|----------------------------------|
| W     | bursts into flames               |
| X     | slowly goes dull                 |
| Y     | no reaction                      |
| Z     | glows brightly                   |

What is the order of reactivity of the metals from **most reactive** to **least reactive**?

- A W, X, Z, Y
- B W, Z, X, Y
- C Y, X, Z, W
- D Z, Y, W, X

Your answer

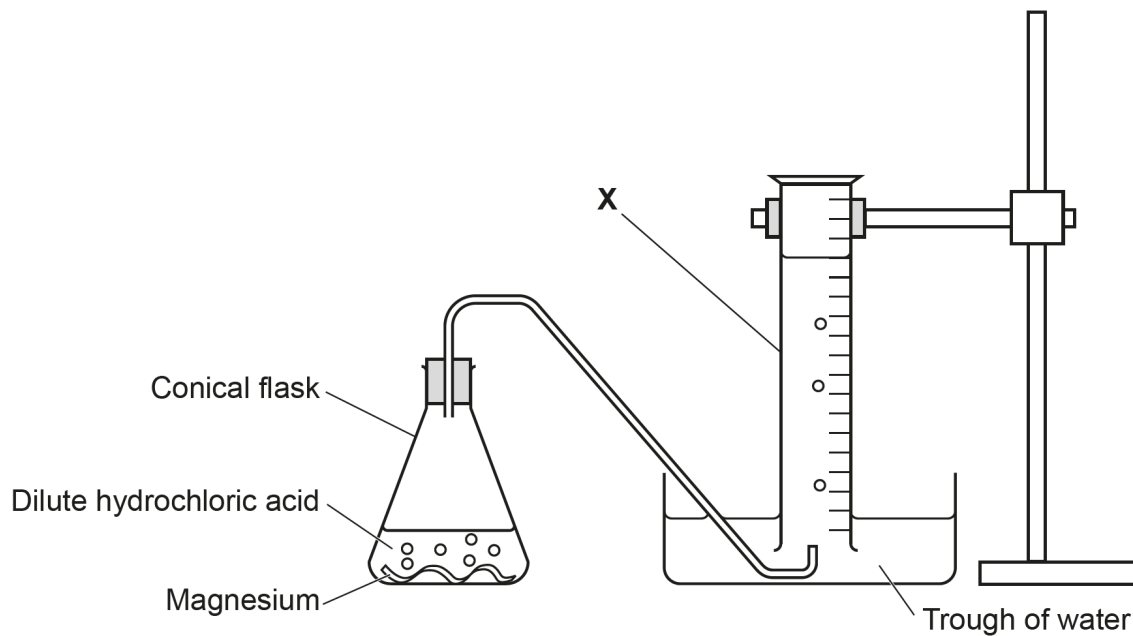
[1]

The majority of candidates interpreted the observations to deduce the correct order of reactivity. The reverse order was a popular choice.

### Question 3

3 A teacher investigates the rate of reaction between magnesium and dilute hydrochloric acid.

The diagram shows the equipment they use.



What is the name of the piece of equipment labelled **X**?

- A Burette
- B Gas syringe
- C Measuring cylinder
- D Test tube

Your answer

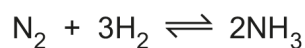
[1]

Measuring cylinder was well known, A and B were also popular responses.



## Question 4

4 Nitrogen,  $N_2$ , reacts with hydrogen,  $H_2$ , to make ammonia,  $NH_3$ .



What is the name of this type of reaction?

- A Combustion
- B Electrolysis
- C Neutralisation
- D Reversible

Your answer

[1]

Many candidates recognised the reversible arrow, C was a very popular choice.

## Question 5

5 Which toxic gas is produced from burning fossil fuels?

- A Carbon dioxide
- B Carbon monoxide
- C Nitrogen
- D Oxygen

Your answer

[1]

Toxicity of carbon monoxide was quite well known, carbon dioxide was the most popular incorrect choice.

## Question 6

6 Alkanes are hydrocarbons with the formula  $C_nH_{2n+2}$ .

Which compound is an alkane?

- A  $C_6H_8$
- B  $C_7H_{12}$
- C  $C_8H_{16}$
- D  $C_9H_{20}$

Your answer

[1]

Higher attaining candidates deduced the formula which adhered to the general formula. A and C were the popular choices.

## Question 7

7 A student has four different solids.

- One of the solids is a **catalyst**.
- The student tests 1 g of each solid in a chemical reaction.

The table shows the student's observations for each solid.

| Solid | Observation           | Mass of the solid at the end of the reaction (g) |
|-------|-----------------------|--|
| A     | disappears            | 0  |
| B     | fizzes and disappears | 0  |
| C     | changes colour        | 1  |
| D     | same colour           | 1  |

Which solid is the **catalyst**?

