Qualification Accredited

AS LEVEL

Examiners' report

CHEMISTRY A

H032

For first teaching in 2015

H032/02 Summer 2023 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 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.

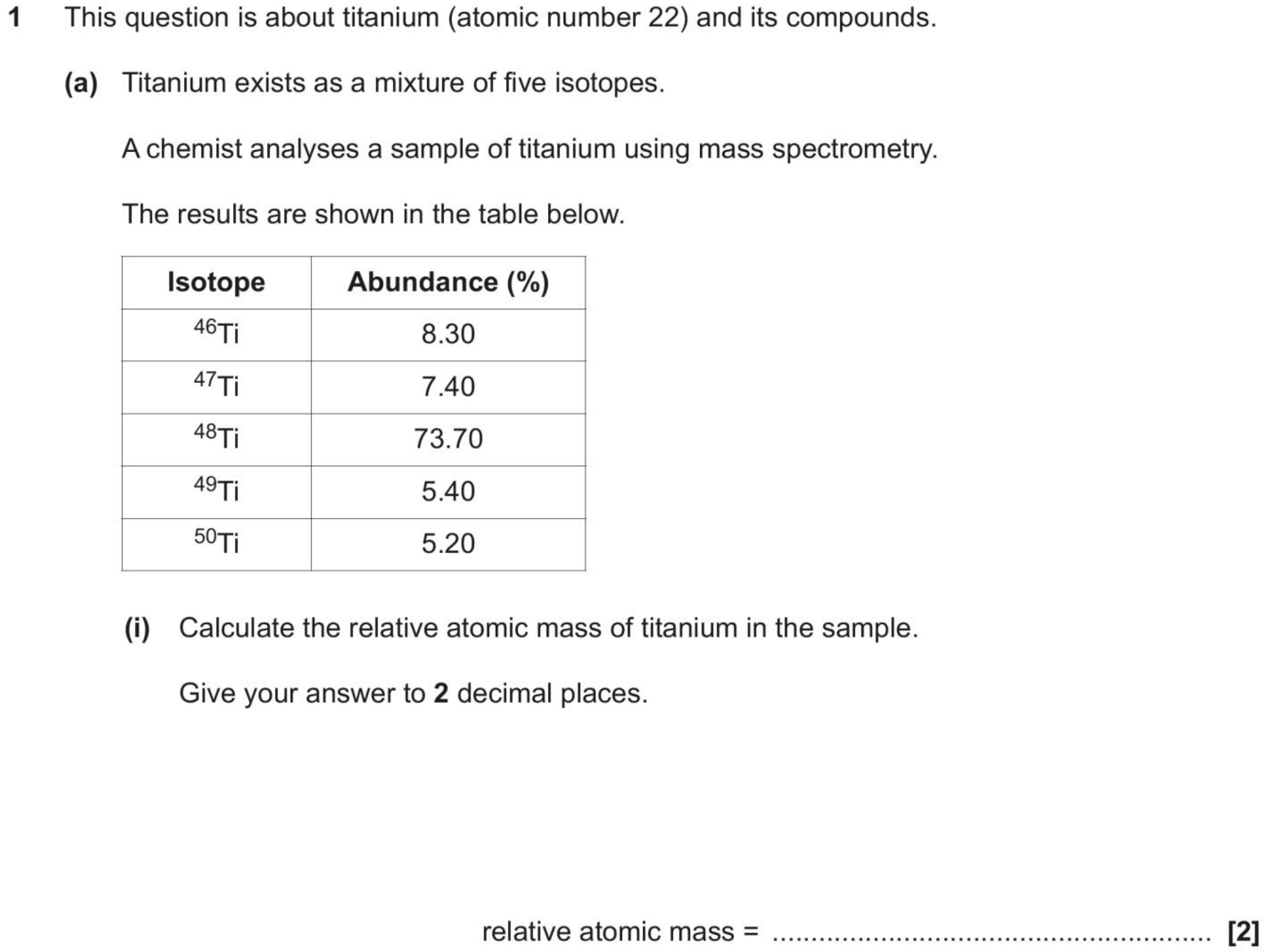
Paper 2 series overview

H032/02 is one of the two examination components for the AS Level examination for GCE Chemistry A.

This synoptic depth in Chemistry paper links together content from all 4 modules and is worth 70 marks. Candidates answer all questions with a range of question styles including short answer (structured questions, problem solving, calculations, practical) and extended response questions, including those marked using Level of Response mark schemes.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• performed calculations in a logical order showing detailed working for each step, with no intermediate rounding of values, giving answers to an appropriate number of significant figures: Questions 1(b)(ii), 2(b)(ii), 3(a), 4(b)(ii) and 4(c)(i) • were confident writing balanced equations using the correct formula for both inorganic and organic reactions – Questions 2(a)(i), 2(b)(i), 3(a) and 5(a)(ii) • used correct terminology and understood the meanings of the words throughout their responses • were able to explain differences in physical properties linking to correct bonding and structure in Questions 2(c)(ii) and 5(b)(i) • achieved Level 2/Level 3 on both LOR Questions 3(a) and 4(b)(ii) - attempting calculations and including detailed descriptions in their answers.	• carried out calculations lacked structure with no clear pathway and often with contradictory calculations given • struggled with writing formula and balancing equations • missed details needed in response by not answering all aspects of the question. For example, missing ΔH calculation in Question 4(b)(ii) • used scientific terminology incorrectly. For example, using nuclear charge when they meant nuclear attraction.

Question 1 (a) (i)



1 This question is about titanium (atomic number 22) and its compounds.

(a) Titanium exists as a mixture of five isotopes.

A chemist analyses a sample of titanium using mass spectrometry.

The results are shown in the table below.

Isotope	Abundance (%)
^{46}Ti	8.30
^{47}Ti	7.40
^{48}Ti	73.70
^{49}Ti	5.40
^{50}Ti	5.20

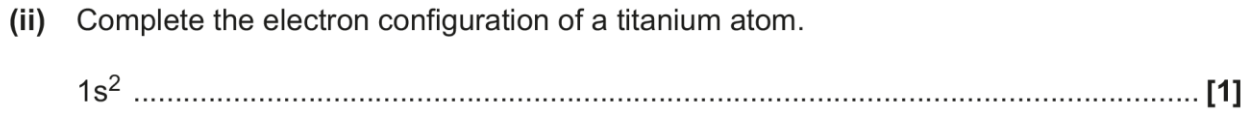
(i) Calculate the relative atomic mass of titanium in the sample.

Give your answer to **2** decimal places.

relative atomic mass = ... **[2]**

Most candidates scored both marks. Some lost marks for minor slips such as not giving their final answer to 2 decimal places or making calculator errors. A few didn't know how to attempt the calculation or calculated the average mass.

Question 1 (a) (ii)



(ii) Complete the electron configuration of a titanium atom.

$1s^2$ .... **[1]**

Again, most scored this mark. Common errors included using the mass number for number of electrons, no 4s but $3d^4$ instead, 4d rather than 3d, $4p^2$ instead of $3d^2$ or filling up d orbital $3d^{10}$.

Question 1 (a) (iii)

(iii) Complete the table to show the number of protons, neutrons and electrons in a $^{48}Ti^{2+}$ ion.

	Protons	**Neutrons**	**Electrons**
$^{48}Ti^{2+}$ ion			

[1]

Most candidates gained this mark. Common errors included giving 24 or 22 for number of electrons, or 48 or 24 for neutrons. A few used the relative atomic mass of 47.9 from the periodic table so gave 24.7 for number of neutrons.

Assessment for learning

Fractional numbers of subatomic particles are not possible. Candidates should be aware that the relative atomic mass is the weighted average of the masses of all of an element's isotopes, and the mass number of an isotope must be used to determine the number of protons and neutrons in the nucleus.

Question 1 (b) (i)

(b) An ore of titanium contains impure TiO_2.

Titanium is manufactured from TiO_2 in a two-stage process.

Stage 1 $TiO_2 + 2C + 2Cl_2 \rightarrow TiCl_4 + 2CO$ **Reaction 1.1**

Stage 2 $TiCl_4 + 4Na \rightarrow Ti + 4NaCl$ **Reaction 1.2**

(i) The common name for TiO_2 is titanium dioxide.

What is the systematic name of TiO_2?

.... **[1]**

Very few candidates gave the correct answer for this question. The most common errors included: titanium oxide, titanium(IV) **di**oxide, titanium oxide(IV), titanium(II) oxide. A few also attempted to give names like those for organic compounds: 1,1-titanium dioxide or the reverse 1,1-dioxytitanium.

How Science Works

It is important in Chemistry to have clear communication by use of systematic and unambiguous nomenclature. This includes the use of Roman numerals to indicate the magnitude of the oxidation number when an element, such as Ti, may have different oxidation numbers in different compounds. See specification statement 2.1.5(c) and HSW8.

Question 1 (b) (ii)

(ii) In **Reaction 1.2**, the percentage yield of titanium from $TiCl_4$ is 72.0%.

Calculate the minimum mass, in kg, of sodium that is needed to produce 1.00 kg of titanium.

