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Examiners' report

A LEVEL

CHEMISTRY A

OCR Level 3 Advanced GCE in Chemistry A

H432

For first teaching in 2015

H432/03 Summer 2025 series

Version 1

Contents

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Introduction

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

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. A selection of candidate 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.

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Paper 3 series overview

H432/03 is one of the three examination components for the A Level examination for GCE Chemistry A. This largely synoptic component links different areas of chemistry within different contexts: some practical, some familiar and some novel. To do well on this paper, candidates need to be comfortable applying their knowledge and understanding to unfamiliar contexts and be familiar with a range of practical techniques.

H432/03 is much more application-based that the other two A Level Chemistry components, H432/01 and H432/02, which have a greater emphasis on knowledge and understanding of the assessment outcomes from the specification. H432/03 also contains more questions set in a practical context than H432/01 and H432/02.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• displayed knowledge and understanding of important chemistry concepts in a familiar context, e.g.: ○ Question 2 (a) (ii) Drawing a skeletal formula from an organic name ○ Question 2 (b) (i) Recognising functional groups in organic structures ○ Question 5 (a) (iii): A nucleophile • performed standard calculations following a set method, e.g.: ○ Question 2 (a) (ii) Calculation using the Avogadro constant ○ Question 2 (b) (ii): mole calculations involving mass, gas volume and unit conversion from g to mg ○ Question 2 (c): Calculation of pH of an alkali ○ Question 3 (a): K_c calculation ○ Question 5 (a) (ii): Percentage yield ○ Question 6: Calculation of an energy change using $mc\Delta T$ • processing raw experimental results to extract relevant values for analysis in a quantitative context, e.g.: ○ Question 5 (a) (ii): Organic preparation ○ Question 6: Determination of an energy change.	• found it difficult to apply knowledge and understanding to unfamiliar situations, e.g.: ○ Question 4 (a) (iii), 5 (c) (ii) Writing equations for unfamiliar reactions using provided information ○ Question 4 (a) (ii), 5 (a) (v), 4 (c) (iv) Could not use provided information and clues within the questions • showed unclear setting out of unstructured calculations, sometimes with unlabelled numbers scattered across the page, e.g.: ○ Question 2 (b) (ii), 2 (c), 5 (a) (ii) Unstructured mole calculations. The same issue was noted in the 2023 and 2024 reports • found it difficult to apply their knowledge and understanding of important chemistry concepts to an unfamiliar context, e.g.: ○ Question 1 (a) (i), 1 (a) (ii) Showed a lack of basic knowledge and understanding of atomic structure in an unfamiliar context ○ Question 1 (b) Did not realise that protons in the same chemical environment and do not split one another.

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Question 1 (a) (i)

1 This question is about spectra.

(a) The mass spectrum for Br_2 has peaks at *m*/*z* values of 79, 81, 158, 160 and 162.
The peaks at *m*/*z* 79 and 81 have virtually the same relative abundance.

(i) Complete the table to show the number of protons, neutrons and electrons in the particles that cause the peaks at *m*/*z* 79 and 81.

m*/*z	**Number of protons**	**Number of neutrons**	**Number of electrons**
79			
81			

[2]

Most candidates answered protons and neutrons correctly, but very few worked out the electrons for the mass spectrometry particles correctly, with 35 being the most common incorrect response.

The information in the question needs to be read very carefully. With 2 marks allocated, there is a clue that the question might not be as straightforward as it first seems.

Question 1 (a) (i) and Question 1 (a) (ii) proved to be excellent discriminators between students at different grades.

Question 1 (a) (ii)

(ii) Explain why there are peaks with *m*/*z* values of 158, 160 and 162 and predict their relative abundances.

Explanation ....

....

....

....

Relative abundances ....

....

....

[3]

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Most candidates gave vague responses in terms of the properties of isotopes.

Some candidates were able to work out that the 158 and 162 peaks resulted from two ^{79}Br and two ^{81}Br isotopes respectively. The peak at 160 proved to be more difficult with many claiming that it resulted from two ^{80}Br isotopes rather than one ^{79}Br and one ^{81}Br isotope.

Predicting the relative abundance of the peaks was difficult, the most common response being that the peaks would have the same heights, presumably because the ^{79}Br and ^{81}Br isotopes have similar abundances.

Question 1 (b)

(b) This question looks at proton NMR spectra of dibromoalkanes.