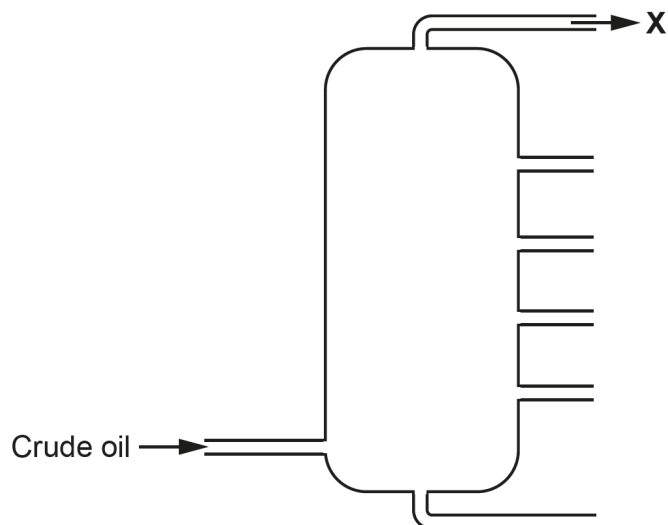
Your answer

[1]

Many candidates appreciated constant mass, higher scoring candidates knew the colour would also be unchanged. C was the most popular choice and B was also common.

## Question 8

8 The diagram shows the fractional distillation of crude oil.



The table shows the boiling point ranges of four different fractions.

| Fraction | Boiling point range (°C) |
|----------|--------------------------|
| A        | below 20                 |
| B        | 20–80                    |
| C        | 180–260                  |
| D        | 260–320                  |

Which fraction is collected at X?

Your answer

[1]

### Misconception



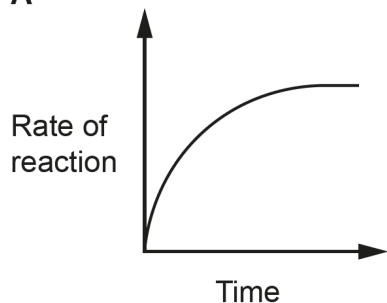
Many candidates inverted the temperature gradient in the fractionating column.

## Question 9

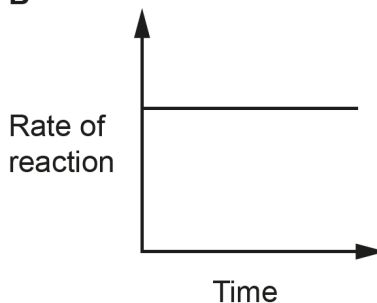
- 9 A student investigates the rate of reaction between magnesium and an excess of dilute sulfuric acid.

Which graph shows how the **rate of reaction** changes with time?

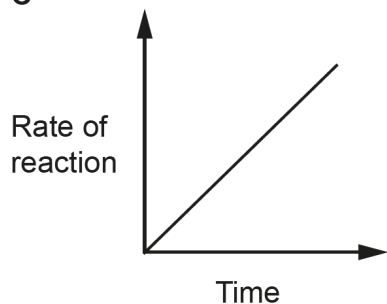
A



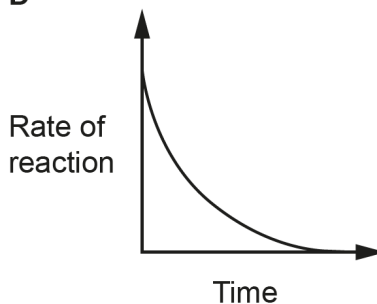
B



C



D



Your answer

[1]

The most successful candidates appreciated that the rate of reaction decreases with time. B was the most common response.

## Question 10

**10** In the UK, one person produces about  $9.5 \times 10^3$  kg of carbon dioxide per year.

One tree can take in 15 kg of carbon dioxide per year.

Approximately how many of these trees are needed to reduce one person's yearly carbon dioxide output to zero?

- A** 15
- B** 650
- C** 1600
- D** 140 000

Your answer

**[1]**

Higher scoring candidates performed the correct calculation. D was a more popular choice.

## Section B overview

The following topics were particularly well answered: Earth's early atmosphere (Question 11 (a)), Group 0 gases (Question 11 (d) (ii)), loss of electrons by atoms (Question 12 (d)), trend in reactivity down Group 1 (Question 12 (e) (ii)) and effect of a catalyst on rate of reaction (Question 14 (b)) were particularly well answered.

Questions on percentage composition of the air (Question 11(b)), potable water (Question 13(a)), activation energy (Question 14 (b) (ii)), using an equation to derive a formula Question 14 (c) (i), reasons for cracking Question 14 (d) and electronic structure Question 16 (f) proved to be the most challenging for candidates.

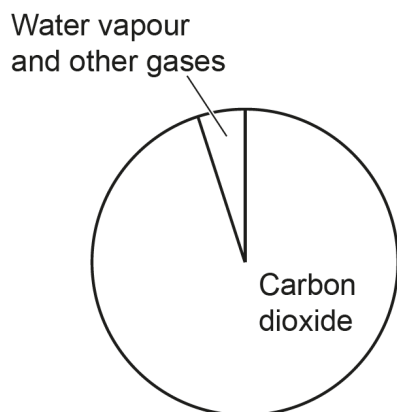
A significant number of candidates omitted calculating amount of krypton (Question 11 (d) (i)), writing a word equation (Question 12 (a) (i)), explaining a reaction (Question 12 (a) (ii)), extraction of metals (Questions 12 (c) (i) and 12 (c) (ii)), trend in reactivity (Question 12 (e) (i)), using an equation to derive a formula (Question 14(c) (i)), describing cracking (Question 14 (c) (ii)), reasons for cracking (Question 14 (d)) and many parts of the overlap (Question 16).

There was no evidence that candidates did not have enough time to complete the paper.

