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Examiners' report

GCSE

TWENTY FIRST CENTURY SCIENCE CHEMISTRY B

OCR Level 1/Level 2 GCSE (9-1) in Chemistry B (Twenty First Century Science)

J258

For first teaching in 2016

J258/04 Summer 2025 series

Version 1

Contents

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 responses is 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 Teach Cambridge.

Paper 4 series overview

This paper is the second of two papers to assess specification content for Higher Tier candidates for Twenty First Century Science, Chemistry (B). This specification has Ideas About Science (Unit 7 of the syllabus) embedded into both the teaching and assessment, and the specification content is accompanied by a narrative which provides additional guidance regarding the scope and exemplification of the specification statements. The assessment is characterised by questions that have unfamiliar information and contexts that the candidates are expected to interpret and apply their knowledge. This paper tests depth of knowledge and requires candidates to show their knowledge, understanding, processing and application of learning of the specification content. The first two questions are shared with the Foundation Tier and so appear on both J258/02 and J258/04.

The paper relies on a short answer format, with some objective questions that require candidates to complete recognition tasks such as to tick or join boxes. In addition, in keeping with the nature of the specification, some questions require candidates to interpret unfamiliar information and use it to support and justify scientific applications, hypotheses, theories and patterns. An example of this is Question 3.

Two questions are Level of Response questions; Question 5 (b) and Question 8 (a). To answer these questions well, it is essential that candidates demonstrate interpretation of all of the data available to them and also that they answer all parts of the task, often indicated by bullet points that link to the question. A common limitation in Level of Response answers is that candidates typically do not fully address either all of the provided data or that they omit some aspects of the task. This is the main reason that some candidates are limited to Levels 2 or 1.

Mathematical questions were generally very well answered. Candidates showed themselves proficient at using standard form, interpreting mathematical symbols, carrying out calculations and extracting data from tables and graphs.

In general terms, the performance of candidates showed that they are committed to the assessment and interact well with the paper. There were few spaces left blank and few un-attempted part questions. Candidates used all available space and remained engaged throughout the paper. Some candidates add answers on additional pages. It should not be necessary to do this, and candidates who write very lengthy answers often contradict themselves. It is not always the case that longer answers earn more marks. For Level of Response question, giving overly long answers sometimes compromises the logical structure or line of reasoning and can result in the lower mark in a level being awarded.

In common with Paper 03, an area for development is practical skills. All practical questions were significantly less well answered than those that relied on knowledge. It appears that some candidates have significant gaps in practical knowledge that is clearly stated on the specification. Candidates were unsure about the collection of a gas in an electrolysis experiment in Question 2 (b) (i), the correct direction of water through a condenser in Question 3 (a) (i) and the test for chloride ions in Question 3 (a) (ii).

Other areas for focus include ensuring that candidates read questions carefully and address the task fully. This includes taking into account the number of marks available and the information given in the question. The amount of detail expected is also indicated by bullets for some questions and by the number of lines provided. Responses to questions such as 6 (a), where 3 marks were available, should be structured carefully to make sure that the candidate addresses enough points to earn all marks.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• planned longer answers to fully address the number of marks available • had checked their learning carefully against the specification to make sure that they remembered the finer details • read the question carefully and address all aspects of the task, including ensuring that any bullet points in the question are fully addressed • set out their working for mathematical questions carefully so that partial marks may be awarded even if the final answer is incorrect.	• gave longer answers than necessary, introducing contradictions and errors • repeated information from the question rather than adding information, explanations or interpretations • showed only partial knowledge of practical techniques that are part of the specification content • gave partial answers that did not address all parts of a question

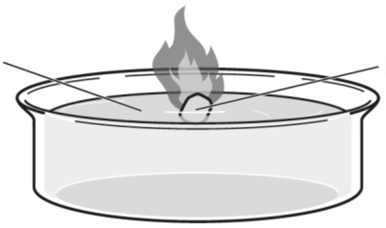
Question 1 (a)

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]

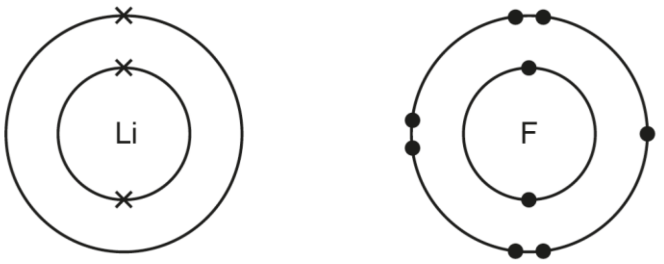
The idea of this question was that products and observations were presented for the reaction of potassium with water and candidates were expected to use this to inform their answer about the reaction of sodium. Those who did this gave three correct points, naming the products and giving two observations, such as that the sodium moves and fizzes less violently and either does not produce any flame or shows a yellow flame. Most candidates were able to name the products. The main fault in answers were firstly that some candidates implied that the reaction of sodium is as vigorous as that of potassium, for example stating that there would be violent fizzing. Secondly, some did not make any reference to the flame.