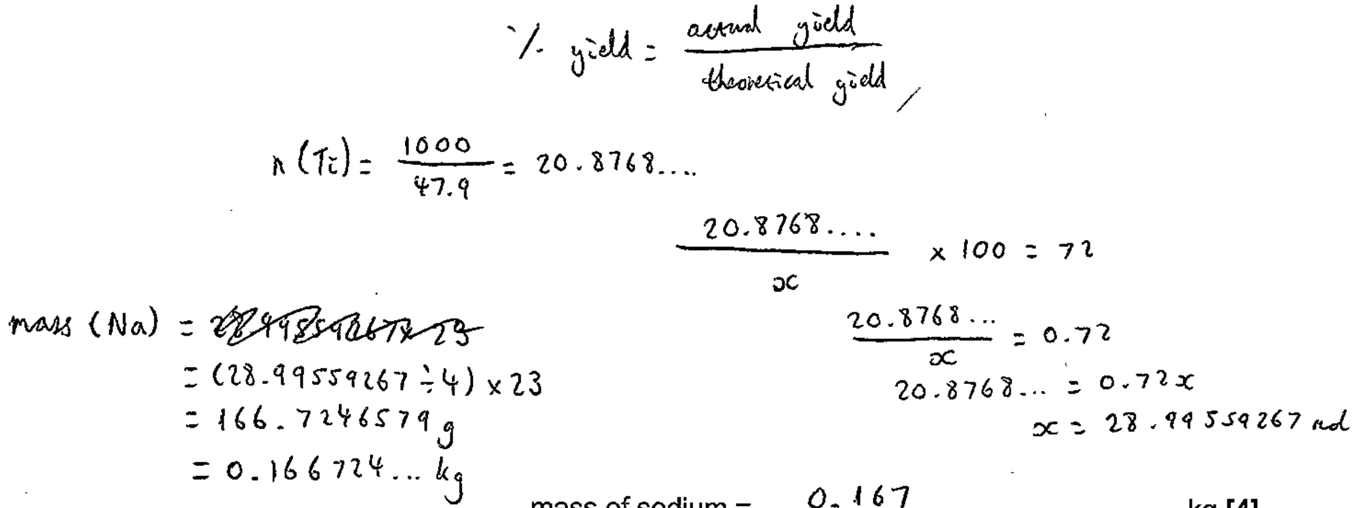
Give your answer to **3** significant figures.

mass of sodium = ... kg **[4]**

Candidates found this calculation quite challenging, with less than a quarter achieving full marks. The most common errors are highlighted on the mark scheme. Many that struggled were often given credit for the x4 ratio mark but only if it was possible to see this in the working. Many gave multiple, often contradictory attempts at the calculation. It was not always clear how the final answer had been obtained. Clear working enables us to follow the logic and give ECF where appropriate.

Many divided 1000 g by the molar mass for $TiCl_4$ and then found 72% of this. It was important here to read the question carefully to ensure complete understanding.

Exemplar 1



% yield = $\frac{\text{actual yield}}{\text{theoretical yield}}$

n (Ti) = $\frac{1000}{47.9}$ = 20.8768....

$\frac{20.8768....}{x}$ × 100 = 72

$\frac{20.8768...}{x}$ = 0.72

20.8768... = 0.72x

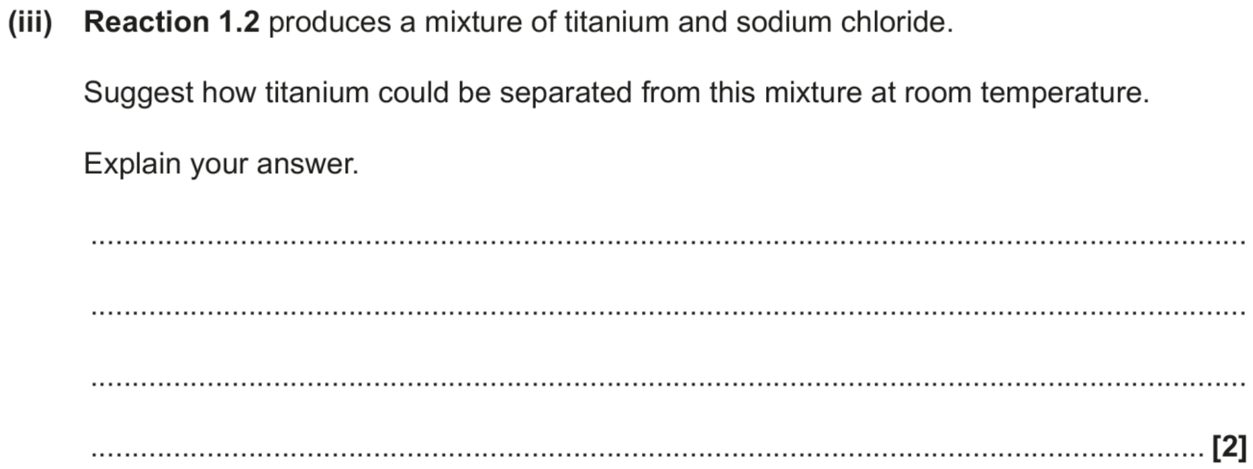
x = 28.99559267 mol

mass (Na) = ~~28.99859267x23~~
= (28.99559267 ÷ 4) x 23
= 166.7246579 g
= 0.166724... kg

mass of sodium = ...0.167...................................... kg **[4]**

This candidate achieved 3 out of the 4 possible marks. The steps in their calculation are logical and it is easy to follow their working and therefore spot the error in their calculation. They have divided by 4 rather than multiplying. It also shows the calculation can be performed in a different order to that on the mark scheme. All intermediate values are used in calculations as calculator values without rounding to ensure an accurate answer.

Question 1 (b) (iii)



(iii) **Reaction 1.2** produces a mixture of titanium and sodium chloride.

Suggest how titanium could be separated from this mixture at room temperature.

Explain your answer.

....

....

....

.... **[2]**

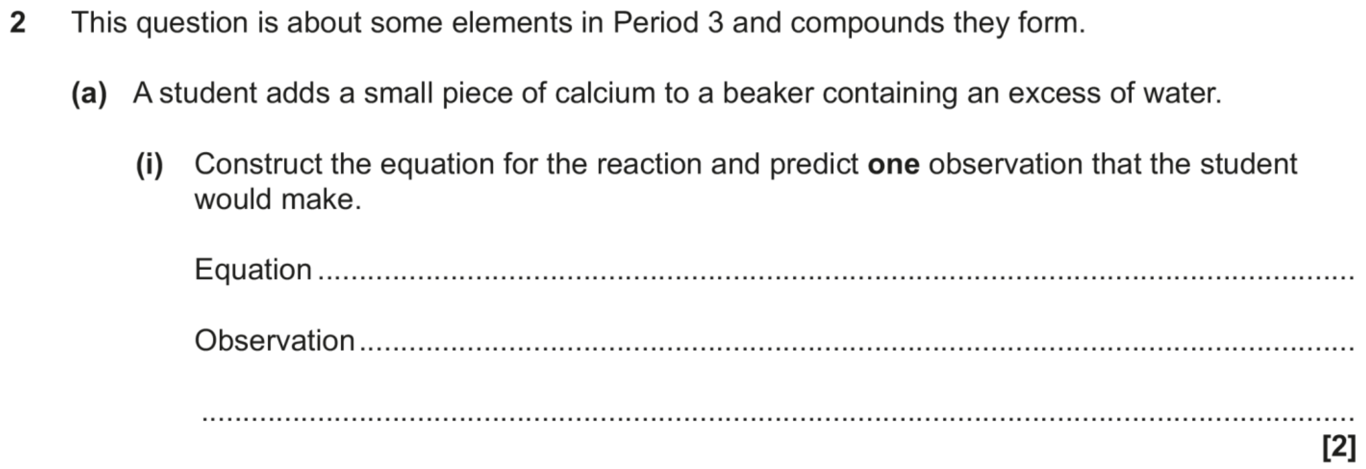
Most candidates did not gain any credit here. However, the range of responses seen highlighted some misconceptions in their understanding of how different mixtures can be separated. Many assumed that sodium chloride was in solution/aqueous, not recognising that water was not present in this reaction. Responses such as "sodium chloride will evaporate" or "remove the water" were seen. Some gave a description of the purification method for an organic liquid - the use of a separating funnel and/or distillation were common. Some suggested the use of a magnet to remove Ti despite it being a non-magnetic metal.

Misconception

Understanding how to separate mixtures is covered in both KS3 and KS4 but it is important that these concepts can be applied during further study. Asking this type of problem solving question would make a good starter activity.

Some useful activities for separating mixtures can be found in the GCSE Chemistry B (Twenty First Century Science) Chemical analysis transition guide

Question 2 (a) (i)



2 This question is about some elements in Period 3 and compounds they form.

(a) A student adds a small piece of calcium to a beaker containing an excess of water.

(i) Construct the equation for the reaction and predict **one** observation that the student would make.

Equation ....

Observation ....

....

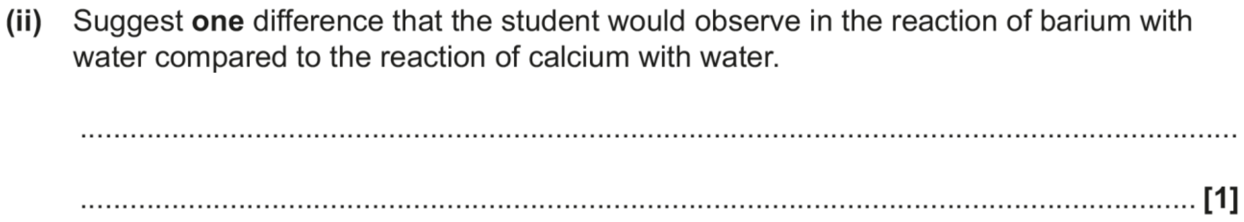
[2]

Most candidates scored the mark for the correct observation. A few said what would happen rather than what they would see, e.g. gas is formed, pH would increase, mass lost or even reference to the 'squeaky pop' test. Many struggled to give the correct balanced equation with either CaO being given as a product or incorrect balancing. Many did not have a gas produced but then had bubbling as an observation.

OCR support

OCR has some resources to help support the understanding of balancing symbol equations such as this delivery guide for Atoms and equations.

