Qualification Accredited

Oxford Cambridge and RSA

GCSE (9-1)

Examiners' report

TWENTY FIRST CENTURY SCIENCE CHEMISTRY B

J258

For first teaching in 2016

J258/03 Summer 2024 series

Version 1

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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 answers 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 OCR.

Paper 3 series overview

This paper is the first of two papers to assess specification content for Higher tier candidates for the Chemistry specification of Twenty First Century Science. This specification has Ideas about Science (Unit 7) 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. In order to assess Ideas About Science, the assessment is characterised by including questions that have unfamiliar information and context that the candidates are expected to interpret and apply in order to answer some questions. The paper is designed to differentiate in the achievement of candidates at standard and higher demand (broadly between grade 4 and 9). This paper tests the breadth of knowledge and, as such, requires candidates to show their knowledge, understanding, processing and application of learning from across a broad range of specification content. The first two questions are shared with the foundation tier and so appear on both J258/01 and J258/03.

The paper relies on a short-answer format, with some objective questions that require candidates to tick boxes, complete tables and put rings around choices in answers. Candidates answered these well and obeyed instructions. It was rare to see candidates who had selected an incorrect number of choices or committed other rubric infringements.

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 unattempted 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.

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. This was evidenced by low marks on what should have been straightforward questions including Question 5 (c) (iii), testing for oxygen, and Question 11 (c) (i), using universal indicator.

In addition, candidates who do well have clearly referred to the required knowledge in the specification as they have revised and know the factual content 'by heart'. This enables them to respond quickly to recall questions, such as the essential elements in fertilisers in Question 1 (a) and the colours and states of halogens in Question 12 (a). Candidates who had not learned specification knowledge could not always access such questions that rely on the recall of factual information.

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. Some answers are scaffolded by information provided, but this information may be overlooked by candidates. This was true for questions such as Question 5 (a) (ii), where the reagents and products of the equation were given.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• had taken care to learn factual specification 'off by heart' so that they could easily access marks in recall questions such as Question 1 (a): fertiliser essential elements and Question 12 (a): colour and states of halogens • read questions carefully in order to make sure the task and the information were understood before beginning to write. This was important in questions such as 'Use the data in the table' in Question 8 (c) (iii) and 'Show all the bonds' in Question 9 (b) (ii) • obeyed instructions in calculations such as 'give your answer to 3 significant figures' or 'give your answer to 1 decimal place' in Question 1 (c) and Question 10 (a) • showed knowledge of practical chemistry, for example the test for oxygen in Question 5 (b) (iii) and the use of Universal Indicator in Question 11 (c) (i) • ensured that they made enough separate points to address the mark allocation for each question.	• gave multiple working routes to calculations and did not clearly show which method was to be taken into account by the examiner, such as Question 6 (b) (i) where both multiplications and divisions were often seen • did not show their working so that partial credit could not be given if the answer was incorrect. This was seen across all the calculations • used incorrect and contradictory scientific terminology, such as confusing ionic with covalent and intermolecular forces in Question 2 (a) (i) and confusing ion and element names for halogens and halides in Question 12 (b) (i).

Question 1 (a)

1 Fertilisers are used to increase the growth of plants.

They are added to soil to provide essential plant nutrient elements.

(a) Nitrogen is one essential plant nutrient element.

Name **two other** essential plant nutrient elements.

1 ....

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

The specification lists the essential plant nutrients as nitrogen, phosphorus, and potassium. Many candidates knew this and stated this correctly, but many other elements and other substances that plants use were often listed, including water and carbon dioxide.

Question 1 (b) (i)

(b)
(i) State **one** disadvantage of the over-use of synthetic fertilisers.

....

.... **[1]**

Best answers identified that over-use leads to eutrophication or to nitrates entering and causing specific issues in watercourses. The most common shortcoming for this question was that many candidates gave vague responses such as 'makes weeds grow' or 'harms the environment'. In such questions, it is important to give specific answers that identify the issue caused.

Question 1 (b) (ii)

(ii) Suggest why farmers still use synthetic fertilisers despite their disadvantages.

....

.... **[1]**

Some candidates correctly identified that use of fertilisers increase the rate of growth or the overall yield, and some went on to justify why this is important in terms of world food demand. Many candidates gave monetary arguments such as 'to make more money'. Such answers are never accepted unless they are qualified with the reasoning behind why it is more profitable. A relatively common error was that candidates discussed issues related to the use of pesticides rather than fertilisers, implying that they confuse the function of the two.

Question 1 (c)

(c) An example of a synthetic fertiliser is ammonium nitrate, NH_4NO_3.

Ammonium nitrate is produced when ammonium hydroxide, NH_4OH, reacts with nitric acid, HNO_3.

$NH_4OH(aq) + HNO_3(aq) \rightarrow NH_4NO_3(aq) + H_2O(l)$

The relative formula masses for the reactants and products are shown in the table.

	NH_4OH	HNO_3	NH_4NO_3	H_2O
Relative formula mass	35.0	63.0	80.0	18.0

Calculate the atom economy for the formation of NH_4NO_3.

Use the equation:

$$\text{atom economy} = \frac{\text{mass of atoms in desired product}}{\text{total mass of atoms in reactants}} \times 100\%$$

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

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

In order to achieve all 4 marks, candidates needed to select the relevant information from the table, calculate the total mass of atoms in the reactants, substitute into the formula and then correctly compute the value, reporting their answer to one decimal place. The majority of candidates completed this calculation correctly. However, it is important to stress that where the answer is not fully correct, examiners will look for partial correct working so that it is important that candidates set out their working clearly so that the examiner can see their method. It was common for candidates to present a series of apparently unrelated expressions, some of which were correct and some incorrect. In such cases the answer will be considered to be contradictory and so partial credit may not be awarded.