Predict the following.

Compound	Number of peaks	CH_2 splitting pattern(s)
$BrCH_2CH_2Br$		
$BrCH_2CH_2CH_2Br$		

[3]

Most candidates identified the number of peaks, for which one mark was available.

The splitting patterns gave a variety of answers, with the triplet and pentet splitting from $BrCH_2CH_2CH_2Br$ proving to be the easier response.

Most candidates predicted that $BrCH_2CH_2Br$ would produce a triplet, rather than a singlet. This part of the question assessed whether candidates could identify protons with the same environment, and that they do **not** split one another.

Misconception

?

Many candidates do not consider chemical environments when predicting splitting patterns.

Protons with the same environment do **not** split one another.

Splitting only occurs between protons in **different** environments. The splitting patterns appear at different chemical shifts in an NMR spectrum.

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Question 2 (a) (i)

2 This question is about different compounds that each contain O and H atoms covalently bonded together.

(a) The alcohol 2,3-dimethylhexan-1-ol has the molecular formula $C_8H_{18}O$.

(i) Draw the skeletal formula of 2,3-dimethylhexan-1-ol.

[1]

Most candidates were able to correctly draw the skeletal formula.

Some candidates labelled the CH_3 groups and OH connectivity was sometimes shown incorrectly as –HO or OH–. Other incorrect responses showed a main carbon chain with more, or less, than 6 carbon atoms or the CH_3 side chains connected to the wrong carbon atoms. Good advice is to count the number of carbon atoms, with 'hexan' signifying 6 for this name.

Question 2 (a) (ii)

(ii) What is the number of H atoms in 8.45 g of 2,3-dimethylhexan-1-ol?

Give your answer to **3** significant figures and in standard form.

Number of H atoms = ... **[3]**

Most candidates correctly calculated the number of H atoms as 7.04×10^{23}.

Some omitted to use 18 or 130 but the mark scheme allowed such omissions so that candidates could get partial credit, provided that clear working had been shown. A common error was to show the answer to more than three significant figures despite the requirement in the question.

Overall, this was one of the more confidently answered questions on the paper.

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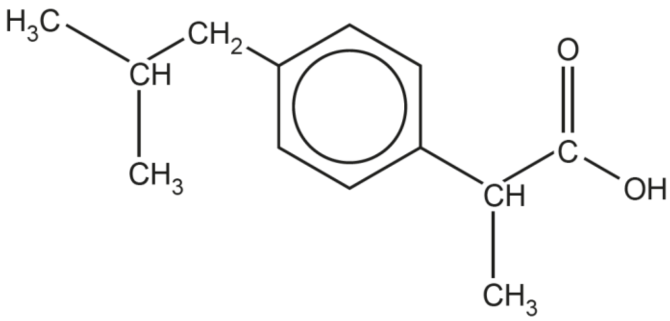
Question 2 (b) (i)

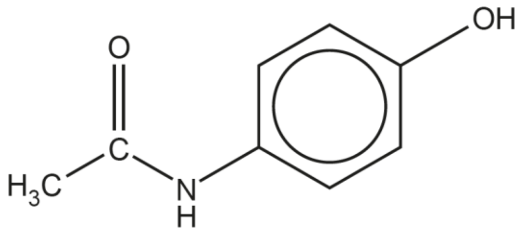
(b) Nuromol tablets are used to relieve pain.

Nuromol tablets contain a mixture of ibuprofen and paracetamol.

The structures of ibuprofen and paracetamol are shown.



Ibuprofen



Paracetamol

A student carries out an investigation to determine the mass of ibuprofen and the mass of paracetomol in one nuromol tablet.

- Ibuprofen reacts with aqueous sodium carbonate, $Na_2CO_3(aq)$, to produce a gas.

  $2RCOOH + Na_2CO_3 \rightarrow 2RCOONa + CO_2 + H_2O$

- Paracetamol does **not** react with $Na_2CO_3(aq)$.

(i) Why does paracetamol **not** react with $Na_2CO_3(aq)$?

....

....

.... **[1]**

This question was answered well, with most candidates identifying that ibuprofen contains a phenol group or that it does not contain a carboxylic acid. A named functional group was required in the answer.

Some described phenol incorrectly as not being an acid and this was not credited. It was rare for incorrect functional groups to be seen in candidate responses.