Question 2 (a) (ii)



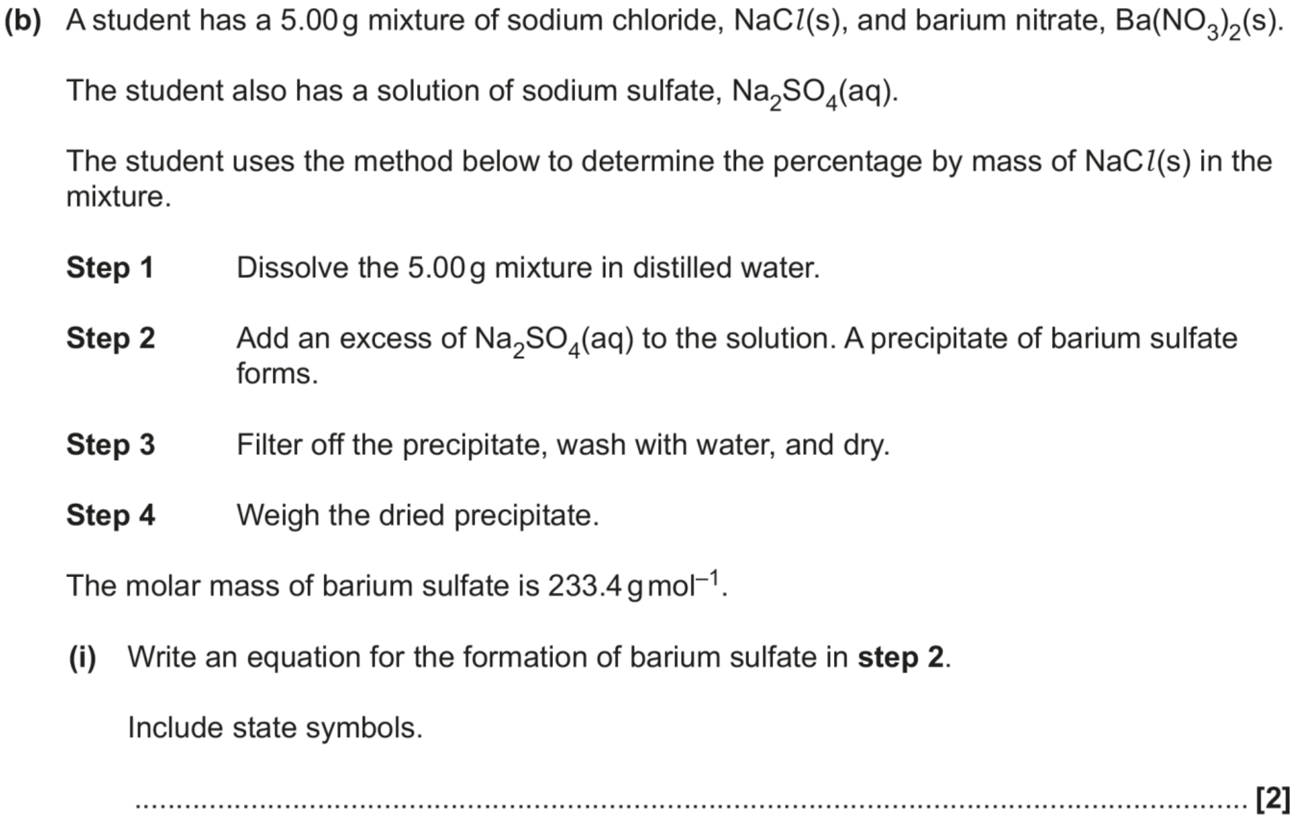
(ii) Suggest **one** difference that the student would observe in the reaction of barium with water compared to the reaction of calcium with water.

....

.... **[1]**

Responses not about observations were very common, e.g. more vigorous reaction, Ba is more reactive. Some described Ba as being less reactive. Many responses did not include the idea of rate (for example, 'more bubbles') or were not comparative (for example, 'vigorous bubbling').

Question 2 (b) (i)



(b) A student has a 5.00 g mixture of sodium chloride, $NaCl(s)$, and barium nitrate, $Ba(NO_3)_2(s)$.

The student also has a solution of sodium sulfate, $Na_2SO_4(aq)$.

The student uses the method below to determine the percentage by mass of $NaCl(s)$ in the mixture.

Step 1 Dissolve the 5.00 g mixture in distilled water.

Step 2 Add an excess of $Na_2SO_4(aq)$ to the solution. A precipitate of barium sulfate forms.

Step 3 Filter off the precipitate, wash with water, and dry.

Step 4 Weigh the dried precipitate.

The molar mass of barium sulfate is 233.4 g mol^{-1}.

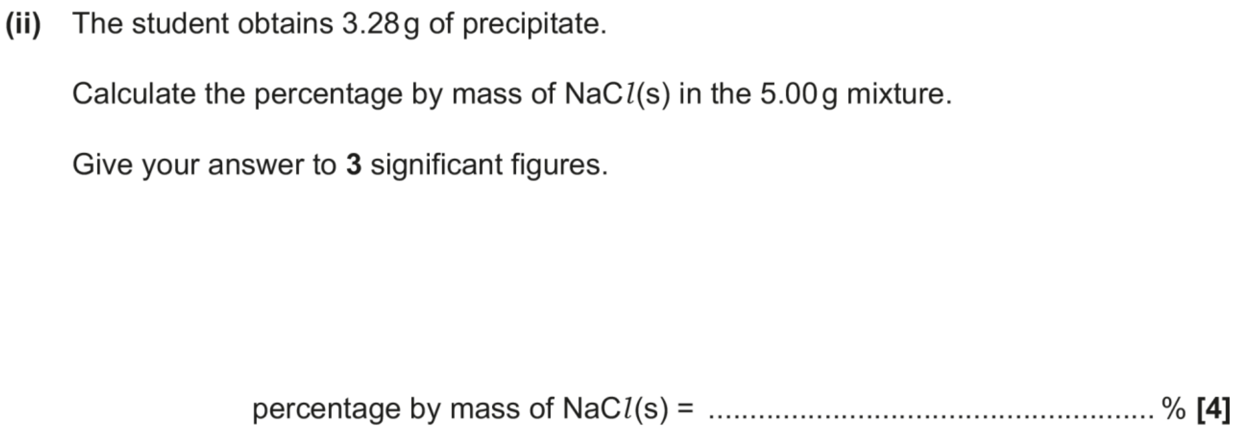
(i) Write an equation for the formation of barium sulfate in **step 2**.

Include state symbols.

.... **[2]**

Less than half the candidates gained credit for this challenging question. There was lots of information to process. Many struggled to give the correct formula for the products, e.g. $NaNO_3$, Ba_2SO_4, or had issues with balancing. Some tried to involve the NaCl in the reaction, either recognising that it didn't react (acceptable on the mark scheme) or forming barium chloride or even Cl_2. Lots of candidates lost the mark for state symbols as they left $Ba(NO_3)_2$ as (s), not recognising that in step 1 the mixture was dissolved in water so should now be (aq).

Question 2 (b) (ii)



(ii) The student obtains 3.28 g of precipitate.

Calculate the percentage by mass of $\mathrm{NaC}l(\mathrm{s})$ in the 5.00 g mixture.

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

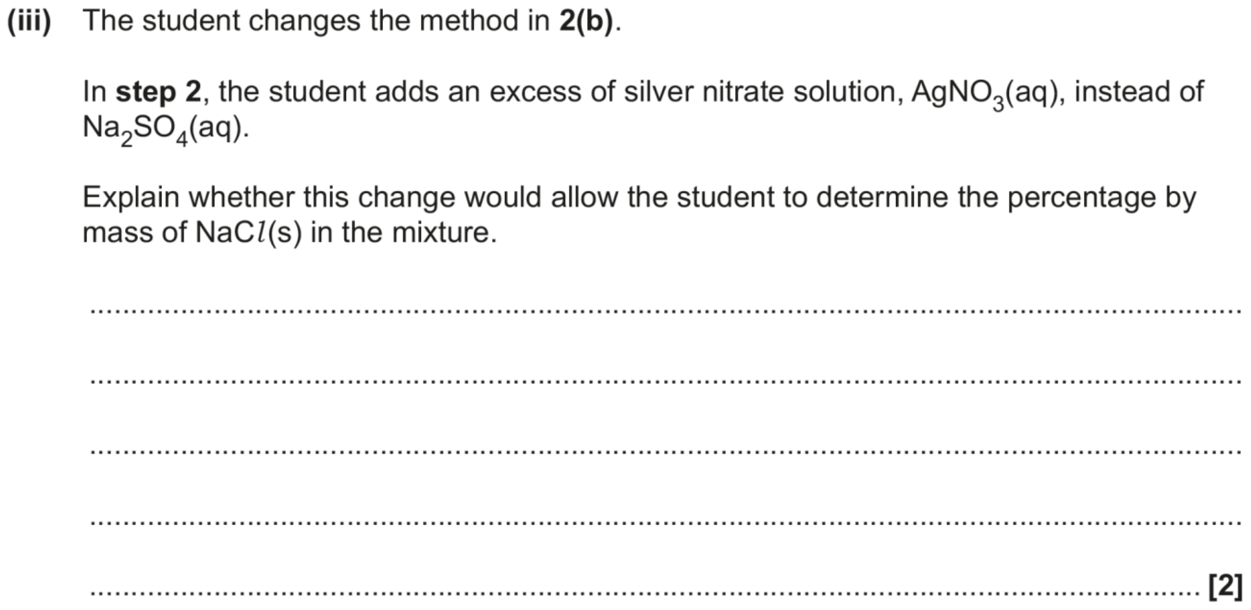
percentage by mass of $\mathrm{NaC}l(\mathrm{s})$ = ... % **[4]**

This was a tricky calculation, made more challenging if candidates hadn't been able to successfully complete (i). Many were able to calculate the moles of $BaSO_4$ but often rounded their answer to only 2 significant figures at this stage i.e. 0.014. Many assumed a direct ratio between $BaSO_4$ and NaCl so mass was found by multiplying moles by 58.5 (molar mass for NaCl) - if this was done then credit was given for ECF for the final marking point.

OCR support

The M1 section of the Mathematical Skills handbook contains useful information on handling data, including M1.1 use of significant figures.

Question 2 (b) (iii)



(iii) The student changes the method in **2(b)**.

In **step 2**, the student adds an excess of silver nitrate solution, $AgNO_3(aq)$, instead of $Na_2SO_4(aq)$.

Explain whether this change would allow the student to determine the percentage by mass of $NaCl(s)$ in the mixture.

....

....