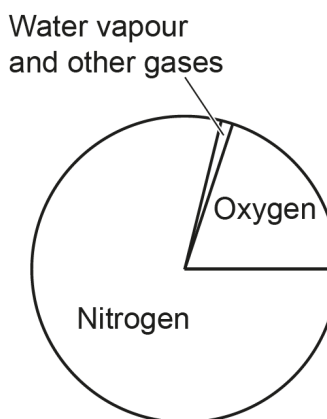
### Question 11 (a)

- 11 The diagram shows how the composition of the Earth's atmosphere has changed over time.

**Earth's early atmosphere**



**Earth's atmosphere today**



- (a) What produced the gases present in the Earth's **early** atmosphere?

Tick (✓) **one** box.

Earthquakes

Thunderstorms

Volcanoes

[1]

Effect of volcanoes was well known. Earthquakes was a common response.

### Question 11 (b)

(b) What is the percentage of oxygen in the Earth's atmosphere **today**?

..... [1]

The most successful candidates knew the percentage of oxygen. Answers ranged from 0.05% to 99%

### Question 11 (c)

(c) The amounts of carbon dioxide and water vapour in the Earth's early atmosphere decreased over time.

Draw lines to connect each **gas** with the correct description of **how it decreased over time**.

| Gas  | How it decreased over time  |
|--|---|
| <div style="border: 1px solid black; width: 100%; height: 100%; display: flex; align-items: center; justify-content: center; margin-bottom: 10px;">Carbon dioxide</div> <div style="border: 1px solid black; width: 100%; height: 100%; display: flex; align-items: center; justify-content: center;">Water vapour</div> | <div style="border: 1px solid black; width: 100%; height: 100%; display: flex; align-items: center; justify-content: center; margin-bottom: 10px;">Condensed to form the oceans</div> <div style="border: 1px solid black; width: 100%; height: 100%; display: flex; align-items: center; justify-content: center; margin-bottom: 10px;">Reacted with bacteria</div> <div style="border: 1px solid black; width: 100%; height: 100%; display: flex; align-items: center; justify-content: center; margin-bottom: 10px;">Reacted with metals in rocks</div> <div style="border: 1px solid black; width: 100%; height: 100%; display: flex; align-items: center; justify-content: center;">Absorbed by plants during photosynthesis</div> |

[2]

More successful candidates gained full credit. Carbon dioxide reacted with metals in rocks was a common response and many candidates drew two lines from each gas.

## Question 11 (d) (i)

(d) The Earth's atmosphere today contains gases from Group 0 in the Periodic Table.

(i) The table shows the amounts of the gases from Group 0 in the Earth's atmosphere today.

| Gas     | Amount of gas (%) |
|---------|-------------------|
| Helium  | 0.000524          |
| Neon    | 0.00182           |
| Argon   | 0.934             |
| Krypton | .....             |

The **total** amount of the gases from Group 0 is 0.938%.

Complete the table by calculating the **exact** amount of krypton in the Earth's atmosphere today.

Write your answer in the box in the table.

[2]

More successful responses added and then subtracted correctly. Many added the values with no subtraction or ignored the exponential in their answer. 0.938% was also a common response.

## Question 11 (d) (ii)

(ii) What is a property of the Group 0 gases?

Tick (✓) **one** box.

They are coloured.

They are unreactive.

They exist as molecules.

[1]

Unreactivity of Group 0 was well known in the more successful responses. Both other responses were common.



## Question 12 (a) (i)

12 The reactivity series lists metals in order from the most reactive to the least reactive.

Fig. 12.1 shows part of the reactivity series, including the non-metal carbon.

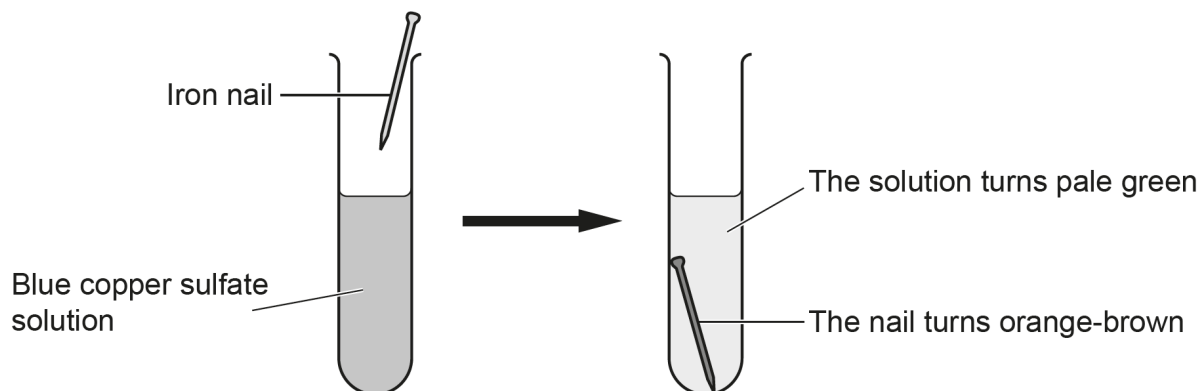
Fig. 12.1

|           |                |
|-----------|----------------|
| Sodium    | most reactive  |
| Lithium   |                |
| Magnesium |                |
| Carbon    |                |
| Zinc      |                |
| Iron      |                |
| Lead      |                |
| Copper    |                |
| Silver    |                |
| Gold      | least reactive |

(a) A student places an iron nail in a solution of copper sulfate. A displacement reaction takes place.

Fig. 12.2 shows their experiment.