Question 1 (b) (i)

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

Fig. 1.2

Lithium atom Fluorine atom



(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]**

Almost all candidates knew that the number of electrons in the outer shell (1 for lithium and 7 for fluorine) is the same as the group number on the Periodic Table.

Question 1 (b) (ii)

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

....

.... **[1]**

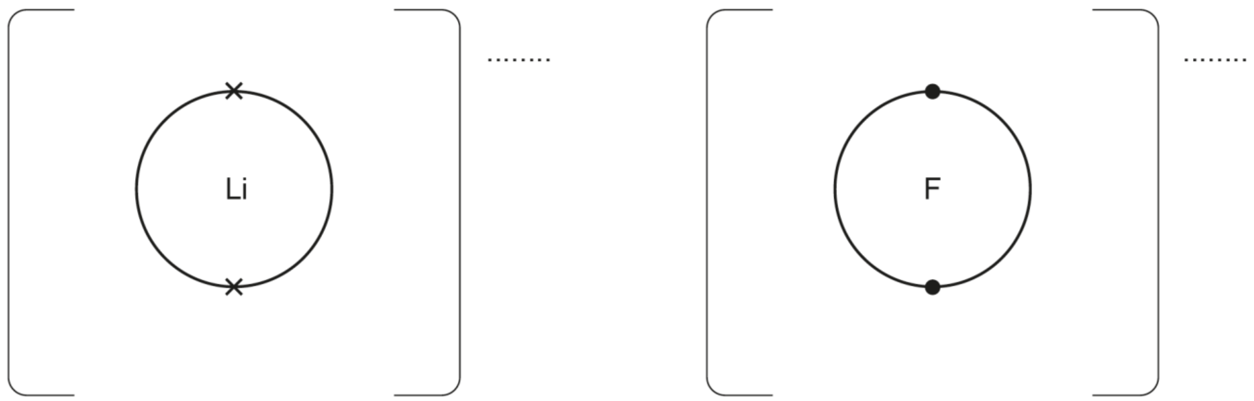
Again, this was well answered with most candidates stating that the number of shells gives the period number. A common incorrect answer was that both have one complete shell of electrons. This is a true statement but does not answer the question.

Question 1 (b) (iii)

(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]**

Most candidates gave the correct charges for lithium and fluoride ions. Some made errors in drawing the electron arrangement. Some completed both identically to the atoms shown in Fig 1.2. Although most knew that fluoride ions have eight electrons, some incorrectly added electrons to the first shell rather than add an additional shell. As this is an ionic dot and cross diagram, it was important that candidates differentiated between the electrons. Best answers showed a second shell on the fluoride ion with seven dots and one cross, indicating an electron gained from lithium.

Question 1 (b) (iv)

(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]

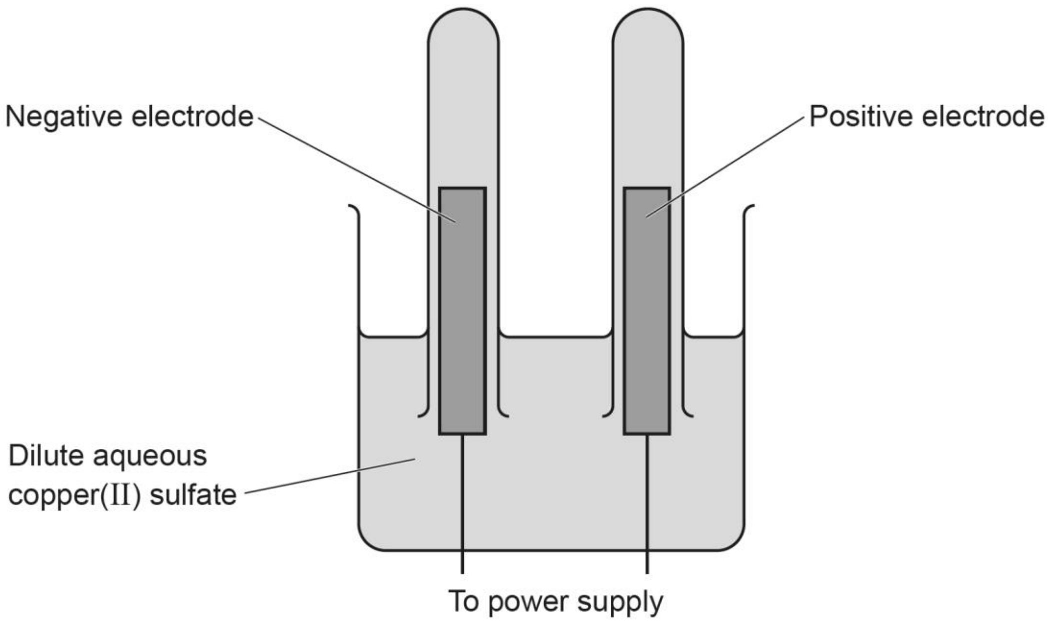
Most selected the correct answer, that the dot and cross diagram does not show that ions are different sizes, although some incorrectly selected the second option, thinking that the ratio of ions is not shown.