In this answer, common errors included:

- candidates did not always identify ammonium nitrate as the 'desired product' and included the relative formula mass of ammonium hydroxide in the numerator of their expression
- candidates added all of the relative formula masses together to use as the denominator, rather than adding together only the mass of atoms in the reactants
- some candidates ignored the relative formula masses provided in the question and attempted to calculate their own. This often resulted in errors.

Assessment for learning

When marking responses to calculations, look for clarity of layout and give support to help candidates to structure their answers to enable examiners to award partial credit for partially correct working.

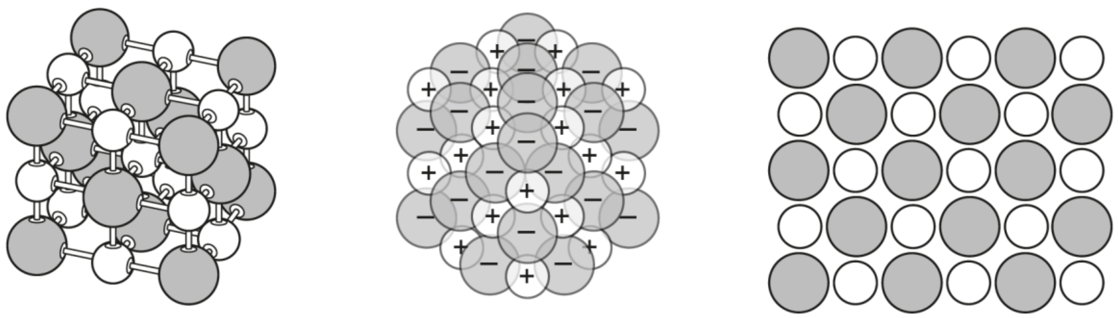
In addition, check that candidates read all information thoroughly (they may use highlighter pens or underlining). For this question, it was important that they identified the desired product and the reactants. It was also important that they used the relative formula masses that were given in the question.

Question 2 (a) (i)

2 Sodium chloride is an ionic compound.

(a) **Fig. 2.1** shows three models of the arrangement of ions in sodium chloride.

Fig. 2.1



Model A **Model B** **Model C**

(i) Describe the attraction between ions in sodium chloride.

....

....

....

.... **[2]**

This question tests knowledge and understanding directly from the specification. Candidates needed to make two clear points about the attraction between ions in sodium chloride. The specification uses the term 'electrostatic forces' and identifies that these occur between ions of opposite charges. Some answers stated this clearly, but many did not mention electrostatic attractions. Others made contradictory and incorrect references which included reference to incorrect species such as chlorine atoms or protons and some discussed incorrect types of bonding, for example referring to single or covalent bonds, intermolecular forces, or forces between molecules.

Misconception

It is very common in questions asking about bonding for candidates to refer incorrectly to all types of bonding (for example covalent bonding and intermolecular forces) rather than focus on the type of bonding in the question (in this case ionic).

It is also common for candidates to use incorrect terms for species interchangeably. For example, 'atom' 'molecule' 'proton' and 'ion' are often confused.

Question 2 (a) (ii)

(ii) Which **two** statements about the limitations of the models in **Fig. 2.1** are **true**?

Tick (✓) **two** boxes.

Model A does **not** show the relative sizes of the ions. ☐

Model C does **not** show the 3-D arrangement of ions. ☐

None of the models show that sodium chloride is a compound containing two elements. ☐

Only one model shows that a chloride ion is an anion. ☐

[2]

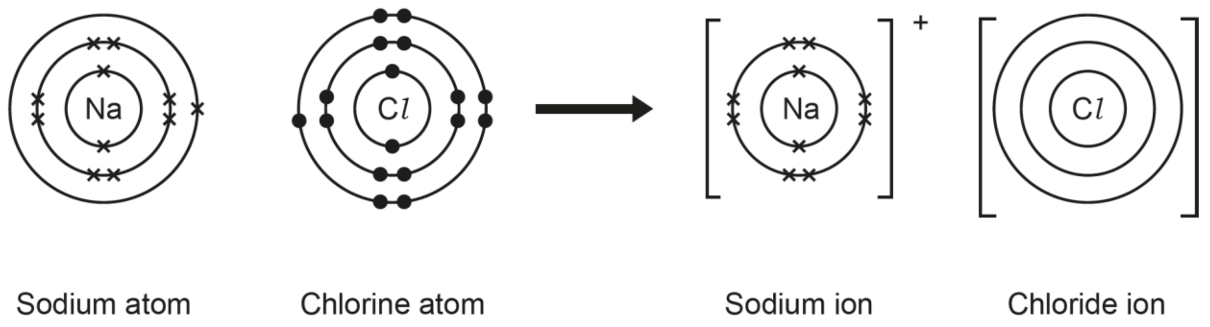
This was well answered, almost all candidates were able to identify limitations of the models.

Question 2 (a) (iii)

(iii) **Fig. 2.2** shows the dot and cross diagram for sodium chloride.

Complete Fig. 2.2 to show the structure and charge of the chloride ion.

Fig. 2.2



[2]

A small but significant percentage of candidates omitted this question. As it is not intended to be a challenging question, this implies that they may have overlooked it. Candidates should look where marks are indicated on the right hand side of the paper (in this case [2]) and make sure that they engage with every task. Most completed the arrangement of electrons around chlorine correctly, representing electrons of chlorine with dots and an added electron from sodium with a cross. Some candidates omitted the overall charge.