Fig. 12.2



(i) The student writes the word equation for the reaction.

iron + copper sulfate  $\rightarrow$  ..... + .....

Complete the word equation for the reaction.

[1]

The more successful responses completed the word equation. Many repeated the left-hand side or gave both substances as sulphates. Iron sulphide and water were also common.

## Question 12 (a) (ii)

(ii) Why does this reaction happen?

Use the reactivity series in **Fig. 12.1**.

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

More successful responses discussed the relative reactivity of copper and iron. Many discussed rusting and some acidic behaviour or rates of reaction.

## Question 12 (b)

Use the reactivity series in **Fig. 12.1** to answer parts (b), (c) and (d).

(b) Another student repeats the experiment but places a **different** metal in the solution of copper sulfate.

There is **no** chemical reaction.

Suggest a metal that this student used.

..... [1]

Many candidates interpreted the order of reaction and chose gold and some silver. Zinc and lead were common.

## Question 12 (c) (i)

(c) (i) Name **one** metal that can be extracted by heating its oxide with **carbon**.

..... [1]

More successful responses chose a correct metal. Magnesium, steel and lithium were common incorrect responses.

## Question 12 (c) (ii)

- (ii) Name **one** metal that can be extracted from its oxide by electrolysis but **not** by heating its oxide with carbon.

..... [1]

More successful responses chose a correct metal. Lead, copper, zinc and silver were common errors.

## Question 12 (d)

- (d) Complete the sentence below to explain the difference in the reactivity of sodium and lithium.

Use **one** of the words.

|                  |                 |                |
|------------------|-----------------|----------------|
| <b>electrons</b> | <b>neutrons</b> | <b>protons</b> |
|------------------|-----------------|----------------|

Sodium atoms lose ..... more easily than lithium atoms. [1]

The majority of candidates understood the role of electrons. Protons was the common incorrect response.

## Question 12 (e) (i)

- (e) (i) State the trend in reactivity of the Group 1 metals.

..... [1]

The most successful responses described the trend and direction within the Group. Many discussed a trend with no direction or discussed the Group as a whole including all reactive, all metals and all have one electron on their outer shell

## Question 12 (e) (ii)

- (ii) Name a Group 1 metal which is more reactive than sodium.

..... [1]

Many candidates chose a more reactive metal the most common being potassium. Lithium was the common incorrect response and hydrogen was also quite popular.

### Question 13 (a)

**13** Drinking water that comes from lakes and reservoirs must be made safe to drink.

**(a)** Which name is given to water that has been made safe to drink?

Tick (✓) **one** box.

Filtered

Ground

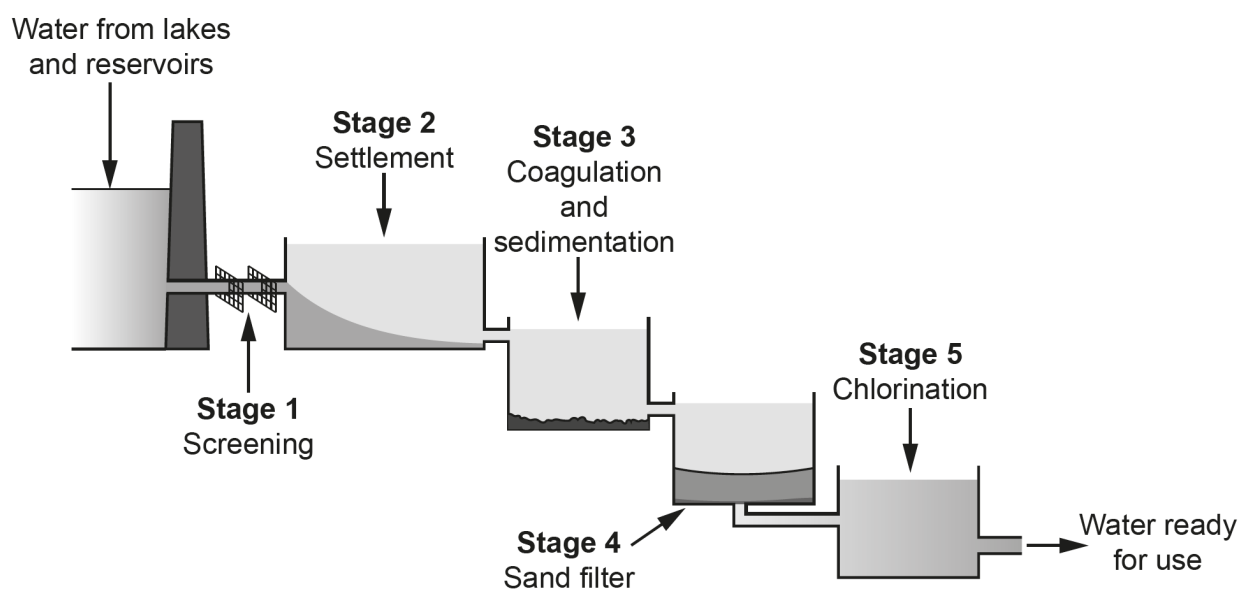
Potable

**[1]**

The most successful responses chose 'potable'. Most candidates chose 'filtered'.

## Question 13 (b)

(b) The diagram shows the stages in the treatment of water from lakes and reservoirs.



In **Stage 1** large objects such as leaves and twigs are removed.

What happens at **Stages 2, 3 and 4**?