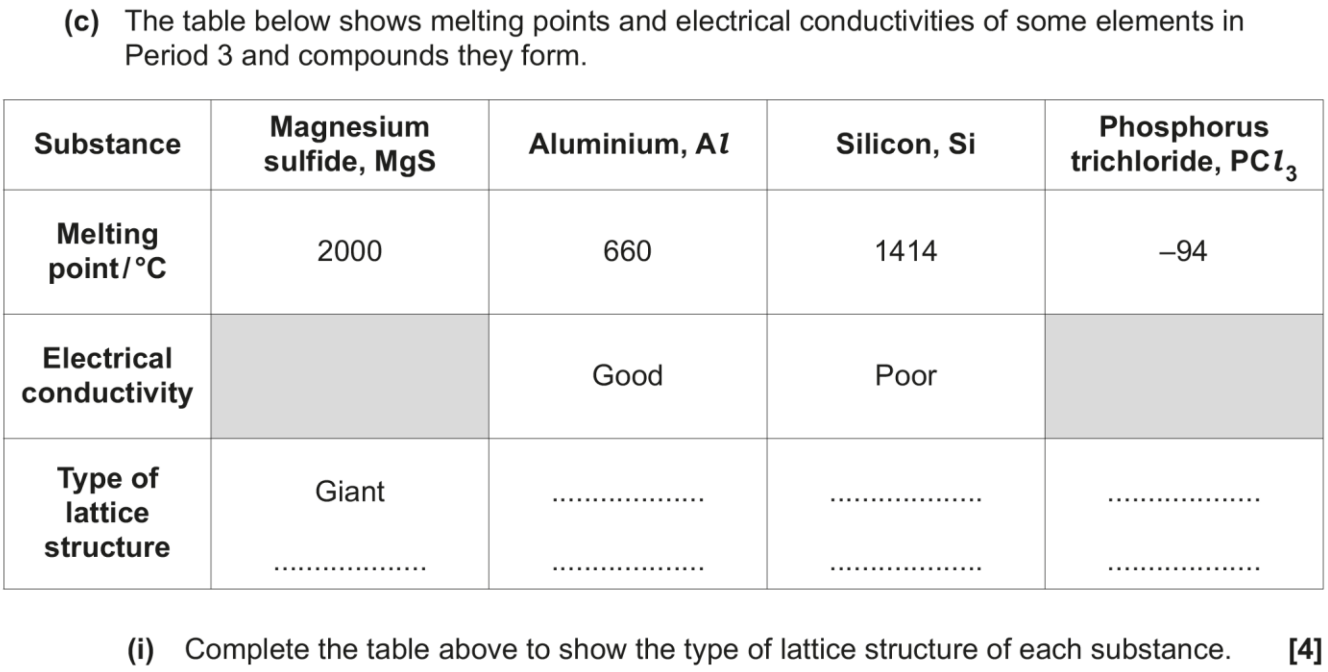
....

....

.... **[2]**

Another tricky question with less than half gaining credit. Many were able to recognise the addition of silver nitrate as the test for halide ions but did not realise that it could be used quantitatively. Many didn't read the question carefully and assumed Na_2SO_4 was still present, giving a mixture of two precipitates. Some, despite recognising the formation of AgCl, could not then see how to calculate the mass of NaCl i.e. "you won't have formation of $BaSO_4$". Some suggested that barium nitrate would also form a precipitate, perhaps confused by the (s) state symbol in the question.

Question 2 (c) (i)



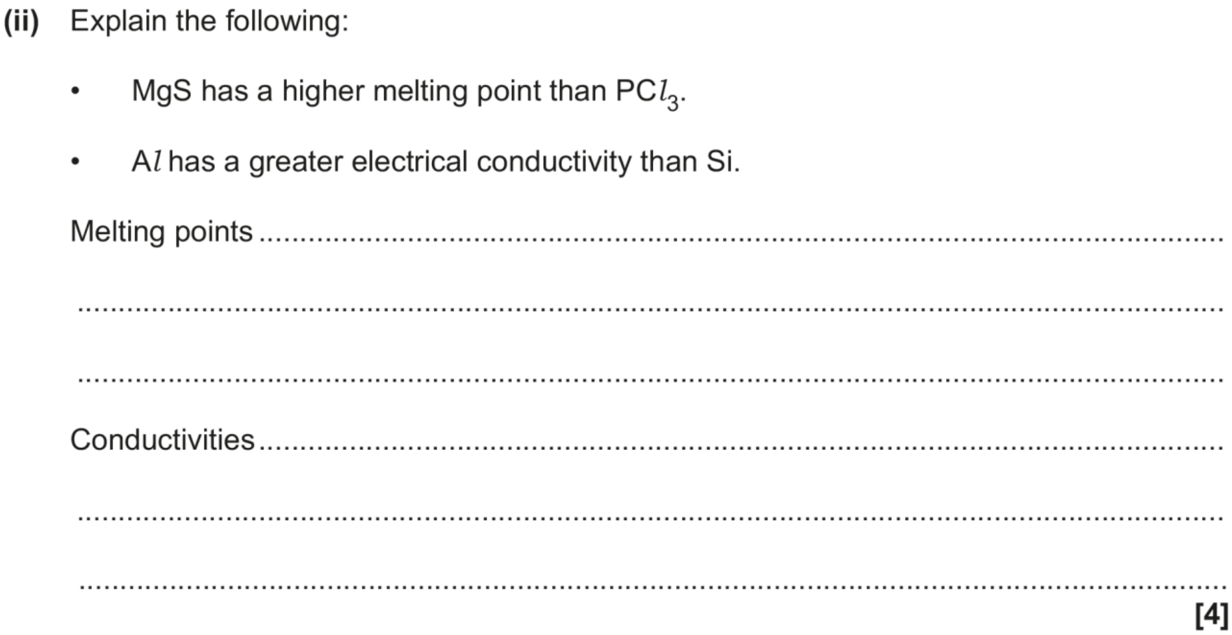
(c) The table below shows melting points and electrical conductivities of some elements in Period 3 and compounds they form.

Substance	**Magnesium sulfide, MgS**	**Aluminium, Al**	**Silicon, Si**	**Phosphorus trichloride, PCl_3**
Melting point / °C	2000	660	1414	–94
Electrical conductivity	▨	Good	Poor	▨
Type of lattice structure	Giant	....	....	....

(i) Complete the table above to show the type of lattice structure of each substance. **[4]**

About half the candidates gained all 4 marks. Candidates often find it tricky to recognise the type of structure even when given some details about physical properties. Often giant was omitted especially for Al as metallic bonding. Some used 'small' in place of 'simple'. Common errors included MgS as metallic and Si as simple covalent with PCl_3 as giant covalent. Many added unnecessary detail such as filling in the greyed-out boxes for conductivity or adding lattice to each box.

Question 2 (c) (ii)



(ii) Explain the following:

- MgS has a higher melting point than PCl_3.
- Al has a greater electrical conductivity than Si.

Melting points ....

....

....

Conductivities ....

....

....

[4]

Candidate explanations often lacked clarity even if the correct structure had been identified in (i). Most gained at least 1 mark, usually for recognising that for MgS to have a higher melting point that it must contain stronger bonds than in PCl_3. Responses highlighted a range of misconceptions including the presence of intermolecular forces in ionic/metallic substances, oppositely charged atoms in ionic compounds, and thinking London forces are between atoms. Most were able to gain the conductivity mark, but some compared to PCl_3 rather than Si as asked in the question. Some described 'mobile ions' in Al or that Si has 'no electrons'. The use of 'free electrons' was seen in many responses, and we would encourage the use of 'delocalised electrons' for a more accurate description of metallic bonding.

OCR support

OCR have produced a KS4-KS5 transition guide for bonding and structure to support teaching of these tricky concepts.

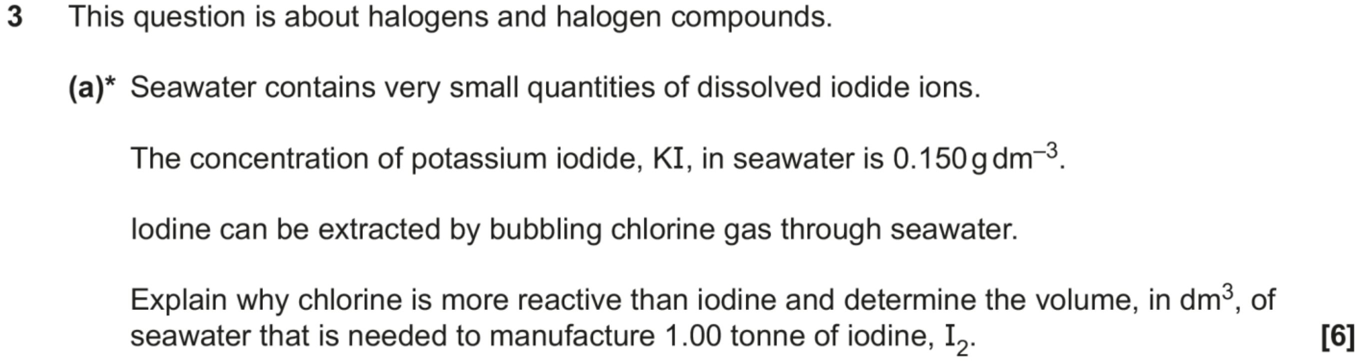
A bonding delivery guide is also available.

Assessment for learning

Checking understanding of different types of bonding and structure plus links to their physical properties is very important. OCR have produced a range of multiple choice question quizzes that can be used to help check understanding - these are available as digital versions as well, enabling you to view responses. Guidance is given on how to use the digital versions on the OCR website.

A useful multiple-choice quiz to use here is on electrons, bonding and structure..

Question 3 (a)*



3 This question is about halogens and halogen compounds.

(a)* Seawater contains very small quantities of dissolved iodide ions.

The concentration of potassium iodide, KI, in seawater is 0.150 g dm^{-3}.