Question 2 (b)

(b) How does the arrangement of electrons in atoms of sodium and chlorine relate to their group and period in the Periodic Table?

....

....

....

.... **[2]**

There were two parts to this question and candidates needed to address both for 2 marks. They needed to talk about both groups and periods and relate these to the arrangement of electrons. Many candidates only discussed one or the other. Most knew that the number of electrons in the outer shell gives the group number. Fewer stated that the number of shells gives the period number. Some did not answer the question, but instead discussed how atoms form ions by gaining and losing electrons.

Exemplar 1

sodium ~~[illegible]~~ has 1 electron in its outer shell putting it in group one on the periodic table. Chlorine has 7 electrons in its outer shell putting it in group seven. **[2]**

> This response illustrates an answer that only addresses part of the question, and so was awarded 1 of the available 2 marks. In this case the candidate has explained how the arrangement of electrons relates to the group but not to the period of the Periodic Table.

Question 2 (c)

(c) An atom of sodium has an atomic number of 11 and a mass number of 23.

State the number of protons, neutrons and electrons in a sodium atom.

Number of protons = ...

Number of neutrons = ...

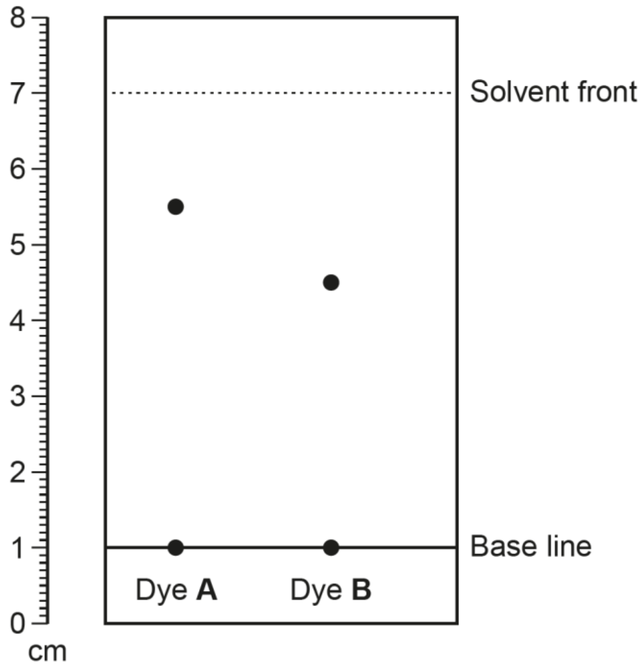
Number of electrons = ... **[2]**

> This question was very well answered. Almost all candidates correctly gave the number of each particle in the atom.

Question 3 (a)

3 A student uses paper chromatography to check the purity of two dyes used to make coloured plastics.

The diagram shows a chromatogram for the two dyes.



(a) Explain why hexane rather than water must be used as the solvent for these dyes.

....

.... **[1]**

Most gave incorrect answers to this question such as 'to make the spots move' or 'to separate the dyes'. Some candidates correctly identified that the solvent chosen for chromatography must be able to dissolve the dyes and/or that they dyes are insoluble in water.

Question 3 (b)

(b) Calculate the Rf value of dye **B**.

Give the answer to an appropriate number of significant figures.

Rf value = ... **[4]**

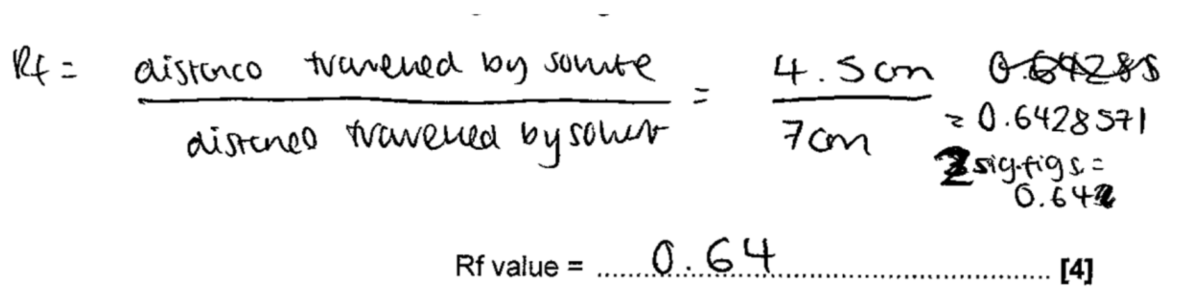
To gain 4 marks on this question, candidates needed to measure the distance travelled by the spot, measure the distance travelled by the solvent front, recall the expression for Rf, substitute and compute their answer. Many did this correctly, but there were some common errors that affected a large number of candidates.

Many candidates did not read the provided rule correctly. They did not take into account that the start line was at 1.0cm and so they did not subtract 1.0 from their readings for the distances travelled by the dot and solvent front.

Some multiplied the values or expressed Rf upside down.

For some candidates, working was laid out with contradictions of method and it was difficult to follow their process so it was difficult to award partial credit.

Exemplar 2


Rf = distanco travelled by soute / distance travelled by solvent = 4.5 cm / 7cm ~~0.64285~~ ≈ 0.6428571

2 sig figs = 0.64

Rf value = 0.64 **[4]**

This answer illustrates some very good examination technique but also a common error.

Firstly, the answer is very well set out. The candidate has shown the formula they have used to calculate Rf. They have also shown their computed value to multiple significant figures before correctly obeying the instruction to give their answer to an appropriate number of significant figures, in this case two.