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Question 2 (b) (ii)

(ii) The student uses the reaction of nuromol tablets with Na_2CO_3(aq) to determine the mass of ibuprofen and the mass of paracetomol in one nuromol tablet.

The student's method is outlined below.

- Weigh **four** nuromol tablets.
- Add the tablets to an excess of aqueous sodium carbonate.
- Collect the gas produced and measure its volume.

Results
Mass of four nuromol tablets = 2.80 g
Volume of gas collected at RTP = 48.0 cm^3

Assume that ibuprofen is the only compound in nuromol tablets that reacts with Na_2CO_3(aq).

Determine the mass of ibuprofen and the mass of paracetomol, in mg, in **one** nuromol tablet.

Mass of ibuprofen = ... mg

Mass of paracetamol = ... mg
[4]

There were a variety of responses to this question, with many obtaining correct answers of 206 mg for ibuprofen and 494 mg for paracetamol.

From the 2:1 stoichiometry in the provided equation, the amount of ibuprofen is 4.00×10^{-3} mol. Candidates then needed to multiply this value by the molar mass of ibuprofen (206 g mol^{-1}).

Most candidates obtained 2.00×10^{-3} mol for CO_2. Common subsequent mistakes resulted from candidates ignoring the 2:1 stoichiometry, working out the molar mass incorrectly, not dividing by 4 for 1 tablet and not converting to mg. Some candidates used the ideal gas equation to work out the moles of CO_2. The question clearly stated RTP and the molar volume at RTP is stated on the *Data Sheet*. When RTP is stated, candidates are wasting valuable time by using the ideal gas equation, which is harder and opens up calculation errors, particularly with powers of 10.

Overall, the question was answered well. However, many calculations were unclearly displayed, with random numbers often sprayed across the page. This could make it very difficult to find answers, especially those containing errors.

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Question 2 (c)

(c) Barium hydroxide, $Ba(OH)_2$, is an alkali.
A student is supplied with a solution of $Ba(OH)_2$ with a concentration of $46.80\,g\,dm^{-3}$ at 25 °C.

The student dilutes $20.0\,cm^3$ of this solution of $Ba(OH)_2$ with water and the solution is made up to $100.0\,cm^3$ at 25 °C.

Calculate the pH of the diluted solution of $Ba(OH)_2$ at 25 °C.

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

pH = ... **[5]**

This unstructured calculation required candidates to work out the concentration of $Ba(OH)_2$, to scale the concentration for the 5 times dilution and to determine the concentration of OH^- ions by multiplying by 2.

Many different methods were seen for working out the moles of Ba $(OH)_2$, but the ÷5 and ×2 operations were often omitted. It was common for concentrations to be shown with the wrong number of powers of 10.

Many candidates used K_w or pOH confidently to obtain a value for pH. Error carried forwards (ECF) could be applied provided that the numbers used had been generated using the numbers in the question.

A good number of candidates determined the pH correctly to 2 decimal places as 13.04. The commonest incorrect answer was 12.74, the result of not using ×2 to find $[OH^-]$. As with Q2b(ii), responses were often unclearly laid out and it could be difficult to find answers.

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Question 3 (a)

3 This question is about equilibrium and rates.

(a) Methanol, CH_3OH, can be made industrially by the reaction of carbon monoxide, CO, with hydrogen, H_2, in the presence of a catalyst. This is a reversible reaction.

The equilibrium below is set up.

$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$ $\Delta H = -91\ kJ\ mol^{-1}$

The concentrations of CO(g) and $CH_3OH(g)$ in the equilibrium mixture are shown in the table below.

	CO(g)	**$CH_3OH(g)$**
equilibrium concentration / mol dm^{-3}	0.27	0.11

The value of the equilibrium constant, K_c, for this reaction is $1.8\ dm^6\ mol^{-2}$.

- Explain the conditions of pressure and temperature that would give the maximum equilibrium yield of $CH_3OH(g)$.
- Calculate the concentration of $H_2(g)$ in the equilibrium mixture to an **appropriate** number of significant figures.

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.... **[5]**

This question was answered confidently with most candidates identified the conditions for a maximum equilibrium yield from the equation: a high pressure from fewer gaseous moles in the product and a low temperature from the exothermic reaction.

This was all that the question asked but candidates often wrote far too much, considering operational conditions, rate, safely and expense. Unfortunately, candidates could end up contradicting themselves and wasting valuable time. Candidates are advised to read what the question is asking and to limit their response to this.