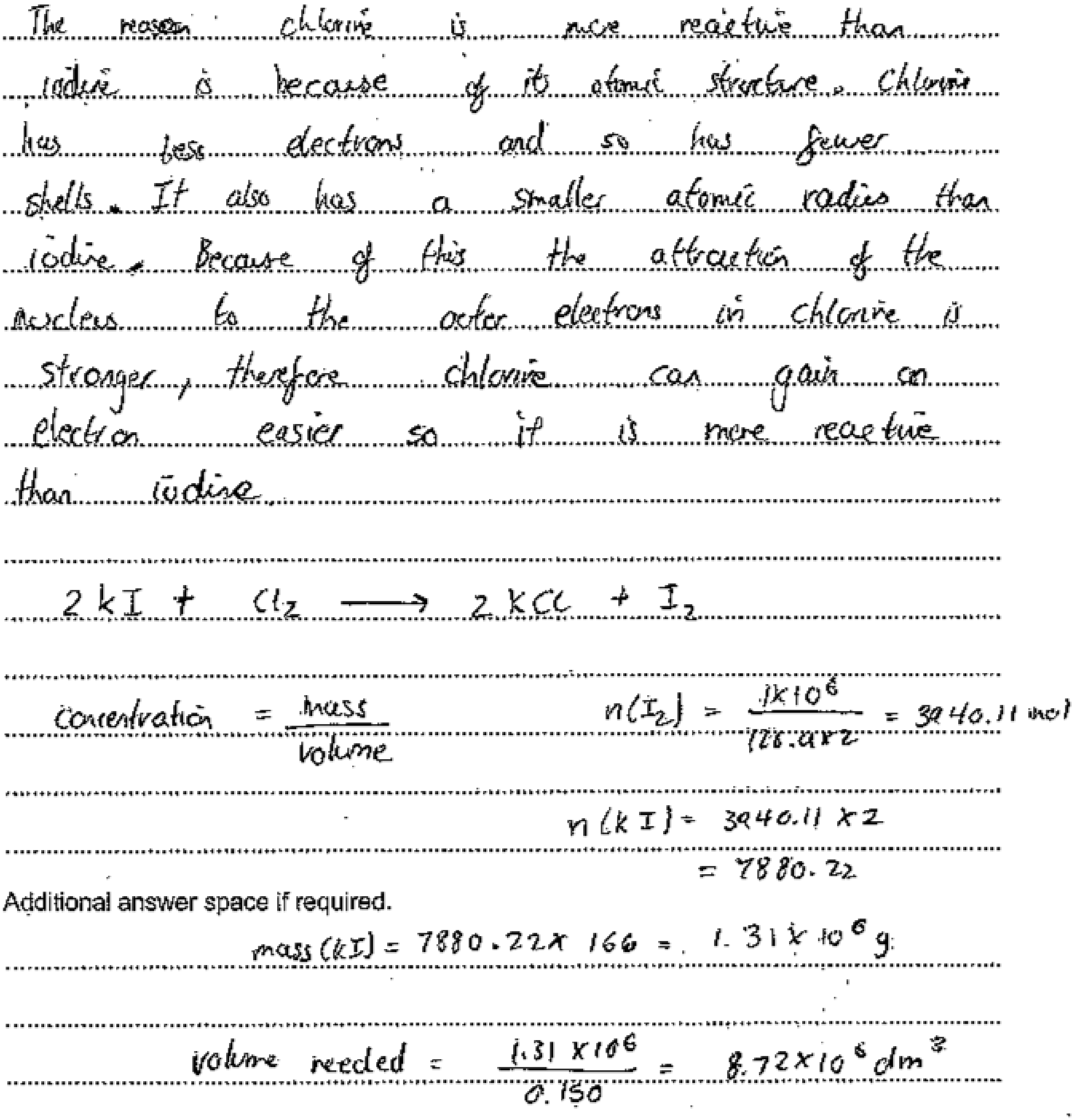
Iodine can be extracted by bubbling chlorine gas through seawater.

Explain why chlorine is more reactive than iodine and determine the volume, in dm^{3}, of seawater that is needed to manufacture 1.00 tonne of iodine, I_2. **[6]**

Very few candidates managed to access the higher level on this question. They found the calculation very challenging. In addition to a typical mole calculation, they needed to use the tonnes conversion (given on the data sheet), look at the ratio of I_2 to KI and use a mass concentration. Many used the mass concentration as a molar concentration. Even if a balanced equation was given, it didn't guarantee the correct ratio in calculations and a common error was to find moles of I_2 using the relative atomic mass of iodine (126.9). As with previous calculations on this paper, it was often challenging to follow the logic in the steps of the calculation. It is important to encourage candidates to label each step of their calculation, showing them as independent steps and only using = when terms are equal.

Explanations of relative reactivities of chlorine and iodine often lacked detail or had extra irrelevant information, such as reference to electronegativity, ionisation energy, bond enthalpy or intermolecular forces. Some candidates gave responses for the general trend in reactivity in the group rather than comparing Cl and I. Confusion around nuclear charge and nuclear attraction was also often seen. A key skill for longer answer questions is to plan out answers to avoid contradictions. Candidates should also be encouraged to re-read their answers to check that what they have written makes sense.

Exemplar 2



The reason chlorine is more reactive than iodine is because of its atomic structure. Chlorine has less electrons and so has fewer shells. It also has a smaller atomic radius than iodine. Because of this the attraction of the nucleus to the outer electrons in chlorine is stronger, therefore chlorine can gain an electron easier so it is more reactive than iodine.

$2kI + Cl_2 \longrightarrow 2KCl + I_2$

$\text{concentration} = \frac{\text{mass}}{\text{volume}}$

$n(I_2) = \frac{1 \times 10^6}{126.9 \times 2} = 3940.11 \text{ mol}$

$n(kI) = 3940.11 \times 2$

$= 7880.22$

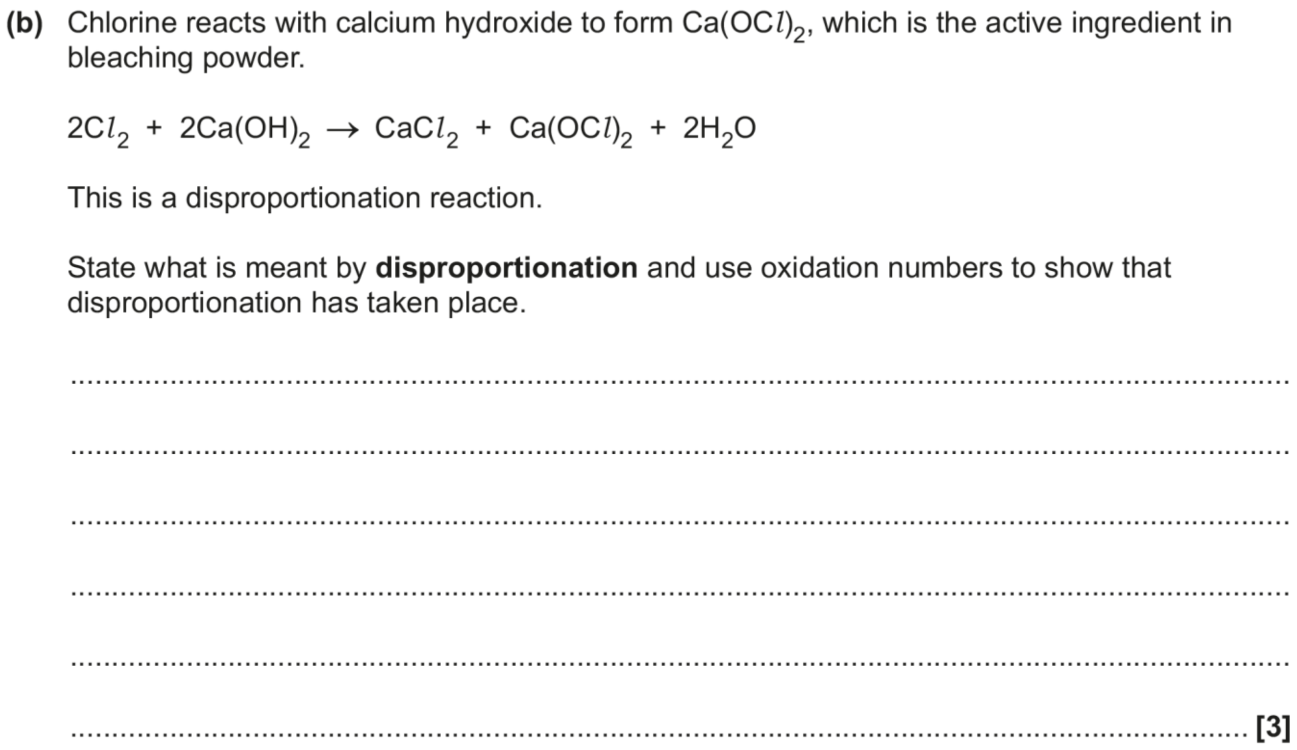
Additional answer space if required.

$\text{mass}(kI) = 7880.22 \times 166 = 1.31 \times 10^6 \text{ g}$

$\text{volume needed} = \frac{1.31 \times 10^6}{0.150} = 8.72 \times 10^6 \text{ dm}^3$

This exemplar demonstrates a L3 6 mark response. A comprehensive explanation of relative reactivities of chlorine and iodine is given. The steps in the calculation are logical with each step labelled, making it easy to follow. A balanced equation is also given.

Question 3 (b)



(b) Chlorine reacts with calcium hydroxide to form $Ca(OCl)_2$, which is the active ingredient in bleaching powder.

$$2Cl_2 + 2Ca(OH)_2 \rightarrow CaCl_2 + Ca(OCl)_2 + 2H_2O$$

This is a disproportionation reaction.

State what is meant by **disproportionation** and use oxidation numbers to show that disproportionation has taken place.

....

....

....