However, the candidate has not read the ruler shown to the left of the diagram properly. They have measured their values for the distance travelled by both the spot and the solvent front from the bottom of the paper rather than from the base line. The very clear setting out of their answer allows 2 marks to be awarded for correct working based on these two incorrect readings.

Question 3 (c)

(c) The student wants to check that there are no colourless substances in the dyes.

What must be sprayed onto the chromatogram so any colourless substances can be seen?

.... **[1]**

Few candidates knew that a locating agent such as iodine needs to be used. UV light was a common incorrect answer. Although this would allow the substances to be seen, the question asks for what can be *sprayed* onto the chromatogram. Acid-base indicators were the most common incorrect answers.

Question 4 (a)

4 Chloride ions, bromide ions and iodide ions are halide ions.

A student tests three solutions, A, B, and C, to find out whether they contain halide ions.

The student adds acidified dilute silver nitrate to the three solutions.

The table below shows their results.

Solution	Observation after adding acidified dilute silver nitrate
A	White precipitate
B	No precipitate
C	Yellow precipitate

(a) What conclusions can the student make about the ions present in each solution?

Solution A ....

....

Solution B ....

....

Solution C ....

....

[3]

In order to answer this question, candidates needed to recall specification knowledge: the reactions of acidified silver nitrate with halide ions. Some candidates had clearly learned this well and earned all 3 marks, but many appeared either not to recall the reactions or to be guessing based on the question information. The most common correct answer was that B does not contain halide ions, but 'contains bromide ions / chloride ions / iodide ions' were often entered randomly on the other two lines. A further issue with this question was incorrect terms being used such as 'contains chlorine' or 'contains iodine'.

Misconception

? It is very common for candidates to confuse the names for halogens and halides, for example 'chlorine' and 'chloride ions'. These errors may lose marks so it is important that candidates pause and think which they mean before they use an incorrect term and put marks at risk.

Question 4 (b)

(b) Complete the **word** equation and **ionic** equation for the reaction between solutions of silver ions and bromide ions.

You need to:

- add the name and the formula for the product
- add the missing state symbols.

silver ions + bromide ions → ....

Ag^{+}(..........) + Br^{-}(..........) → ....(s)

[3]

Most candidates were able to name the product as 'silver bromide' but 'silver bromide ions' was a common incorrect answer. Many continued to give the correct formula, AgBr, but some gave incorrect formulae such as Ag_2Br or $AgBr_2$. The state symbols were the most demanding aspect of the question. Many confused (aq) with (l).

Question 4 (c)

(c) Before the tests, silver nitrate solution is acidified by adding a dilute acid.

Explain why dilute hydrochloric acid is **not** a suitable acid to use to acidify the silver nitrate solution.

....

.... **[1]**

Candidates found this a very challenging question. Few realised that hydrochloric acid contains chloride ions which would give a 'false positive' result for chloride ions. Most gave vague answers such as 'it is too acidic' or 'it is too strong an acid'. In common with other questions, the confusion between 'chloride ions' and 'chlorine' was often seen here.

Question 5 (a) (i)

5 Some metals can be extracted from their ores using electrolysis.

(a) Copper can be extracted from an aqueous solution of copper sulphate using electrolysis with inert electrodes.

The table shows some information about the changes during this electrolysis.

	Cathode	Anode
Ions attracted	Cu^{2+}, H^+	SO_4^{2-}, OH^-
Products formed	Copper	Oxygen and water
Half equation	$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	

(i) Write the **balanced half** equation for the formation of oxygen gas and water from OH^- ions at the anode.

.... **[2]**

This was another question that the candidates found very challenging. This equation is difficult to construct, but some candidates had clearly learned the equation by heart and so gained 2 marks. Many did not look at the information given.

The question says that oxygen gas and water are formed from OH ions. This should have been the starting point for constructing the equation. However, many candidates did not include these three species in their equation, including instead mixtures of products or reactants including hydrogen ions, hydrogen gas and sulphate ions.

Key point call out : constructing equations

In questions that ask for chemical equations to be constructed, it is usual for help to be included in the question. In this case all the reactants and the product were given in the question stem. Candidates need to pause and consider the information given and use it to support their answer.

Question 5 (a) (ii)

(ii) Why is the formation of copper from copper ions a reduction reaction?

....

.... **[1]**

Almost all candidates correctly stated that copper ions gain electrons and are hence reduced. Some candidates gave the incorrect answer that copper ions lose oxygen. Although this is a general definition of reduction, it is not relevant here where copper ions do not lose oxygen.

Question 5 (a) (iii)

(iii) Explain why copper and not hydrogen is formed at the cathode.

....

....

....

.... **[2]**

This question was targeted at very high demand. Most candidates attempted to answer, but few correct responses were seen. Incorrect responses gave various incorrect explanations. Some stated that hydrogen is a non-metal and so forms at the anode. Some discussed how copper ions are more attracted due to their higher charge. Very few discussed the ease of electron gain by copper and hydrogen in terms of their relative reactivity.

Question 5 (a) (iv)

(iv) Describe **one** observation that can be seen as the electrolysis proceeds.

....

.... **[1]**

The question asks for observations. In such questions, candidates need to ensure that they state observations that can be seen, rather than identify products. Hence answers that stated 'bubbles' were considered to be correct, but answers stating 'a gas is made' are not given a mark because this is not an observation. Some candidates listed the products of the reaction, such as 'copper is made' but did not state the observation (orange coating).