Question 2 (a)

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]

Almost all candidates made at least one correct selection, and many gained both marks, implying that the formation of non-metal products at the anode is well known.

Question 2 (b) (i)

(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]**

Many candidates offered a gas syringe to measure the volume of gas, and as this is commonly a good way to measure gas volume, it was accepted here. A graduated collection tube would be a more appropriate solution.This would not typically be appropriate in this situation but it is a teaching point that the measuring apparatus needs to be appropriate to the practical context.

Assessment for learning

Candidates need to be able to select apparatus appropriate to a particular practical context. For gas collection, a gas syringe is not always a suitable choice.

Question 2 (b) (ii)

(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]**

In order to measure rate, two results need to be collected; time and volume of gas. There are two basic methods for finding rate. Either the volume of gas in a fixed time can be measured, or the time to collect a fixed volume of gas can be measured. This was not always clearly stated. Many candidates said that they would ‘count bubbles’ or ‘find the amount of gas’ without specifically stating that this would be measured by volume. Most knew that the ‘amount’ or ‘volume’ needed to be divided by time to get a value for rate.

Assessment for learning

In general, gases, liquids and aqueous solutions are always measured by volume and solids are measured by mass. Marks are not usually awarded for 'measure the amount' as this is insufficient to clearly show what they are measuring.

Question 2 (c)

(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]

Most candidates stated the mass change at each electrode, showing that they had interpreted the data provided. Many correctly stated that a gas forms at the positive electrode and a solid or metal is formed at the negative electrode. One common error was that some candidates did not offer explanations for the mass changes at each electrode. Others made incorrect statements using 'ions' incorrectly. For example, some stated that ions (rather than a metal or a solid) form around the negative electrode, increasing its mass.

Question 3 (a) (i)

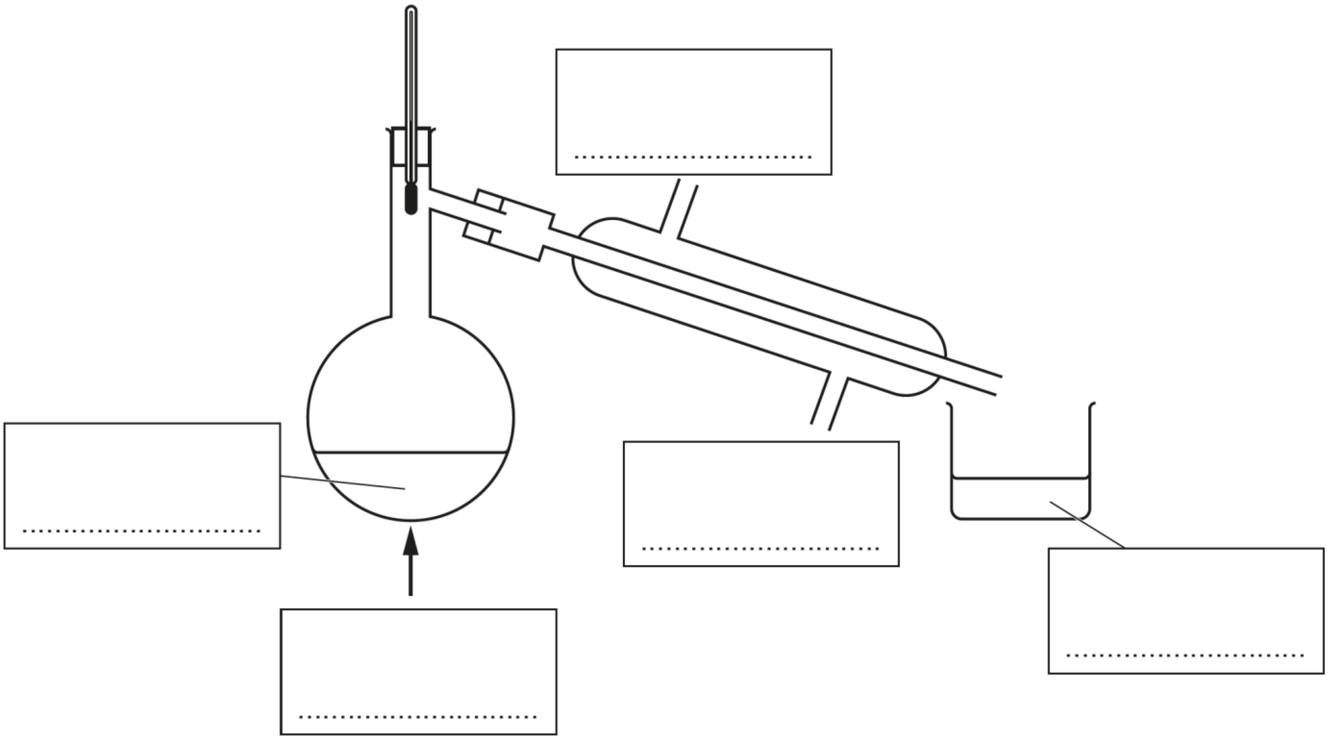
3 Water for drinking can be separated from sea water by distillation.