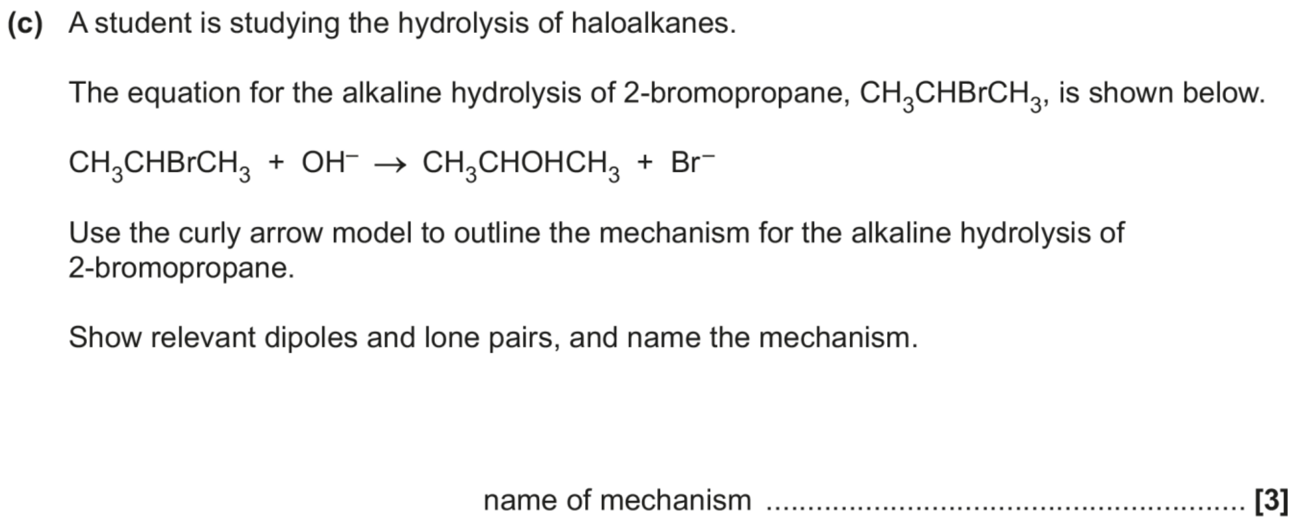
....

....

.... **[3]**

Most were able to explain the term disproportionation. Some missed the mark by not stating an element or chlorine. A very common error was giving final oxidation numbers of Cl as +2 and/or -2, rather than per atom. The link between oxidation number and species was not always clearly indicated or changes not specified as oxidation/reduction (or given as the wrong way round). It is vital to set out answers clearly showing oxidation numbers, species and stating if oxidised or reduced. It is not enough to write on the equation given in the question as it often challenging to read these numbers, or they contradict the main answer. Some attempted to show that Ca has been disproportionated.

Question 3 (c)



(c) A student is studying the hydrolysis of haloalkanes.

The equation for the alkaline hydrolysis of 2-bromopropane, $CH_3CHBrCH_3$, is shown below.

$CH_3CHBrCH_3 + OH^- \rightarrow CH_3CHOHCH_3 + Br^-$

Use the curly arrow model to outline the mechanism for the alkaline hydrolysis of 2-bromopropane.

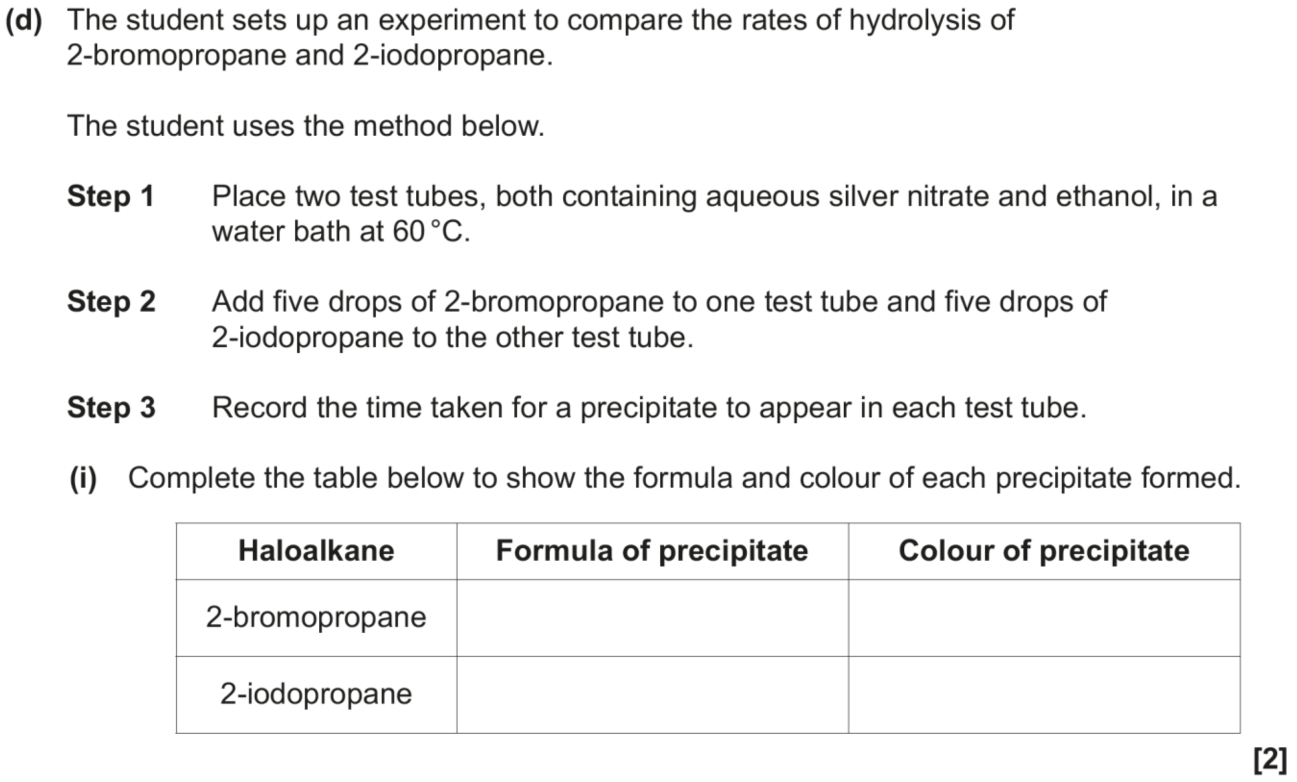
Show relevant dipoles and lone pairs, and name the mechanism.

name of mechanism .... **[3]**

Just under half the candidates gained all 3 marks for this mechanism. Marks were often lost for incorrect positioning or a missing arrow for the breaking of the C-Br bond. Dipoles were often added to the hydroxide ions. Some also showed the lone pair for OH- going to the C-Br bond and not to the $C^{\delta+}$.

A range of spellings of nucleophilic were seen, including: nucleophilic, nucleophilic, nucleophilic, and nucleophilic. It is important to promote good literacy in science, including meanings and spellings of technical language.

Question 3 (d) (i)



(d) The student sets up an experiment to compare the rates of hydrolysis of 2-bromopropane and 2-iodopropane.

The student uses the method below.

Step 1 Place two test tubes, both containing aqueous silver nitrate and ethanol, in a water bath at 60 °C.

Step 2 Add five drops of 2-bromopropane to one test tube and five drops of 2-iodopropane to the other test tube.

Step 3 Record the time taken for a precipitate to appear in each test tube.

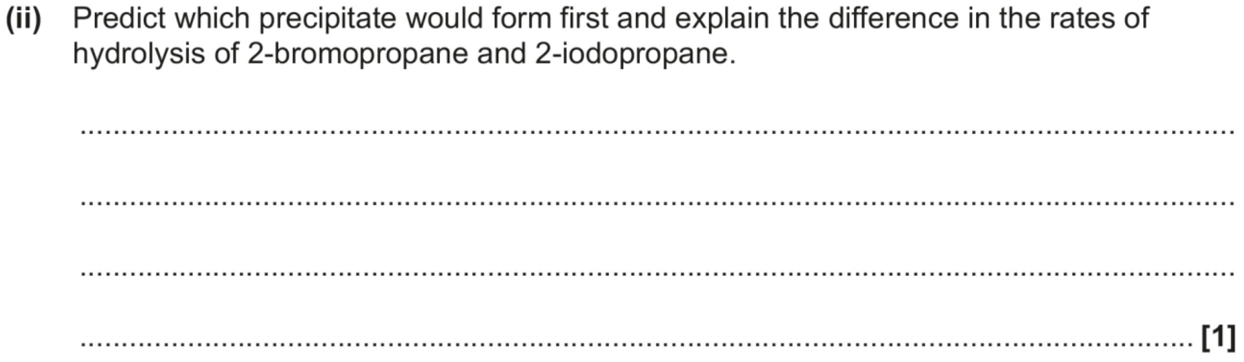
(i) Complete the table below to show the formula and colour of each precipitate formed.

Haloalkane	Formula of precipitate	Colour of precipitate
2-bromopropane		
2-iodopropane		

[2]

The majority of candidates scored both marks. Some scored 1 mark only mainly for correct colours of the precipitates but with incorrect formulae. Common errors included $AgBr_2$ and AgI_2, giving the formula of the haloalkane or formulae involving a halogen and a nitrate ion.

Question 3 (d) (ii)



(ii) Predict which precipitate would form first and explain the difference in the rates of hydrolysis of 2-bromopropane and 2-iodopropane.

....