Assessment for learning

When asked for 'observations' in a question, candidates need to state clearly what is seen. For gases, 'fizzing' 'bubbles' or 'effervescence' are common correct observations. If the gas is coloured, this may be accompanied with a colour. For aqueous solutions or solids/precipitates, the observation should give both a colour and a state, for example 'colourless solution' or 'brown solid' or, where the question demands it 'white precipitate'.

Question 5 (b) (i)

(b) Aluminium is extracted from aluminium oxide by electrolysis.

Oxygen is also made in this process.

(i) Complete the **balanced symbol** equation for the electrolysis of aluminium oxide.

$$\text{..........}Al_2O_3 \rightarrow \text{..........}Al + \text{..........}O_2$$

[2]

Most candidates were able to at least partially balance this equation. Many gained both marks.

Question 5 (b) (ii)

(ii) Which **two** statements explain why the industrial electrolysis of aluminium oxide is very expensive?

Tick (✓) **two** boxes.

A high temperature is needed for the process.	☐
Electrolysis uses a large amount of energy.	☐
Oxygen is a by-product of the reaction.	☐
The demand for aluminium is very high.	☐
The process must be done quickly.	☐

[2]

Almost all candidates identified the energy input for the process and hence identified the main costs.

Question 5 (b) (iii)

(iii) Describe a test to identify oxygen.

....

....

....

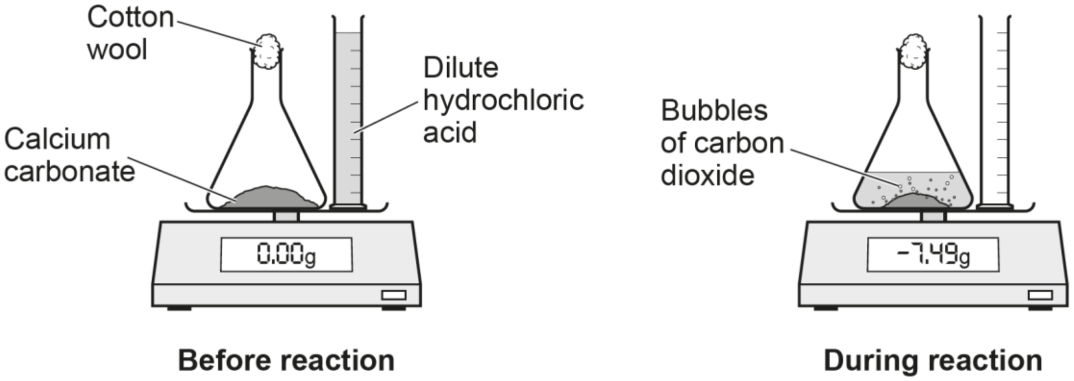
.... **[2]**

This question was intended to be a simple recall question of a common gas test ('oxygen relights a glowing splint'). However, some candidates found the question difficult, mainly due to difficulties in describing the test. It was relatively common for candidates to state that a lit splint would be used or a 'blown out' splint, neither of which are correct. The splint needs to be glowing. Secondly, many confused the hydrogen test with the oxygen test, stating that a lighted splint pops.

Question 6 (a) (i)

6 A student adds dilute hydrochloric acid to calcium carbonate to form calcium chloride, water and carbon dioxide.

The diagram shows how the student measures the mass before and during the reaction.



(a) The equation for the reaction of calcium carbonate with dilute hydrochloric acid is:

$CaCO_3(s) + 2HCl(aq) \rightarrow \mathbf{X}(aq) + H_2O(l) + CO_2(g)$

(i) Write the chemical formula for **X**.

.... **[1]**

There are two routes to working out the formula $CaCl_2$. The candidate could consider the charge on the calcium and chloride ions, either from knowledge of the periodic table or by working out the charges based on the other formulae in the question. The second route is to count the number of atoms of calcium and chlorine on the left hand side of the equation and put these together into the formula, $CaCl_2$. About half the candidates gave the correct answer. CaCl was the most common incorrect response, although varieties of attempted carbonates were also seen.

Question 6 (a) (ii)

(ii) The mass decreases during the reaction.

Explain why.

....

....

....

.... **[2]**

In this question, 2 marks were available for identifying that a gas (carbon dioxide) forms and this leaves the flask (and so does not contribute towards the mass). Most explained this well. A common reason for full marks not being awarded was that candidates listed other changes, implying that these also contributed towards the change in mass. Answers that stated that 'the calcium carbonate dissolves' or 'the solid is used up' were considered as contradictions; these changes do not directly impact the mass of the contents of the flask.

Question 6 (b) (i)

(b) 100 cm^3 of dilute hydrochloric acid contains 5.0 g of HCl.

(i) Calculate the number of moles of HCl in 100 cm^3 of dilute hydrochloric acid.

Relative atomic masses (A_r): H = 1.0 $\quad$ Cl = 35.5

Use the equation: number of moles = $\frac{\text{mass of substance}}{\text{relative formula mass}}$

Number of moles = ... **[3]**

There are three stages in this calculation. Firstly, candidates need to calculate the relative formula mass (RFM) of the hydrochloric acid (36.5). Secondly, they need to substitute correctly into the equation. Thirdly they need to compute their value. In this case, no rearrangement of the formula is necessary. Most candidates calculated the RFM correctly but some then multiplied this value by the mass, implying incorrect substitution. Candidates should take care to give answers to calculations to at least 2 decimal places until instructed otherwise. In common with other mathematical questions, in some cases the layout of working was contradictory and unclear, and this compromises the award of partial credit.

Question 6 (b) (ii)

(ii) There are 6.0×10^{23} atoms in one mole of atoms.