(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.

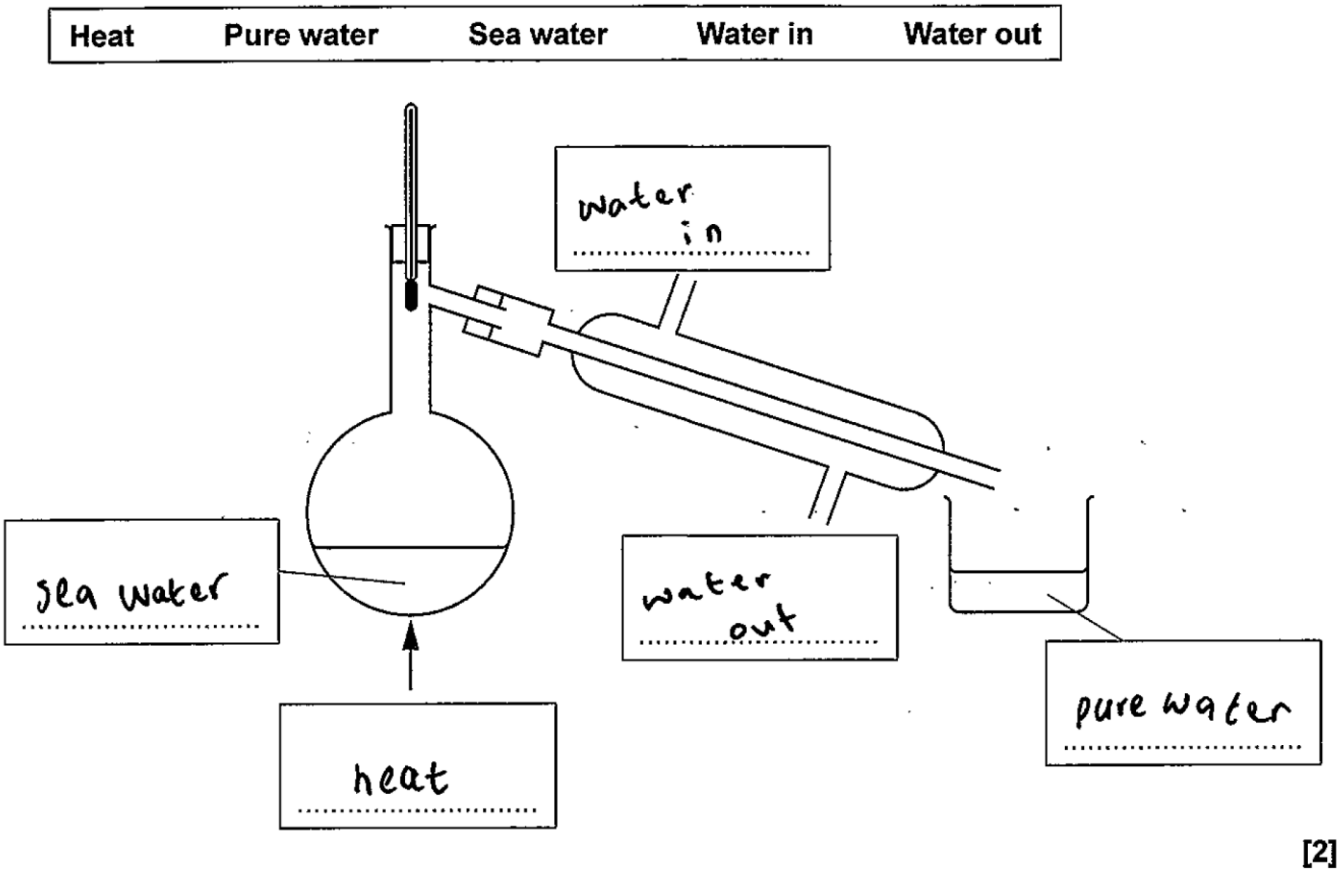
Heat	**Pure water**	**Sea water**	**Water in**	**Water out**



[2]

Almost all gained one mark. The challenge for most candidates was that most thought that water enters the top, rather than the bottom, of the condenser.

Exemplar 1



This answer is typical of the most common partially correct response seen. The candidate has correctly identified that the seawater is in the round bottomed flask, the pure water is in the beaker and has labelled the point of heat correctly. However, notice that they have the water flowing into the top, rather than the bottom, of the condenser. Connected in this way the condenser does not fill with water and so does not cool the vapour sufficiently. This answer was given 1 mark.

Question 3 (a) (ii)

(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]

Candidates found this practical question very challenging. Most did not know the correct positive and negative test result for acidified silver nitrate when added to chloride ions. Best answers clearly stated the correct 'text book' observations for the positive and negative test; white precipitate for sea water and remains colourless for water after distillation. Most gave what appeared to be guesses such as 'fizzing', or 'goes cloudy'. 'No change' was accepted as a negative result, but not incorrect statements such as 'clear' or 'nothing'. In the explanation, it was necessary to state that the ion that causes a change with silver nitrate is the chloride ion. Most incorrectly stated that sea water 'contains sodium chloride'. This is incorrect because it does not clearly identify which ion in the sea water is causing the change.