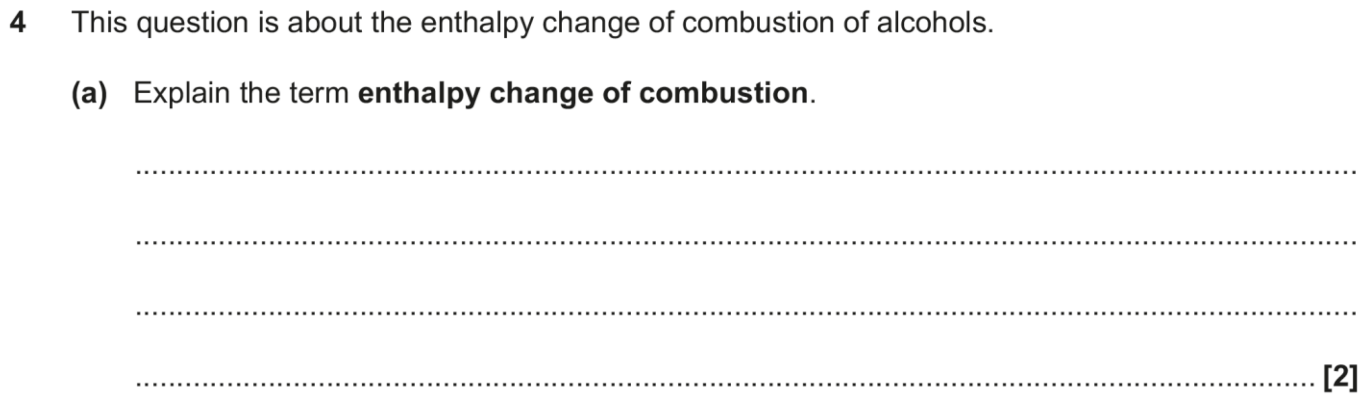
....

....

.... **[1]**

Most responses did not gain credit here. Some recognised that AgI would form first but then gave an incorrect reason (such as 'held by weaker London forces') or their answers lacked detail (e.g., 'weaker bonds' without specifying which bonds). Many said AgBr because Br is more reactive or more electronegative.

Question 4 (a)



4 This question is about the enthalpy change of combustion of alcohols.

(a) Explain the term **enthalpy change of combustion**.

....

....

....

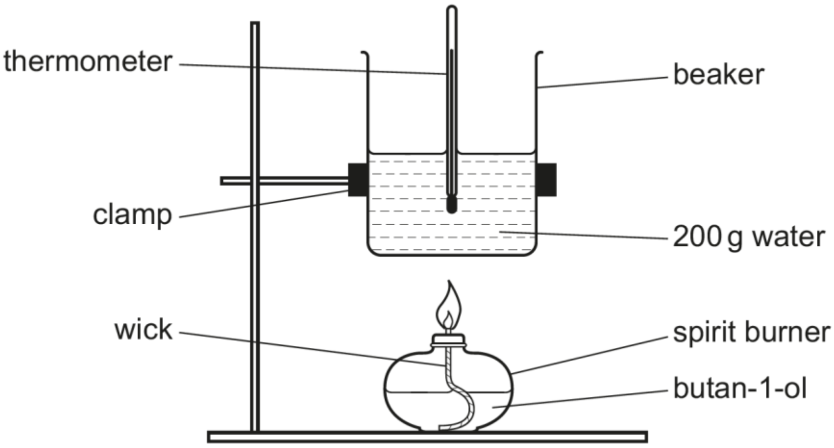
.... **[2]**

Approximately half of candidates scored both marks. Many lost marks for saying ‘energy required’ or ‘energy needed’ which demonstrated a lack of understanding that for an exothermic reaction this would be the activation energy not the enthalpy change. Some also had 1 mole of substance but this was reacted with 1 mole of oxygen or formed 1 mole of products.

Question 4 (b) (i)

(b) A student carries out an experiment to determine the enthalpy change of combustion, $\Delta_c H$, of butan-1-ol, $CH_3CH_2CH_2CH_2OH$.

The student sets up the apparatus as shown below.



The student's results are shown in the table below.

Initial temperature of water / °C	18.5
Final temperature of water / °C	49.5
Mass of burner before heating / g	212.38
Mass of burner after heating / g	211.07

(i) The thermometer had an uncertainty of ± 0.25 °C in each temperature reading.

Calculate the percentage uncertainty in the temperature change.

percentage uncertainty = ... % **[1]**

More than half of candidates gave the correct answer. Common mistakes included not multiplying the uncertainty by 2 for each measurement (0.81) or using the initial or final temperatures rather than the difference in their calculations.

Question 4 (b) (ii)*

(ii)* Use the student's results to determine $\Delta_c H$ of butan-1-ol in $kJ\,mol^{-1}$.

Explain why this value of $\Delta_c H$ is different from the data book value and suggest how the experimental design could be modified to improve the accuracy of the $\Delta_c H$ value obtained. **[6]**

Many candidates limited themselves to only L1 here by not calculating the enthalpy change from the student's results. Remind candidates to read the question carefully and to use all the information provided (such as tables of results). Some missed out on L3 as their evaluation lacked detail, as they needed to include at least two differences and two suitable improvements. Not all improvements given were suitable, with some suggesting candidates confusing different practicals - for example, 'use a polystyrene cup' or 'heat to a constant mass'. It was evident that some lacked understanding about complete combustion, with suggestions to 'measure mass until it doesn't change any further' or 'heat water for longer' to make sure complete combustion had occurred. Some also suggested 'using a larger mass' but further information was needed for credit to be given.

OCR support

Further information about practical skills assessed on written exams can be found in Section 3 of the practical skills handbook. If using the suggested practical activities developed by OCR, then encourage candidates to answer the extension opportunity questions to help develop a deeper understanding in preparation for written assessments.

Exemplar 3

$q = mc\Delta T = 200 \times 4{\cdot}18 \times (49{\cdot}5 - 18{\cdot}5)$

$= 25916\ \text{J} \quad = 25{\cdot}916\ \text{kJ}$

$n = \frac{m}{M_r}$

moles burnt $= \frac{212.38 - 211{\cdot}07}{74} = \frac{131}{7400} = 0{\cdot}0177027027$

$25{\cdot}916 \div 0{\cdot}0177027027 = 1463{\cdot}957252\ \text{kJmol}^{-1}$

$\Delta_c H = -1460\ \text{kJmol}^{-1}$ (3sf)

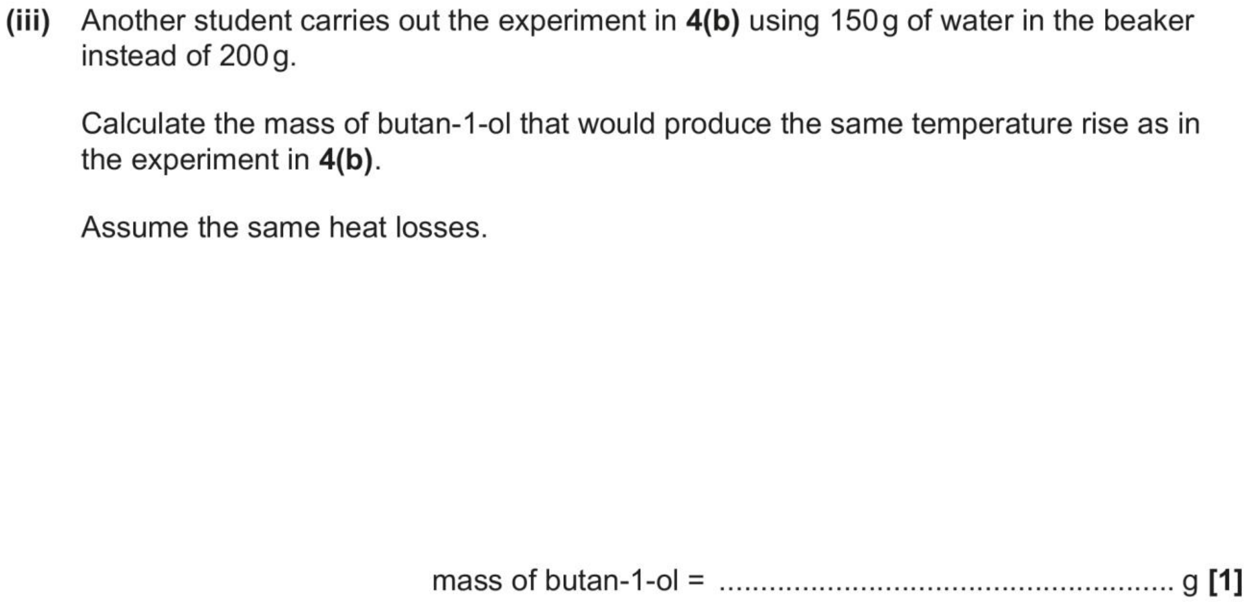
This ~~is~~ may be different to the data book value because the reaction ~~may not have occurred~~ did not occur at standard conditions (100 kPa, 298 K). ~~so use~~ Heating the beaker to 25°C first may have improved the accuracy. ~~a water bath to control the temperature~~ Also, may have been due to heat loss to the surroundings from the water. Add more insulation to the beaker to reduce this. Some butan-1-ol may have evaporated from the wick so our calculated moles would be too high and our $\Delta_c H$ value too low. Incomplete combustion may have occured, so ensure there is a plentiful supply of oxygen. They could have warmed the beaker for longer to reduce the percentage uncertainty in temperature change and therefore $\Delta_c H$.

Additional answer space if required.

Decreasing distance between beaker and spirit burner may improve accuracy.

This exemplar shows a candidate who achieved L3 with all 6 marks given. Working for the calculation of ∆H is clear with all steps shown, in a logical order, and the final answer has correct negative sign. More than 2 differences and 2 improvements are given. The communication is clear, linking potential differences with suggestion for improvements.

Question 4 (b) (iii)



(iii) Another student carries out the experiment in **4(b)** using 150 g of water in the beaker instead of 200 g.

Calculate the mass of butan-1-ol that would produce the same temperature rise as in the experiment in **4(b)**.

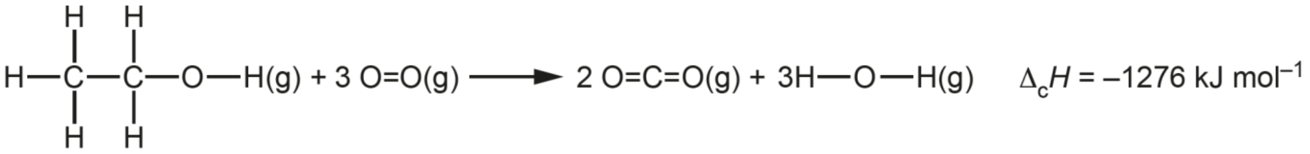
Assume the same heat losses.

mass of butan-1-ol = ... g **[1]**

Those that were more confident with the calculation in (ii) were more likely to get the answer here. ECF was occasionally seen from an incorrect mass or enthalpy change depending on method used. Many were able to work out q using 150g of water even if they had incorrectly calculated q in (ii) - such as previously using 1.31g.