The calculation was answered well, with most identifying that 2 significant figures is appropriate as the lowest number of significant figures present in the data provided in the question. Thus 0.48 mol dm^{-3} was commonly seen, rather than 0.476. The K_c expression was usually correct and most candidates rearranged this correctly to make $[H_2]$ the subject. The square root calculation showed that some candidates did not appear to have the required calculator skills.

A significant number of candidates showed the K_c expression upside down and the mark scheme allowed ECF to be applied following this error.

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Question 3 (b)*

(b)* A reaction takes place when aqueous solutions of propanone, $CH_3COCH_3(aq)$, and bromine, $Br_2(aq)$, are mixed in the presence of dilute acid, $H^+(aq)$.

The overall equation for this reaction is shown below.

$CH_3COCH_3 + Br_2 \rightarrow CH_3COCH_2Br + HBr$ **Reaction 3.1**

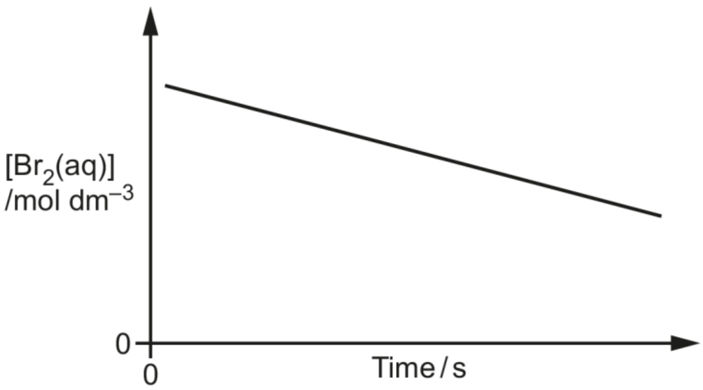
- A student carries out three experiments to investigate the rate of this reaction.
- In each experiment, the student investigates the effect of changing the concentration of one of the three chemicals whilst keeping the concentrations of the other chemicals constant.

The student's results are shown below.

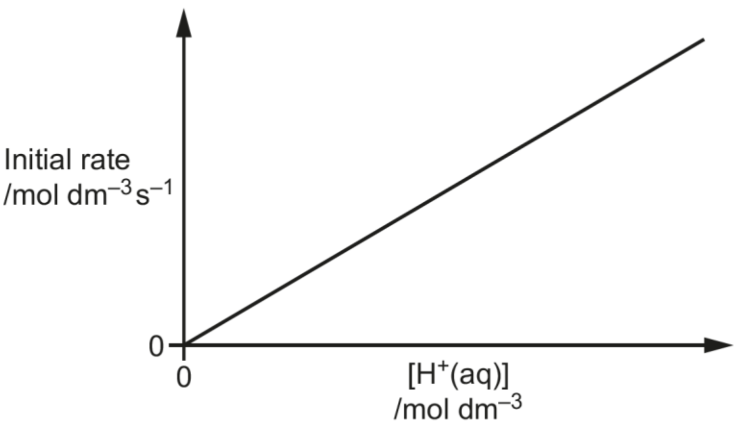
Experiment 1
Only $[CH_3COCH_3(aq)]$ is varied.

Initial concentrations			Initial rate /mol dm^{-3} s^{-1}
$CH_3COCH_3(aq)$ /mol dm^{-3}	**$Br_2(aq)$ /mol dm^{-3}**	**$H^+(aq)$ /mol dm^{-3}**	
1.50×10^{-3}	2.00×10^{-1}	2.50×10^{-1}	1.70×10^{-7}
4.50×10^{-3}	2.00×10^{-1}	2.50×10^{-1}	5.10×10^{-7}

Experiment 2
Only $[Br_2(aq)]$ is varied.



Experiment 3
Only $[H^+(aq)]$ varied.



Use the student's results to determine the order with respect to each of the three chemicals, the rate equation and rate constant for **Reaction 3.1**. Explain your reasoning.

Explain how the student's results can be used to show that the mechanism of **Reaction 3.1** has more than one step.

....

....

....

....

....

.... **[6]**

Most candidates were able to gain some marks for this Level of Response (LoR) question, with very few obtaining no marks.

To achieve Level 1, candidates needed to identify at least 2 of the 3 orders with no further correct analysis.