How many atoms are in 4 moles of HCl?

Put a (ring) around the correct option.

1.2×10^{24} **2.4×10^{24}** **4.8×10^{24}** **8×10^{23}**

[1]

The correct answer is 4.8×10^{23}. Most candidates multiplied $4 \times 6.0 \times 10^{23}$ to give the incorrect answer 2.4×10^{23}. This incorrect answer does not take into account that each molecule of HCl contains two atoms.

Question 7 (a)

7 Aqueous hydrogen peroxide breaks down slowly to form oxygen gas and water.

$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$

(a) Manganese dioxide is a catalyst for this reaction.

Which statement explains how manganese dioxide speeds up the reaction?

Tick (✓) **one** box.

It decreases the frequency of particle collisions. ☐

It lowers the activation energy of the reaction. ☐

It lowers the temperature of the reaction. ☐

It provides energy for the reaction. ☐

[1]

Almost all candidates knew that a catalyst lowers the activation energy of the reaction.

Question 7 (b)

(b) Explain why increasing the concentration of the aqueous hydrogen peroxide also speeds up the reaction.

Use ideas about particles.

....

....

....

.... **[2]**

Most candidates expressed that particles collide 'more' but this alone is insufficient to earn a mark. To explain rate, it is essential that the answer refers to either a greater frequency of collisions or to a higher number of collisions per second or per unit time. 'More collisions' alone was a common zero mark answer.

The second issue is that candidates found it difficult to explain increased concentration in terms of particles. Few stated clearly that increasing concentration increases the number of particles per unit volume, or that particles are closer together. A relatively common misconception is that increasing the concentration increases the energy of the particles or impacts the number of particles that possess the minimum activation energy.

Misconception

?

Not all candidates discuss collisions in terms of frequency of collisions.

It is common for candidates to confuse increasing concentration explanations with increasing temperature explanations, hence adding incorrect points about energy of particles or activation energy.

Question 7 (c)

(c) In one experiment, 0.1 moles of oxygen is collected when hydrogen peroxide decomposes.

Calculate the volume of 0.1 moles of oxygen at room temperature and pressure.

Use the formula: $\text{number of moles of gas} = \dfrac{\text{volume of gas (dm}^3\text{)}}{24\ (\text{dm}^3)}$

Give your answer in cm^3.

Volume of oxygen = ... cm^3 **[3]**

A spread of marks from 0 to 3 was seen across the candidates for this question. The calculation required a rearrangement of the formula as well as a substitution of the values given in the question. For such answers it is recommended that candidates show their rearranged formula before substitution so that partial credit may be given for answers that are not fully correct. In common with other mathematical questions, some candidates give a variety of mixed working methods, some of which were correct and some of which were incorrect. A second demanding aspect of this question is that the final answer needed to be given in cm^3. An instruction to this effect was in the body of the question, and the units were included on the answer line. This was often ignored, and the final answer of 2.4 was given which shows that no unit conversion of dm^3 into cm^3 had been included.

Assessment for learning

Candidates should be encouraged to cross out all but the answer they want to be considered, and to set out their working clearly enough for partial credit to be awarded for incorrect final answers.

Question 8 (a) (i)

8 Fossil fuels are used as energy sources.

(a) Natural gas contains an alkane with the formula CH_4.

(i) Name this alkane.

.... **[1]**

Most candidates knew that CH_4 is methane, but some appeared not to take the formula into account and instead name unrelated gases, including hydrogen, carbon dioxide and ethane.

Question 8 (a) (ii)

(ii) Combustion of natural gas increases the temperature of the surroundings.

Name of the type of reaction that increases the temperature of the surroundings.

.... **[1]**

Erratum notice

Turn to **page 14** of the **question paper** and look at **question 8 a (ii)**.

The second line reads:

Name of the type of reaction that increases the temperature of the surroundings.

Cross out the second word in that line, which is '**of**'.

The line should now read:

Name the type of reaction that increases the temperature of the surroundings.

Almost every candidate correctly answered this question with the correct term 'exothermic'.

Question 8 (a) (iii)

(iii) Incomplete combustion occurs when not enough oxygen is present.

Name **one** pollutant caused by the incomplete combustion of natural gas.

.... **[1]**

Most candidates correctly named carbon monoxide but other emission gases that are not the product of incomplete combustion were also given, for example nitrogen oxides, sulphur dioxide and carbon dioxide.

Question 8 (b)

(b) Hydrogen can also be used as an energy source in a fuel cell.

The balanced symbol equation for the reaction in the hydrogen fuel cell is:

$2H_2 + O_2 \rightarrow 2H_2O$

The table shows the bond energies involved in the reaction.

Bond	Bond energy (kJ)
O═O	498
H—H	434
O—H	464

Calculate:
- the energy needed to break bonds in the reactants
- the energy given out when bonds form in the products
- the overall energy change of the reaction.

Energy needed to break bonds in the reactants = ... kJ

Energy given out when bonds form in the products = ... kJ

Overall energy change = ... kJ
[3]

A spread of marks was seen for this question. Commonly, candidates calculated the energy needed to break bonds correctly. In the products there are four O-H bonds broken. Candidates sometimes made errors here, only taking account of two. Most knew that they needed to subtract one value from the other to calculate the overall energy change, although some did not use the correct sign on the last line. Error carried forward was allowed for the overall energy change based on the earlier values used by each candidate.

Question 8 (c) (i)

(c) Hydrogen fuel cells can be used in cars, but many cars use fossil fuels, such as diesel.

The table shows information about hydrogen and diesel.