Question 4 (c) (i)

(c) The enthalpy change of combustion of ethanol, $\Delta_c H$, in the gaseous state can be calculated using average bond enthalpies.



$$\mathrm{CH_3CH_2OH(g)} + 3\ \mathrm{O{=}O(g)} \longrightarrow 2\ \mathrm{O{=}C{=}O(g)} + 3\mathrm{H{-}O{-}H(g)} \qquad \Delta_c H = -1276\ \mathrm{kJ\ mol^{-1}}$$

(i) Use this value of $\Delta_c H$ and the average bond enthalpies below to calculate the average bond enthalpy of C=O.

Bond	**Average bond enthalpy / kJ mol^{-1}**
C–H	+413
C–C	+347
C–O	+358
O–H	+464
O=O	+498

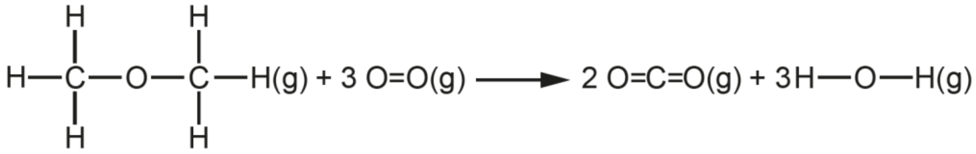
C=O bond enthalpy = ...kJ mol^{-1} **[4]**

Candidates' working was often unclear and very difficult to follow for this question, making it challenging to find errors and award ECF where appropriate. Despite being given the displayed formula, many were unable to correctly count the bonds in the molecules. Missing some or all of C-C, C-O and 3 x O=O from the bonds broken was often seen. Some only counted 2 x C=O bonds in the products. Some subtracted the bonds broken from bonds made or omitted the enthalpy change from their calculation. Very few candidates gave a negative value for their final bond enthalpy.

Question 4 (c) (ii)

(ii) Methoxymethane, CH_3OCH_3, is an isomer of ethanol.

On combustion, methoxymethane, in the gaseous state, produces carbon dioxide and steam.



$$\mathrm{H{-}\overset{H}{\underset{H}{C}}{-}O{-}\overset{H}{\underset{H}{C}}{-}H(g) + 3\ O{=}O(g) \longrightarrow 2\ O{=}C{=}O(g) + 3H{-}O{-}H(g)}$$

$\Delta_c H$ for methoxymethane is more negative than $\Delta_c H$ for ethanol.

Explain why the $\Delta_c H$ values are different, in terms of the bonds broken and the bonds formed.

....

....

....

....

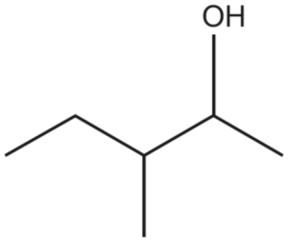
.... **[2]**

Very few candidates scored both marks here. Many just gave a generic response describing an exothermic reaction i.e. 'more energy is released in bond forming than needed for bond breaking' rather than answering the question asked. It was evident from many responses that candidates are unclear that energy is needed for bond breaking and released in bond forming. Some tried to compare specific bonds but often failed to account for them all, comparing presence of C-O and extra C-H in methoxymethane to O-H in ethanol but forgetting the C-C bond, resulting in methoxymethane having stronger bonds/more energy to break bonds. Lots didn't recognise that the same products were formed in both reactions.

Question 5 (a) (i)

5 This question is about alkenes.

(a) A mixture of alkenes is produced when water is eliminated from alcohol **A**.



Alcohol A

(i) What is the systematic name of alcohol **A**?

.... **[1]**

A significant number of candidates lost the mark for missing -an- in their answer i.e. 3-methylpent-2-ol. Others lost the mark for incorrect spelling of methyl.

Question 5 (a) (ii)

(ii) Alcohol **A** is refluxed with an acid catalyst.

- A mixture of alkene isomers **B**, **C** and **D** is formed.
- Alkenes **B** and **C** show *E*/*Z* isomerism but alkene **D** does not.

Construct the equation for the formation of alkene **D** from alcohol **A**.

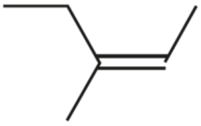
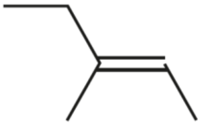
Show the structure of the organic product.

[2]

Most candidates did not score either mark here, despite the structures for B and C being given in the table below for (iii). Many thought this was oxidation, showing [O] in equations and giving a carbonyl product. Many had alkenes but still with the -OH present. Some attempted to use structural or displayed formulae but errors were made in giving the correct number of H atoms. For those that did have the correct structure, they often did not give an equation, added the acid as a reactant, or missed off the water as a product.

Question 5 (a) (iii)

(iii) The skeletal formulae of alkenes **B** and **C** are shown below.

	Alkene B	**Alkene C**
Skeletal formula		
Isomer	*Z*	*E*

Use the Cahn-Ingold-Prelog priority rules to explain why alkene **B** is the *Z* isomer.

....

....

....

....

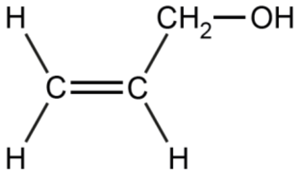
.... **[2]**

Many responses made no reference to 'priority' and/or discussed alkene C, suggesting that they didn't read the question fully. Candidates often struggled to find the right language to express themselves, such as reference to 'functional groups' or 'molecules' rather than priority groups. Lots discussed using M_r to assign priority with only a few stating correctly that it is atomic number that is used for CIP rules. Many, despite stating that priority groups are on the same side, didn't identify these groups so didn't get the second mark.

Question 5 (b) (i)

(b) A chemistry company is developing water-soluble polymers.

The chemists decide to use compound **E**, shown below, as the monomer.



Compound E

(i) Draw a section of the polymer formed, showing **two** repeat units, and suggest why this polymer is likely to be soluble in water.

Section of polymer (**two** repeat units)

Reason for solubility in water ....

....

....

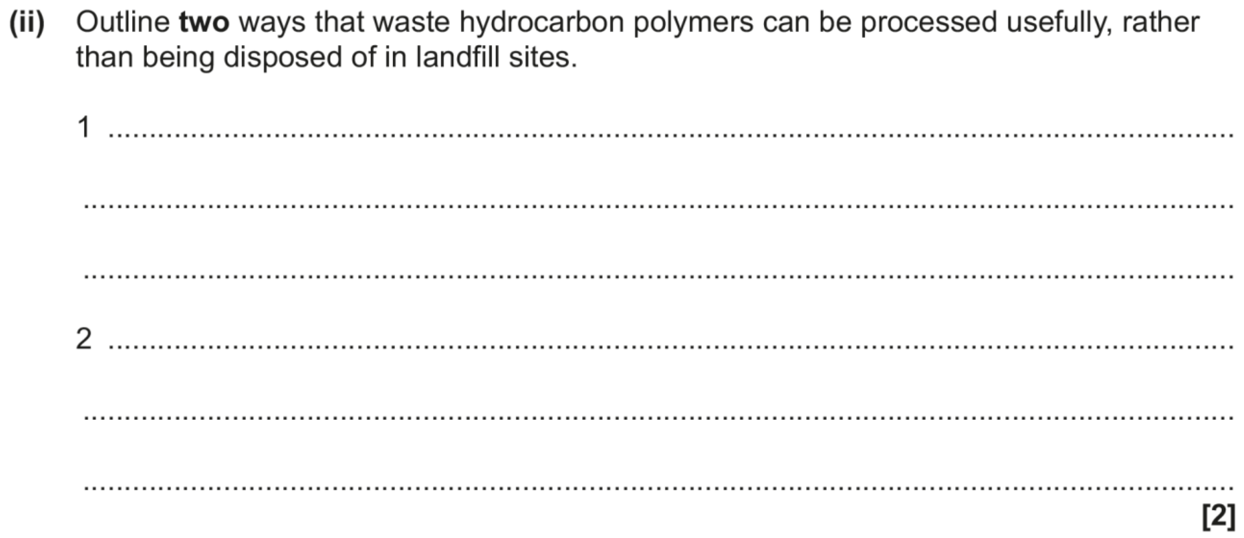
....

[2]

Most candidates were able to gain credit for their structure, with only a few missing out by only drawing one repeat unit, keeping the C=C, having no end bonds or missing/extra Hs. Lots struggled to gain the second mark for the reason for solubility in water as they didn't refer to H-bonding.

There were quite a few misconceptions highlighted in the responses to this question. These included the misunderstanding that a H-bond is an an intermolecular force between -OH on alcohol and water, rather than the covalent bond in the molecule. Some thought the -OH would behave as an alkali, even referring to ions, so would 'fully dissociate'. Some described a reaction with water and breaking apart, perhaps confusing with condensation polymers which can be hydrolysed.

Question 5 (b) (ii)



(ii) Outline **two** ways that waste hydrocarbon polymers can be processed usefully, rather than being disposed of in landfill sites.

1 ....

....

....

2 ....

....

....

[2]

About a quarter of candidates didn't gain any credit here as they struggled to identify useful processes. Lots referred to cracking or breaking down into smaller chains, possibly thinking about fractional distillation of crude oil and how we make better use of larger fractions. Some identified possible use as a fuel but didn't say to generate energy/electricity. We also saw reference made to photodegradable/biodegradable polymers which isn't relevant to hydrocarbon polymers. There was evidence of the misunderstanding of the use as 'feedstock' with reference being made to animals (livestock or animal feed) or as food to eat.

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