For Level 2 candidates were also expected to show the correct rate equation to match their orders or to provide a reason for why the mechanism must proceed via more than one step. Most candidates reaching Level 2 wrote a correct rate equation and usually calculated the rate constant. At this level, comparatively few produced a valid analysis of the mechanism.

For a Level 3 response, all three aspects of the analysis were required: correct orders, correct rate equation and rate constant, and a correct explanation of the mechanism. Many candidates were able to provide all three aspects.

Candidates usually determined the 1st order with respect to propanone from the initial rates data provided. The 1st order with respect to H^+ from the rate–concentration graph was often seen. The zero order with respect to bromine from the concentration–time graph caused more problems, with many candidates incorrectly choosing 1st or 2nd order.

The communication strand for this LoR question was given if the candidate had linked their orders with the evidence provided. Most candidates gave the initial rates but the evidence from the graphs was often omitted and vague. Responses such as 'because of the graph' are inadequate.

The candidate's response also had to be structured in a comprehensive way. This strand was usually given.

Exemplar 1 has been included as a superb and comprehensive response. The response goes far beyond the minimum requirements for Level 3 including the communication strand.

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Exemplar 1

Explain how the student's results can be used to show that the mechanism of **Reaction 3.1** has more than one step.

① experiment 1 = $[CH_3COCH_3] \times 3$, rate $\times 3$
the order with respect to $[CH_3COCH_3] = 1$.

② experiment 2.
the rate (gradient $\frac{[Br_2]}{time}$) stays constant in decreasing $[Br_2]$ over time.
The rate doesn't change. ~~$[Br_2]$ order is~~ Order with respect to $[Br_2]$ is 0.

③ experiment 3.
the rate increases directly proportionally with $[H^+]$, and graph passes through (0, 0). The rate changes and $[H^+]$ changes.
The order with respect to $[H^+]$ is 1.

rate = $k [CH_3COCH_3][H^+]$

$$k = \frac{rate}{[CH_3COCH_3][H^+]} = \frac{1.70 \times 10^{-7}}{(1.5 \times 10^{-3})(2.5 \times 10^{-1})} = 4.53 \times 10^{-4} \ mol^{-1} dm^3 s^{-1}$$

rate = $4.53 \times 10^{-4} [CH_3COCH_3][H^+]$

The rate equation shows the slowest step of the mechanism called the rate determining ~~step~~ step.
The rate equation has $[CH_3COCH_3]$ and $[H^+]$.
overall equation has $CH_3COCH_3 + Br_2 \rightarrow CH_3COCH_2Br + HBr$ [6]

Extra answer space if required.

The overall equation and ~~RDS~~ rate equation doesn't match: ~~No Br_2~~,
This suggests that the mechanism reactions are consisted of more than one step to form 1-Bromopropanone.
→ no Br_2 in the rate equation, and no $[H^+]$ in the overall equation.

Question 4 (a) (i)

4 This question is about inorganic chemistry.

(a) The flowchart shows reactions involving SO_3^{2-}(aq) ions.

(i) What is the systematic name of a SO_3^{2-} ion?

.... **[1]**

Candidates answered this question well. Overall, there has been an improvement of candidates' ability to write systematic names involving Roman numerals

Most incorrect responses either didn't use a Roman numeral or referred to sulfur oxides or sulfides. Although not a systematic name, the mark scheme did allow sulfite.

The old spellings, "sulphate" and "sulphur" are still commonly seen and were allowed.