Misconception

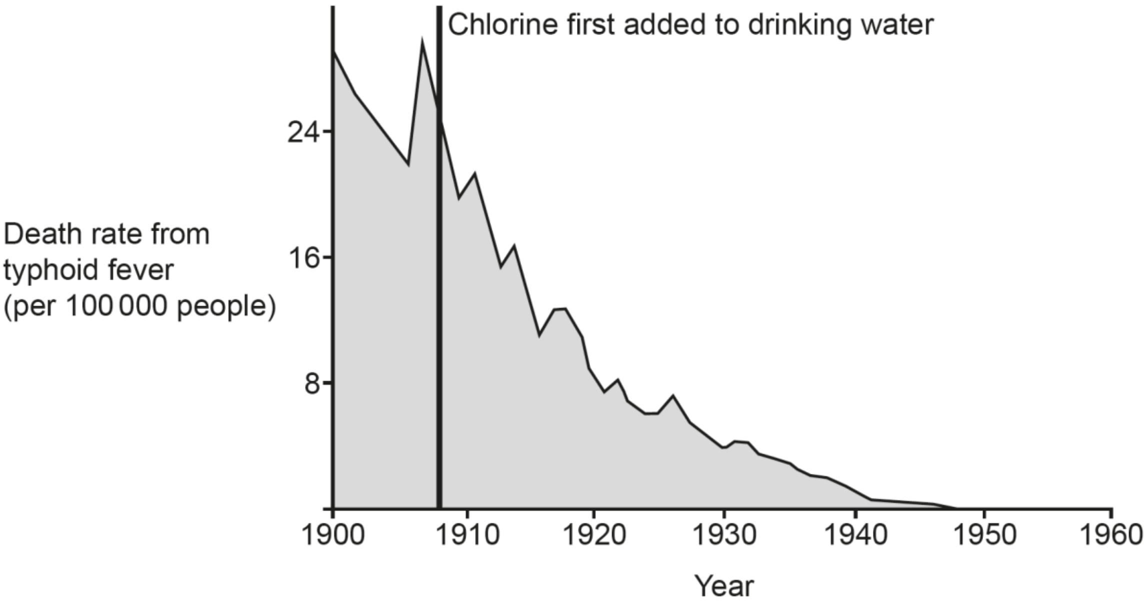
Many candidates use the term 'clear' instead of 'colourless'. This is not accepted as even coloured solutions are 'clear'.

Question 3 (b) (i)

(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]**

This question was well answered. Candidates typically identified the approximately 40 year period between when chlorine was first added, in 1908 and 1947 when the death rate fell to zero.

Question 3 (b) (ii)

(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]**

The question has two bullet points that need to be addressed. The candidates needed to include ideas about risk and benefit and refer to data from the graph. The most common reason for partial marks was that most candidates did not address both bullet points. Many did not clearly state that in this case the benefit of preventing death far outweighs the risk of causing allergies to a minority of people. A further limitation of answers was that some candidates repeated information in the question rather than showing that they understood its significance. Answers that stated 'chlorine causes allergies in some people' is a direct copy of the information in the question and so this statement alone does not gain any marks.

Question 3 (c)

(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]**

Most candidates understood the peer review process in terms of scientists checking the work of other scientists. They also knew that newspapers are written for a public audience. A common misconception seen was that the validity of the information differs depending on where it is published. Some candidates said that newspapers publish misleading or incorrect information, others said that information in the newspapers is 'proved to be true'.

Question 4 (a)

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]

Almost all candidates gave the correct symbol for oxygen, and balanced the numbers of oxygen atoms. Fewer gave '4Fe'. A common error was to write '$2Fe_2$'. The state symbols were challenging. Some gave (G) rather than (g) for oxygen. Iron oxide was sometimes represented as (aq).

Question 4 (b) (i)

(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.	$\leqslant 2\%$
Copper	Increases electrical conductivity. Increases corrosion resistance in sea water.	~4%
Manganese	Increases hardness but can make steel more easy to break when bent.	$\leqslant 15\%$

(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]**

Best answers here made reference to the effect on properties of carbon in the table, stating that steel with 2% carbon breaks easily and does not have corrosion resistance. Weaker answers gave vague references to 'iron rusts' or 'iron is weak'. In common with other questions where information is given, it is important that all of the information is used. Some candidates made reference to 'easy to break' or 'no corrosion resistance' but did not refer to both.