Tick (✓) **one** box in each row.

|  | <b>Stage 2</b><br>Settlement | <b>Stage 3</b><br>Coagulation and<br>sedimentation | <b>Stage 4</b><br>Sand filter |
|--|------------------------------|--|-------------------------------|
| Any remaining mud or grit is removed.                  |                              |  |                               |
| Sand and soil sink to the bottom of the tank.          |                              |  |                               |
| Small particles of dirt clump together to form sludge. |                              |  |                               |

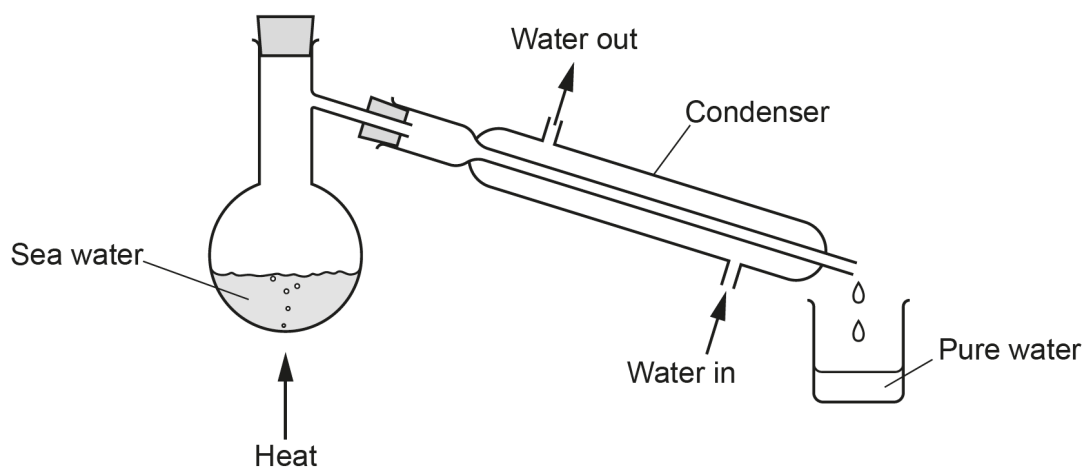
[2]

Many candidates gained partial credit usually for Stage 3 or Stage 4, the most successful gained full credit.

## Question 13 (c)

(c) Water can also be purified by simple distillation.

The diagram shows the equipment used by a student to distil sea water.



Give **two** reasons why this equipment is **not** suitable to produce water on a large scale.

1 .....

.....

2 .....

.....

[2]

Both a long time and only a small amount of water produced were both well-known with more successful candidates gaining full credit. Needing a large amount of energy was much less popular and some repeated the question stem.

## Question 13 (d)

(d) On average **one person** in the UK uses 149 litres of water every day.

Only 3% of this water is used for drinking.

Calculate the amount of drinking water a family of **four** uses every day.

Give your answer to **3** significant figures.

Amount of drinking water = ..... litres **[3]**

Calculation of the amount of drinking water was achieved by many candidates with higher scoring candidates quoting their answer to 3 significant figures. Multiplying by four was common, calculation of percentage was the more challenging part of this question. Showing working in calculations worth more than one mark is advised as working and error carried forward marks can often be given even when the final answer is incorrect.

## Question 14 (a)

14 The processing of crude oil by the petrochemical industry can be shown by different experiments.

Fig. 14.1 shows an experiment where paraffin is turned into decane and gas X.

Fig. 14.1

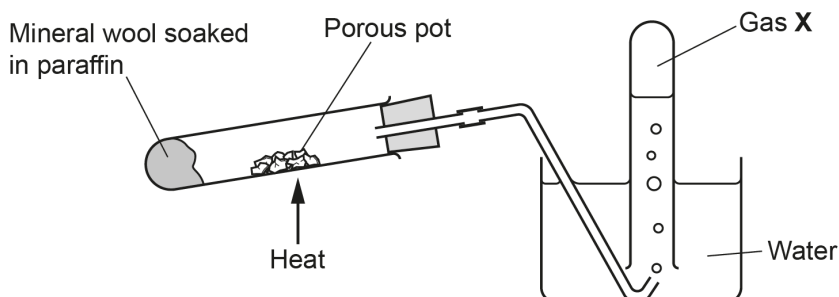
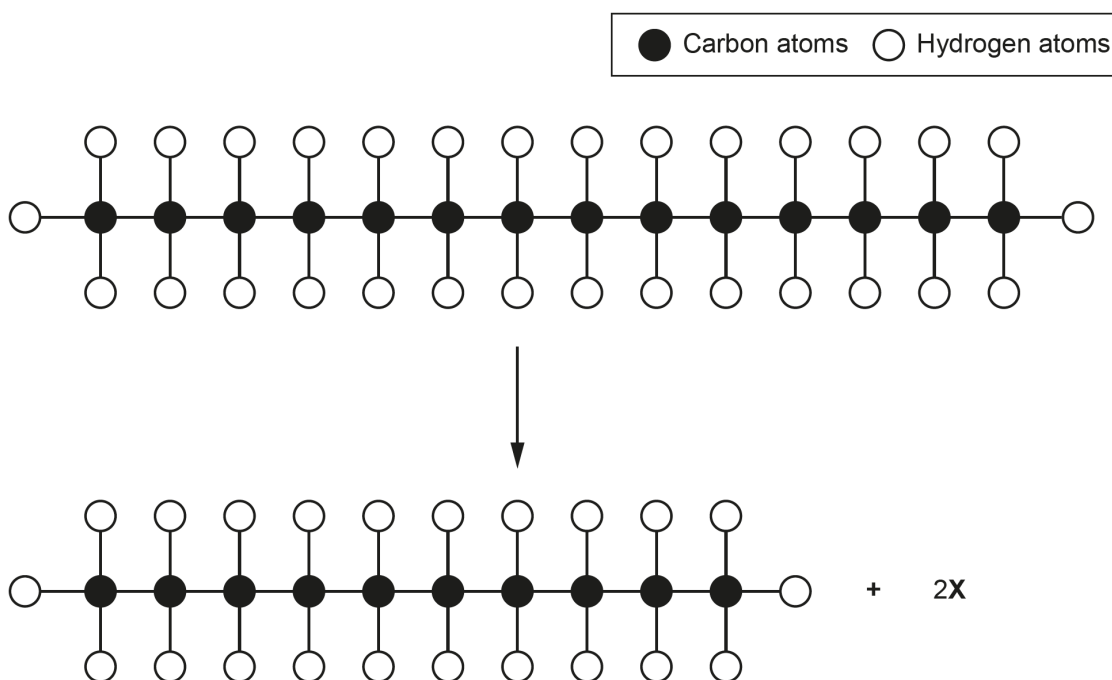