Fuel	Products formed during complete combustion	Source	Melting point (°C)	Boiling point (°C)	Density at room temperature and pressure (g/cm^3)
Hydrogen	water	water	–259	–253	0.09
Diesel		crude oil	–80 to 0	200 to 350	0.85

(i) Diesel is a hydrocarbon.

Name the products formed during complete combustion of diesel.

....

.... **[1]**

Most candidates did not earn this mark. The most common issue was that they only stated 'carbon dioxide' as the product and did not include 'water' despite the word 'products' being plural in the question.

Question 8 (c) (ii)

(ii) Evaluate the impact on the environment of producing and using hydrogen and diesel as fuels.

....

....

....

.... **[2]**

The command word used for this question is 'evaluate', and the question also asks about both producing and using the two fuels. Most candidates earned 1 of the 2 available marks. This was usually due to an omission in the answer. Firstly 'evaluate' requires a clear comparison between the two fuels. Secondly, answers needed to refer to both production and use. The most common 1 mark answer was to state that diesel produces a named pollutant that hydrogen does not. Note that 'hydrogen produces water' was not awarded a mark because the combustion of diesel also produces water. The answer needed to make it clear that hydrogen combusts to produce *only* water. A comparison of the production of the two fuels was usually omitted in the answers seen. Best answers identified that diesel comes from non-renewable sources (crude oil).

Question 8 (c) (iii)

(iii) Explain why the density of hydrogen and diesel are very different.

Use data from the table.

....

....

....

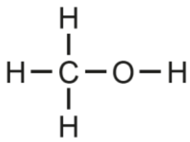
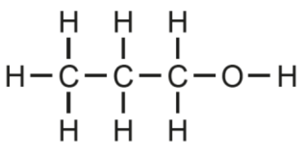
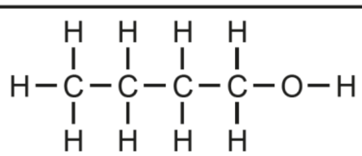
.... **[2]**

The question states that candidates should 'Use data from the table'. However, very few candidates did this. Common incorrect answers explained density in terms of mass per unit volume and discussed the relative distances between particles. Although such statements are correct, they are not relevant to the question asked, which requires processing of the data. Best answers identified that diesel is a liquid and hydrogen is a gas. Very few explained this in terms of the data by comparing the boiling points of each with room temperature.

Question 9 (a)

9 The table shows some information about the homologous series of alcohols.

(a) Complete the table by adding the missing name and displayed formula.

Name	Formula	Displayed formula
....	CH_3OH	
Ethanol	C_2H_5OH	....
Propanol	C_3H_7OH	
Butanol	C_4H_9OH	

[2]

Almost all candidates correctly named methanol and drew the displayed formula for ethanol. Note that for a displayed formula to be fully correct, the O—H bond should be shown.

Question 9 (b) (i)

(b) Alcohols oxidise to form carboxylic acids.

(i) Name the carboxylic acid formed when propanol is oxidised.

.... **[1]**

Most knew that the carboxylic acid name needed to begin with 'prop….' but some incorrect answers such as propanolic and propanol were sometimes seen. Propane was another relatively common incorrect answer.

Question 9 (b) (ii)

(ii) Draw the displayed formula of the carboxylic acid formed when propanol is oxidised.

Show all the bonds.

[1]

Only a small percentage of candidates answered this question correctly. A range of compounds were seen, including esters, aldehydes, and alkanes. The instruction to 'Show all the bonds' was often not followed, leading to candidates condensing the O—H bond to —OH.

Question 10 (a)

10 Black silver oxide powder decomposes when heated to form silver and oxygen gas.

The balanced symbol equation for the reaction is:

$2Ag_2O \rightarrow 4Ag + O_2$

(a) Calculate the theoretical yield of silver made when 250 g of silver oxide completely decomposes.

Relative atomic mass (A_r): O = 16 Ag = 108

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

Theoretical yield = ... g **[4]**

This calculation was more demanding than the previous ones because no formula to help candidates was provided. Many candidates completed the calculation fully correctly and gained all 4 marks. It was also common to see errors leading to a 1 or 2 mark response.

The first stage was to use the equation and work out the relative formula mass of silver oxide. Many did so and then correctly multiplied this by two, showing the correct value of 464 in their answer.

Fewer were able to take this into a correct expression for theoretical yield. A range of incorrect multiplications and divisions were seen which did not show evidence either of a correct relationship or of a correct value for the mass of silver formed.

The final instruction to give the answer to 3 significant figures was usually followed, and an error carried forward was allowed for candidates who expressed a correctly rounded value based on their own working.

Question 10 (b)

(b) The actual yield of silver in an experiment is 215 g.

Some black silver oxide powder remains visible after the experiment.

Suggest **two** ways the experiment could be changed to increase the actual yield.

1 ....

....

2 ....

....

[2]

Not all candidates understood the difference between 'make more silver' and 'increase actual yield'. This led to many giving answers that would increase the mass of silver formed, without increasing actual yield. Such incorrect answers included 'use more silver oxide'. Best answers discussed heating for longer and using a higher temperature. Most candidates gained a single mark for saying one or the other. Add a catalyst was a common incorrect answer.

Misconception

?

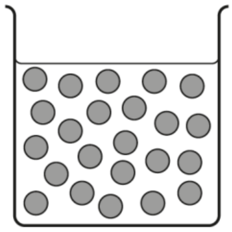
Many candidates do not distinguish between 'making more product' and 'increasing actual yield'. This leads to confusion in how to increase yield because they typically think that using more reactant will increase yield, which is incorrect.