Question 4 (b) (ii)

(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]

In common with part (b) (i) the main issue here was that some candidates appeared to try to answer the question without reference to the information in Table 4.1. Many chose the correct three elements, but the percentages suggested did not align with the percentages given in the table. Notice that nickel is given as >8 <10%. This means that the value suggested for nickel must be greater than 8 but less than 10. Most correct answers gave a value of 9 but values with decimal places, for example 8.1-9.9, were accepted. Part of the question demand was testing understanding of the mathematical symbols for 'greater than' and 'less than', which are part of the mathematical requirements of the specification.

Question 5 (a)

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.		

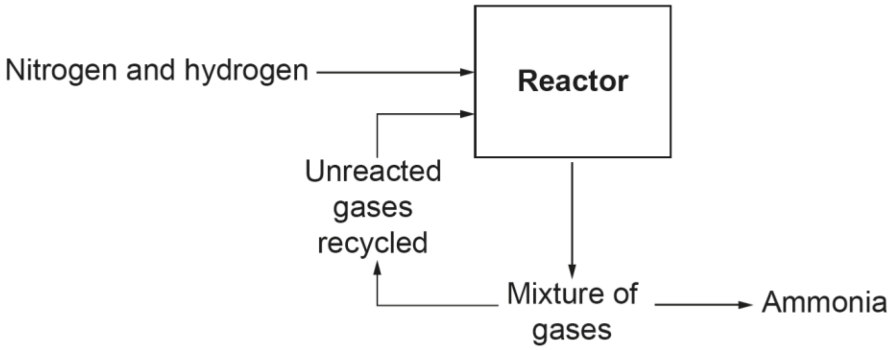
[2]

Candidates found this question very challenging. It was relatively common to see all three choices incorrectly indicated. This implies that this is an area of the specification that candidates find difficult.

Question 5 (b)*

(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]**

This is the first of the two Level of Response questions. In common with other questions, there is information to interpret and two bullets to define what candidates need to address in their answers.

Candidates who answered this question well looked carefully at the bullets and made sure to fully answer both. They referred to 'each condition' as stressed in bullet point 1, hence discussing temperature, pressure, the use of a catalyst and the recycling of gases. They also discussed why higher or lower values of temperature and pressure and not used.

The most common errors and omissions included;

- Some candidates did not fully answer each bullet. Some omitted some of the conditions from their answer, some did not discuss why higher or lower values of temperature and pressure are not used.
- Some candidates made errors such as stating that increasing rate always increases yield. This was usually linked to increasing the temperature or use of a catalyst.
- Some answers used large amounts of extra space, either repeating points or sometimes contradicting points. These answers often compromised the line of reasoning and logical structure, leading to the lower mark in the level being awarded.

Exemplar 2

• The forward reaction of the Haber process is Exothermic,
so a lower temperature would produce a higher yield.
• However, at a lower temperature, the rate of reaction is too
slow so 450°C is a compromise temperature.
• Higher temperature and pressure means a faster rate of
reaction
• A higher pressure causes a higher yield
• Higher pressures are expensive – cost of energy and very
dangerous – so compromise 200 atm is used.
• Iron catalyst increases the rate of reaction, without
increasing the yield
• Recycling unreacted gas, ~~also~~ increases the overall
yield. **[6]**

Notice the detail and structure of this answer. The candidate addresses each condition in turn, stating clearly why higher or lower values of temperature and pressure are not used. This is a Level 3, 6 mark answer.

Question 6 (a)

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]**

Questions relating to climate issues arising from use of fuels are usually well answered, but this question revealed some misconceptions in candidates' understanding. Best answers identified that burning methanol releases carbon dioxide, a greenhouse gas, but burning hydrogen produces only water. Common errors included:

- Some answers stated that burning hydrogen 'produces water'. Although this is a true statement, burning methanol also produces water. To earn a mark 'only' was an important addition; candidates needed to say 'produces water *only'*.
- Some candidates discussed the environmental effect of hydrogen or methanol themselves, rather than their combustion products.
- Many candidates gave incorrect combustion products for methanol. Methane and carbon were common incorrect answers. Although particulates are formed by incomplete combustion, the question was not about pollutants in general but about climate change, so the main issue to be identified was the production of carbon dioxide.

Question 6 (b)

(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]**

Candidates found it difficult to articulate the difference between a by-product and a waste product. The first difficulty was that many appeared to confuse 'by-product' with a recycled product. Many talked about by-products being 'used again' or waste products cannot be 'used again'. Some stated clearly that by-products have a use (and waste products do not) earning one mark. Fewer identified that the waste products need to be disposed of. Again, it was sometimes language ambiguities that meant that answers were not clear. Some answers stated that waste products 'go to waste', which does not add any significant clarity to the term 'waste product'.

Question 6 (c) (i)

(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]**

Almost every candidate correctly calculated the relative formula mass of carbon dioxide.

Question 6 (c) (ii)

(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]**

Most candidates gained partial marks for this calculation. Most knew that all the relative formula masses of either the products or the reactants need to be used as a denominator and most followed the instruction to 'give your answer to 1 decimal place'. The main issue was that many calculations used the relative formula mass of methane (the reactant) rather than hydrogen (the main product) as the numerator of the atom economy expression.