Fig. 14.2 shows the reaction of paraffin,  $C_{14}H_{30}$ , to make decane,  $C_{10}H_{22}$ , and gas X.

Fig. 14.2



(a) Complete the sentences below to describe the experiment.

Put a ring around the correct choice to complete each sentence.

The experiment is called **cracking** / **displacement** / **distillation**.

It is an example of **combustion** / **reduction** / **thermal decomposition**.

[2]



The most successful responses chose both of the correct descriptions with many choosing one. Distillation, displacement and combustion were all common responses.

### Question 14 (b) (i)

(b) The porous pot in **Fig. 14.1** acts as a **catalyst** in the reaction.

(i) What effect does the porous pot have on the **rate of the reaction**?

Put a **ring** around the correct answer.

**decreases it**

**increases it**

**no effect**

[1]

The role of a catalyst was well known.

### Question 14 (b) (ii)

(ii) What effect does the porous pot have on the **activation energy** of the reaction?

Put a **ring** around the correct answer.

**decreases it**

**increases it**

**no effect**

[1]

The most successful responses understood the role on activation energy. All responses were seen.

### Question 14 (c) (i)

(c) Use **Fig. 14.2** to answer these questions.

(i) Write the formula of gas **X**.

..... [1]

Some candidates calculated  $C_4H_8$  by omitting the two before the X. Carbon dioxide and many other hydrocarbons were common.

### Question 14 (c) (ii)

(ii) Describe what happens to a molecule of paraffin as it turns into a molecule of decane.

.....

.....

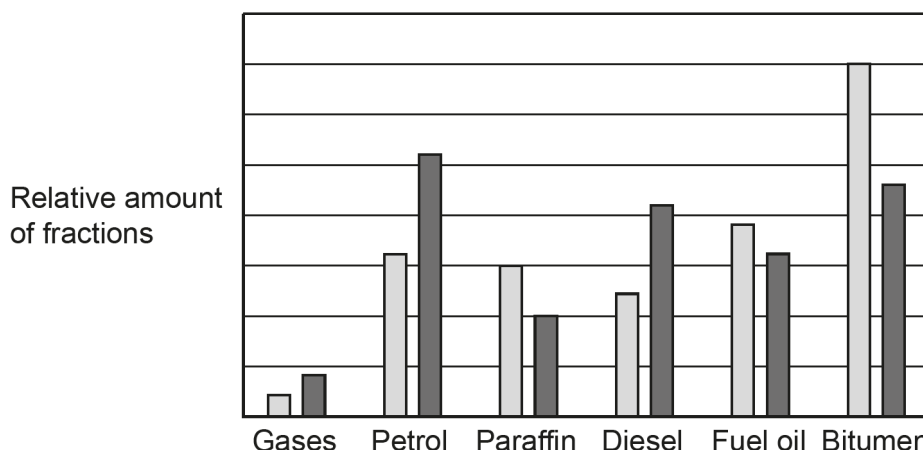
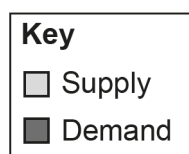
..... [2]

The most successful responses used the Figure and described the changes to the molecule of paraffin. Change of state was a popular response and many omitted the question.

### Question 14 (d)

(d) Fig. 14.3 shows the supply and demand of different fractions of crude oil.

Fig. 14.3



Give **two** reasons why the oil industry turns paraffin into different hydrocarbons.

Use data from **Fig. 14.3**.

1 .....

.....

2 .....

..... [2]

The more successful responses interpreted the graph to compare the demand and supply of paraffin, with many discussing either the supply or the demand, The very highest scoring candidates discussed the greater usefulness of the products. Making more money was a popular response.



The majority of candidates attempted this Level of Response Question and gained some credit. Most candidates discussed the data in the graphs without adding any relevant scientific knowledge which restricted their answer to Level 1. More successful responses linked the greater carbon dioxide emissions to global warming and climate change, the lesser amount of solid waste to needing less landfill, less use of fossil fuels to their finiteness or sulphur dioxide production leading to acid rain, or the relative strength of the bags when wet. Unspecified pollution, environmentally friendly and green were popular vague responses.