Question 11 (a)

11 A student does some experiments with dilute and concentrated acids.

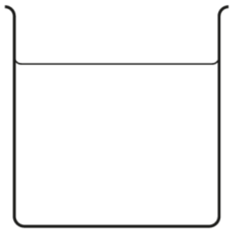
Fig. 11.1 represents the H^+ ions in a concentrated solution of acid.

Fig. 11.1



(a) **Complete Fig. 11.2** to show the H^+ ions in a dilute solution of acid.

Fig. 11.2



[1]

Almost all candidates correctly represented the dilute acid with fewer particles.

Question 11 (b) (i)

(b)
(i) The student says that all concentrated acids are strong acids and all dilute acids are weak acids.

Explain why they are **incorrect**.

....

.... **[1]**

Answers to this question were poorly expressed and usually repeated the information in the question. So common answers were 'strong acids can be dilute and weak acids can be concentrated'. Fewer discussed the extent of ionisation into hydrogen ions. The answers to Question 11 (b) (ii) were often well expressed, showing that candidates do understand that acid strength is related to the concentration of hydrogen ions, but such ideas were not typically well expressed here.

Question 11 (b) (ii)

(ii) The student adds a carbonate to three dilute acids, A, B and C, with the same concentration.

They record the pH of each acid and the time taken for each reaction to finish (the reaction time).

The table shows the results.

Acid	**pH**	**Reaction time (s)**
A	1	10
B	3	200
C	5	1000

Which acid is the weakest acid?

Explain your answer.

Use:
- data from the table
- ideas about hydrogen ions.

....

....

....

....

....

.... **[3]**

This question was very well answered, with most candidates gaining at least 2 marks. Almost all candidates chose 'C' (A was the common incorrect choice) and justified this choice with reference to the data in the table, stating either that C has the highest pH or that its reaction was the slowest. Fewer gave the higher level response that this is an outcome of the concentration of hydrogen ions in the acid, which is lowest in C.

Question 11 (c) (i)

(c)
(i) Describe how to use Universal indicator to measure the pH of a solution.

....

.... **[1]**

The question asks candidates to 'describe how to use….'. Most answers did not give a description to emphatically describe how pH is measured. Most answers said, 'Add the indicator and the colour tells you the pH' or 'if it's red it's an acid'. In order to measure pH, the colour of the indicator must be compared to a colour chart to exactly match the colour to a pH. Very few stated this clearly.

Question 11 (c) (ii)

(ii) A solution of pH 1 has a hydrogen ion concentration of 0.1 mol / dm^3.

What is the hydrogen ion concentration of a solution of pH 3?

Put a (ring) around the correct option.

1×10^{-1} mol / dm^3 **1×10^{-2} mol / dm^3** **1×10^{-3} mol / dm^3** **1×10^{-4} mol / dm^3**

[1]

Most candidates correctly identified that a solution with a pH of 3 has a hydrogen ion concentration of 1×10^{-3} mol / dm^3.

Question 12 (a)

12 Group 7(17) of the Periodic Table contains non-metals called halogens.

(a) The table shows the properties of three Group 7(17) elements at room temperature and pressure.

Complete the table.

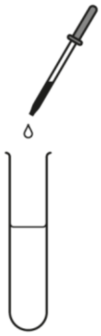
Element	**Colour**	**State at room temperature**
Chlorine	Pale green	....
Bromine	....	Liquid
Iodine	Grey	Solid

[2]

The colours and states of the halogens are specification knowledge that candidates are expected to recall. Most, but not all stated that chlorine is a gas. Fewer gave an acceptable colour for the element bromine. Many appeared to be describing aqueous bromine. 'Brown' alone was not accepted. Bromine liquid is red, although orange-brown or orange were accepted.

Question 12 (b) (i)

(b) A student adds aqueous sodium iodide to aqueous chlorine.



The balanced symbol equation for the reaction is:

$Cl_2(aq) + 2NaI(aq) \rightarrow 2NaCl(aq) + I_2(aq)$

(i) Explain what the student observes when the reaction takes place.

....

....

....

.... **[3]**

Most candidates gained 1 or 2 marks for this question. Most knew the explanation but did not clearly reference this to a correct observation. Many gained a mark for stating that a displacement reaction occurs. Some continued to explain that this occurs due to chlorine being more reactive than iodine. Fewer stated that a brown colour would be seen due to aqueous iodine forming in the solution.

In common with other questions, candidates need to take care not to confuse their language when referring to halogen elements and halide ions. Confusion of these terms can lead to marks not being given. It is incorrect to state that 'chloride displaces iodide or 'chloride ions are more reactive than iodine'.

Exemplar 3

The iodide is displaced by chlorine, so ~~Fizzing~~ ~~occurs,~~ a colour change occurs. since chlorine ~~grou~~ is in group 7 and sodium is in group 1, the reaction will be vigorous so fizzing will ocur. **[3]**

This answer shows a common error and a common difficulty that candidates faced in answering this question. Firstly, an incorrect term has been used. The answer states that 'iodide' (rather than iodine) is produced. Displacement or an explanation in terms of relative reactivity of the elements is not given. Lastly, the candidate does not know (or is not clear about) what is seen, stating fizzing and a 'colour change' without identifying the actual colour.

Question 12 (b) (ii)

(ii) Write an **ionic** equation for the reaction.

Use the symbol equation to help you.

.... **[1]**

Candidates found this ionic equation very challenging, with very few giving a fully correct balanced equation. Many included sodium ions, many included incorrect formulae for ions or elements such as I_2^- as an ion or Cl as the formula for chlorine.

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