Exemplar 3

$8 + 44 \rightarrow 52$

$CH_4 \Rightarrow 12 + (1 \times 4) = 16$

$\frac{16}{52} = 4/13$

$\frac{\text{mr of wanted}}{\text{mr of all}} \times 100$

$\left(\frac{16}{52}\right) \times 100 = 30.76923077$

Atom economy = 30.8 % [4]

$4H_2$

$4 \times (1 \times 2) = 8$

This answer starts well. The candidate calculates that the total relative formula mass of hydrogen (the useful product) is 8 and that the total relative formula mass of the products is 52. This would have gained the first marking point, but the candidate then contradicts this by omitting the '8' entirely from their calculation. Instead, they have calculated atom economy based on methane, which is incorrect and does not answer the question. The only mark now available is the decimal place mark. Notice that the candidate shows that they have correctly rounded their answer to 1 decimal place, so error carried forward can be applied and one mark was given.

Question 6 (d)

(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]**

The relative values that needed to be included in the calculation were provided in the table, with two 'distraction' values. The first mark was for selecting the two relevant values (the theoretical yield and actual mass formed, 500 and 370) and the second mark was for processing these values correctly. Many candidates did this, but a common error was to use 1000 (the mass of methane used) as the denominator, rather than 500 (the theoretical yield of hydrogen).

Question 6 (e) (i)

(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]**

It is common for questions to ask about percentage yield and atom economy in the same question, as doing so tests whether candidates understand the difference between the two terms. This question proved very challenging because most stated the misconception that the yield cannot be 100% if more than one product is formed. The most successful candidates on this paper identified that the relevant point is not the number of products but the reversible nature of the reaction, showing that an equilibrium is reached so the yield does not reach 100%

Misconception

?

Many candidates confuse atom economy with yield. Many think that both are related to the number of products in the reaction equation.

Question 6 (e) (ii)

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

....

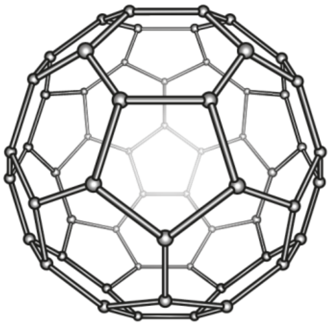
.... **[1]**

Candidates often referred correctly to the production of more than one product, or that a waste product is formed.

Question 7 (a)

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.

$1\,nm = 1 \times 10^{-9}\,m$

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

Tick (✓) **one** box.

$1 \times 10^{-8}\,m$ ☐

$1 \times 10^{-10}\,m$ ☐

$10\,nm$ ☐

$1 \times 10^{10}\,nm$ ☐

[1]

Understanding of nano-measurements expressed in standard form is an improving area of understanding. Most correctly estimated the diameter of a carbon atom.

Question 7 (b)

(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]**

In common with part (a), this area of the specification has seen an improvement over recent years. Many candidates were able to correctly calculate the surface area to volume ratio. Some candidates attempted to multiply the provided data by 10^{-9}, leading to values in the wrong order. This implies that candidates sometimes confuse the unit 'm' with 'nm', as given in the question.

Question 7 (c) (i)

(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]

Best answers referred to the structure of the buckyballs and applied this to the situation in the question. Hence, best answers stated that the hollow structure meant that buckyballs can carry medicine molecules and that their very small size enables them to travel in the blood or enter cells. Answers that did not gain credit were often vague, for example stating 'they can enter the body' or 'they can carry medicines'. Such statements do not significantly add to the information given. Another point that was not given a mark was that nanoparticles can target areas. This is partially true, but so can medicines that are delivered by conventional methods so this is not unique to buckyballs.

Question 7 (c) (ii)

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

....

.... **[1]**

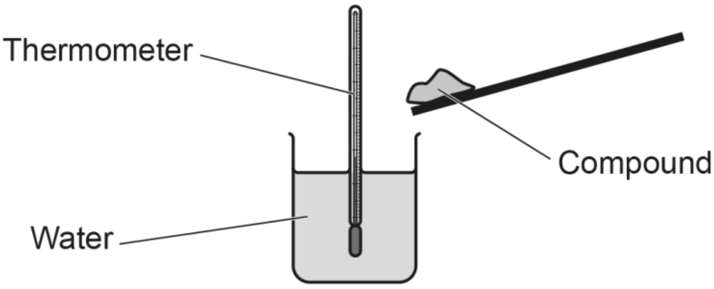
Best answers referred either to the very small size meaning that nanoparticles can penetrate tissue or the blood-brain barrier or referred to the limited research into side effects, particularly over a longer time frame. Vague answers such as 'they might have side effects' or 'they may be harmful' were not given credit.

Question 8 (a)*

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

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]**

This is the second Level of Response. In common with the first such question, candidates are presented with information and given a task to process it with reference to two bullet points. Very few candidates gave full answers to lead to full marks.