### Exemplar 1

I think carrier bags should be made from biodegradable plastic because even though it uses more CO<sub>2</sub> emissions than recycled paper, less energy is used and also less solid waste, also the amount of water used is equal so overall the plastic is better. Also recycled paper you would have to do it over and over again when its recycled the biodegradable plastic just goes finally plastic paper bags are not very practical.

Biodegradable plastic is chosen and all of the data from the graphs are discussed, less energy, more carbon dioxide, less waste and same amount of water. There is no extra knowledge. This gains Level 1, 2 marks.

## Exemplar 2

biodegradable plastic should be used so that less energy is used. It also uses less solid waste, and uses the same amount of water as recycled paper. However, this plastic emits more carbon dioxide than recycled paper. This ~~can~~ could be avoided by ~~filtering~~ the ~~air~~ using sustainable energy such as wind turbines. That way it can ~~produce~~ emit less carbon dioxide.

Biodegradable plastic is chosen and all of the data from the graphs are discussed, less energy, more carbon dioxide, less waste (the use of use is condoned) and same amount of water. There is one piece of extra knowledge, reducing the carbon dioxide emissions by using sustainable energy, e.g. wind. This is Level 2, 3 marks.

## Exemplar 3

\* Recycled paper takes more energy to be made (negative point) \* Biodegradable takes less energy (positive point) \* recycled paper has less CO<sub>2</sub> emissions, which is better for the planet, causing less global warming \* Biodegradable plastic has a high CO<sub>2</sub> emissions  
 \* recycled paper ~~releases~~ releases more solid waste, which is bad as they all end up in ~~landfills~~ landfills not being recycled or even re-used again \* Biodegradable has lower amount of solid waste \* Have the same amount of water used \* I would suggest biodegradable plastic as it uses less energy and solid waste compared to \* [6]

15) \*1 recycled paper  
15) ~~a waste of energy is a bad thing as~~  
~~this energy could be used as it requires~~  
~~more energy to produce more recycled~~  
~~bags this means there will be a higher~~  
~~input in energy than output of bags.~~

All of the data from the graph are discussed for either recycled plastic or paper and biodegradable plastic is chosen at the end of the response. There are two explanations using own knowledge, less emission of carbon dioxide linked to less global warming and more solid waste linked to landfill. This gains Level 3, 5 marks.

## Question 16 (a)

16 This question is about the Group 7 elements.

Table 16.1 shows some information about the Group 7 elements.

Table 16.1

| Element  | Molecular formula | Appearance at room temperature | Size of molecule (pm) | Boiling point (°C) |
|----------|-------------------|--------------------------------|-----------------------|--------------------|
| Fluorine | F <sub>2</sub>    | pale-yellow gas                | 128                   | -188               |
| Chlorine | Cl <sub>2</sub>   | green gas                      | 204                   | -34                |
| Bromine  | Br <sub>2</sub>   | orange-brown liquid            | 240                   |                    |
| Iodine   | I <sub>2</sub>    | grey-black solid               | 278                   | 184                |
| Astatine | At <sub>2</sub>   | .....                          | 300                   | 350                |

(a) Complete the table by predicting the appearance of astatine at room temperature.

Write your answer in the box in Table 16.1.

[1]

More successful responses followed the trend in Table 16.1. Many either gave the colour or the state. Orange, purple blue and liquid were common responses.

## Question 16 (b)

(b) The sizes of the molecules are measured in picometres (pm).

$$1 \text{ picometre} = \frac{1}{1\,000\,000\,000\,000} \text{ metre}$$

What is the size of a fluorine molecule in metres (m)?

Tick (✓) **one** box.

$1.28 \times 10^{-12} \text{ m}$

$1.28 \times 10^{-10} \text{ m}$

$1.28 \times 10^{10} \text{ m}$

$1.28 \times 10^{12} \text{ m}$

[1]

Many candidates chose the correct size.  $1.28 \times 10^{-12}$  was a popular response.

## Question 16 (c)

(c) Which element has a molecule that is **closest** to twice the size of a molecule of fluorine?

Tick (✓) **one** box.

Chlorine  Bromine  Iodine  Astatine

[1]