There were several common issues seen in the attempted responses:

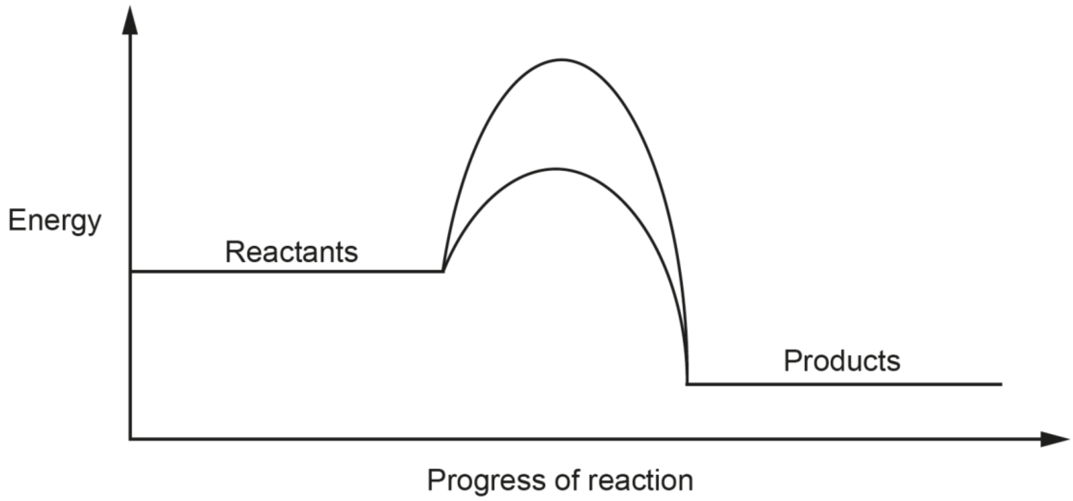
- Very few candidates addressed both bullet points fully. Most identified endothermic and exothermic changes, sometimes by annotating the table. However almost no candidates fully addressed the instruction to discuss trends for ions in Group 1 and Group 7. Some discussed energy changes down Group 1, but very few discussed any trends in energy changes down Group 7.
- Some candidates confused exothermic and endothermic changes, classifying every change incorrectly. Some incorrectly thought that a temperature increase indicated an endothermic change.
- A very common issue was that candidates misunderstood the information. Rather than discussing the energy changes in terms of ionic compounds dissolving, many candidates referred to Group 1 ions reacting with Group 7 ions.

These issues caused this question to prove very challenging for the majority of candidates, with many gaining fewer than half the available marks.

Question 8 (b)

(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]

There were 3 marks for the labelling of this diagram. Firstly, candidates needed to identify which 'hump' represented the uncatalysed reaction and which represented the catalysed reaction. Most, but not all, candidates did this correctly. Secondly, candidates needed to label the activation energies for each reaction. A common issue here was to draw arrows that were too short. Correctly drawn arrows should start at the level of the reactants and end at the top of the hump. It is perfectly correct to draw these to the side. Some candidates drew dotted lines across the diagram to make sure that their arrows were the correct length. This is good practice. The energy change of the reaction should start at the level of the reactants with the point of the arrow exactly in line with the level of the products. Again, some arrows were short, some were upside down and some started at the top of the hump.

Assessment for learning

Correctly drawing arrows to represent activation energy and energy change of reaction would be a useful area of focus for candidates. Correct arrows need to point in the correct direction and start and end accurately to show the correct size of the energy change they represent.

Question 9 (a) (i)

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

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

(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]**

In a question such as this, which asks candidates to explain a principle, best answers should start by clearly stating the principle involved. Hence, the first mark available was for clearly stating what is meant by 'the law of conservation of mass'. Some clear explanations were seen in terms of mass being neither created or destroyed. Some candidates discussed conservation of energy, which is not relevant here. This marking point was not aways awarded as many answers did not show that the candidate understood the law. However, many were able to state that the total relative formula mass on both sides of the equation is 103, leading to one mark being awarded.

Question 9 (b)

(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]**

The reaction of hydrogen ions with hydroxide ions is one of the specification statements, so this question is a recall test. Many candidates attempted to write equations which included other ions, often including nitrate and sodium ions, making it a more complex task than necessary. Some gained one mark for giving the correct formulae for they hydrogen and hydroxide ions, fewer gave a fully correct equation.

Question 9 (c) (i)

(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]**

This question was well answered with most candidates correctly entering information on at least some of the lines available.

Question 9 (c) (ii)

(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]**

Most correctly selected Acid 4 as requiring the largest volume of aqueous sodium hydroxide for neutralisation and some linked this to the acid having the highest concentration of hydrogen ions.

Question 9 (c) (iii)

(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]**

This was the last question on the paper and candidates did not always give full answers. The main points to make were that the concentration of hydrogen ions is the same as the concentration for Acids 1, 2 and 3 but different (double) for Acid 4, and that this relates to the formulae of the acids; Acids 1 to 3 are monobasic and Acid 4 is dibasic. Few candidates made all 3 points and some incorrectly discussed acid strength or degree of dissociation, which, as all the acids are strong mineral acids, was irrelevant to this context.

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