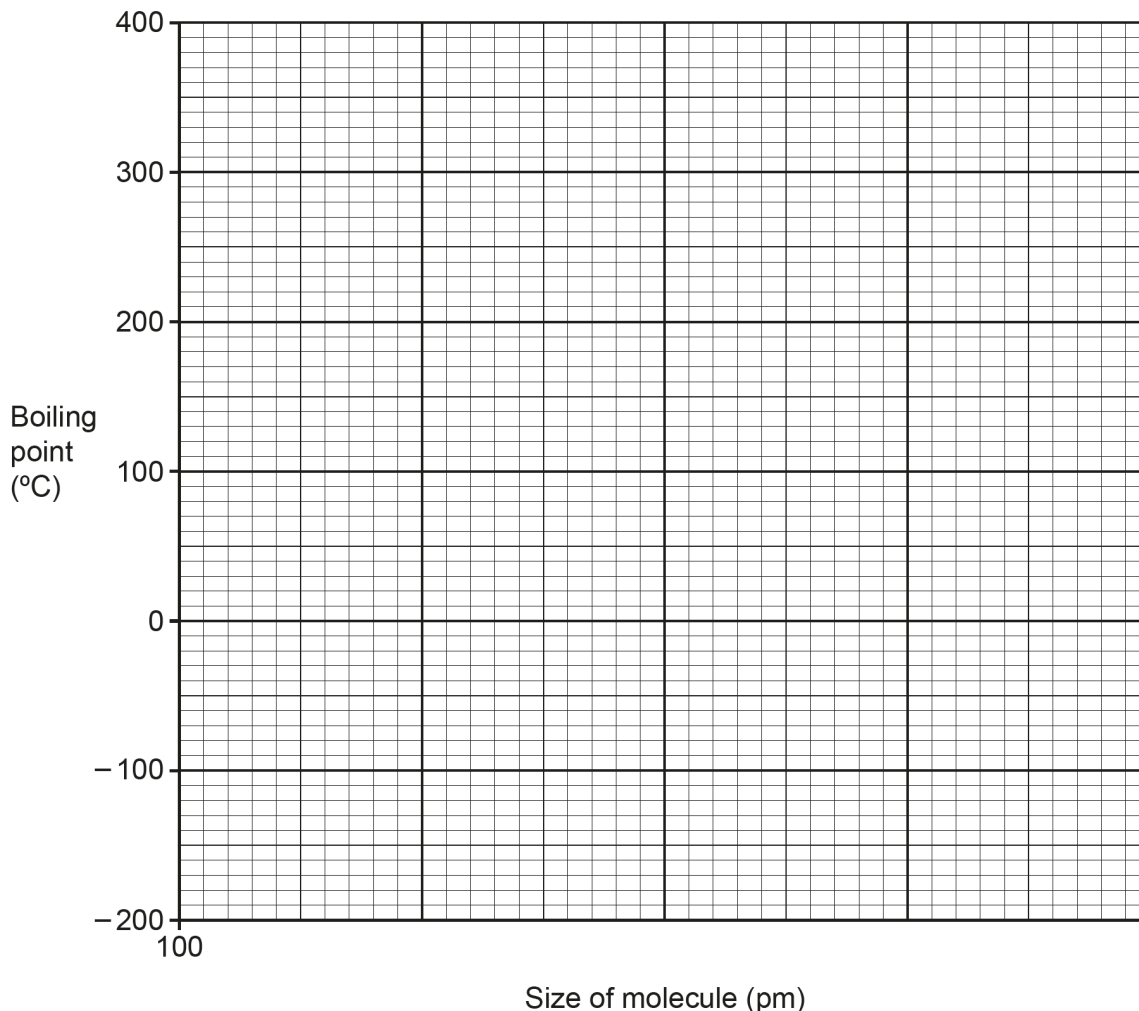
Many candidates multiplied the size of fluorine by two and chose bromine. Iodine and chlorine were popular responses.



## Question 16 (d) (i)

- (d) (i) Use **Table 16.1** to complete the x axis and plot a **line graph** of the boiling points of fluorine, chlorine, iodine and astatine against the size of their molecules.

Draw a line of best fit.



[4]

More successful responses deduced a linear scale for the x-axis, plotted the points and drew a curved line of best fit. This graph was challenging as the data points were difficult and many interpreted line of best fit as a straight line.

### Assessment for learning

Scales should be chosen so that the plotted points cover at least half of the grid and also be straightforward to use; points which require the use of a calculator are usually then misplotted.

A line of best fit may be a straight line or a curve depending on the plotted points. It should be a single line and not feathery.

**Misconception**

Interpretation of a line of best fit to mean a straight line.

A line of best fit is the line which is the best fit for the points and so may be a straight line or a curve dependent on the points.

**Question 16 (d) (ii)**

(ii) Use your graph to predict the boiling point of bromine.

Boiling point of bromine = ..... °C [1]

More successful responses used their line to predict the boiling point.


**Assessment for learning**

Drawing construction lines onto the graph will help candidates to read the required value from it.

## Question 16 (e)

Table 16.1 is repeated below.

Table 16.1

| Element  | Molecular formula | Appearance at room temperature  | Size of molecule (pm) | Boiling point (°C) |
|----------|-------------------|---|-----------------------|--------------------|
| Fluorine | F <sub>2</sub>    | pale-yellow gas   | 128                   | -188               |
| Chlorine | Cl <sub>2</sub>   | green gas   | 204                   | -34                |
| Bromine  | Br <sub>2</sub>   | orange-brown liquid   | 240                   |                    |
| Iodine   | I <sub>2</sub>    | grey-black solid  | 278                   | 184                |
| Astatine | At <sub>2</sub>   |  | 300                   | 350                |

(e) A student thinks that fluorine molecules have the **weakest** intermolecular forces.

Give **two** reasons why they are correct.

Use data from **Table 16.1**.

- 1 .....
- .....
- 2 .....
- .....

[2]

More successful responses interpreted the data in Table 16.1 and gave the comparative answers smallest and lowest boiling point. Small and low boiling point were very popular responses.

**Question 16 (f)**

- (f) Describe **one** similarity and **one** difference in the arrangement of electrons in **atoms** of fluorine and chlorine.

Similarity .....

.....

Difference .....

.....

[2]

The most successful responses compared the arrangement of the electrons in the two atoms. Many discussed properties of the two substances or repeated the data from Table 16.1.

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