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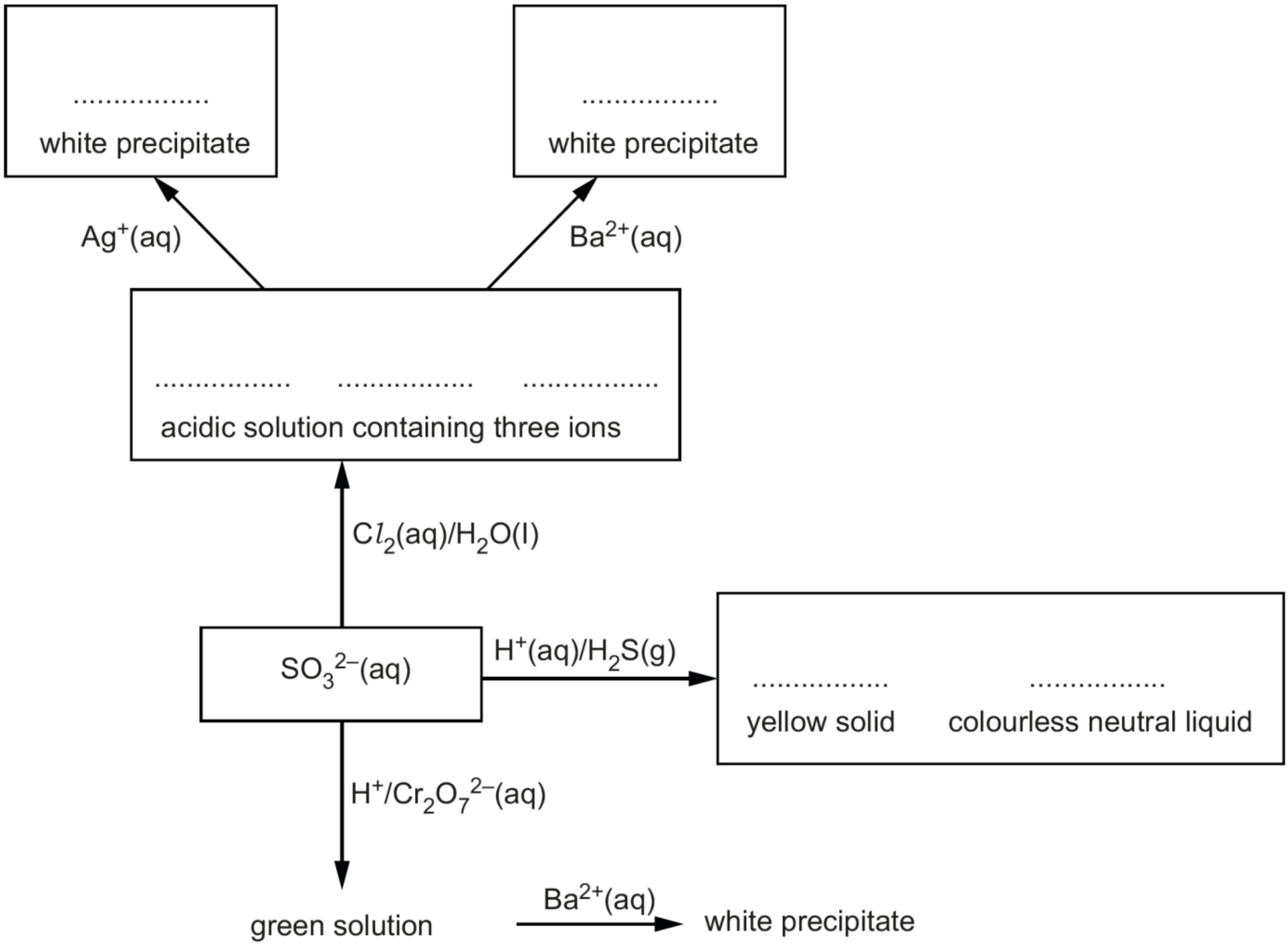
Question 4 (a) (ii)

(ii) Complete the flowchart by adding formulae in the boxes.



[7]

Candidates produced a range of answers, and the question discriminated extremely well. The higher attaining candidates often gave 6 or 7 correct formulae. The flowchart contained many clues which most candidates used.

Most were able to provide at least 3-4 of the required formulae and there was no consistently wrong answer.

Most candidates gave H^+ and Cl^- as two of the three ions, and AgCl for the white precipitate with $Ag^+(aq)$. Both S and S_8 were allowed for sulfur but S_2 was not allowed. As SO_4^{2-} ions are present, Ag_2SO_4 was also allowed for the precipitate with $Ag^+(aq)$.

Common errors included acid formulae such as H_2SO_4 in place of water, an incorrect formula for $BaSO_4$, giving $BaSO_3$, writing SO_4^- for the sulfate ion, and OH^- as one of the three 'acidic' ions.

Lower attaining candidates added formulae without using information in the question. Examples include full formulae such as HCl in the box labelled 'ions' and $CuCl_4^{2-}$ for the yellow solid, despite Cu being absent in the flowchart.

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Question 4 (a) (iii)

(iii) Construct an ionic equation for the reaction of SO_3^{2-} with $H^+/Cr_2O_7^{2-}$.

.... **[2]**

Candidates found all aspects of this question extremely difficult, one of the most testing's on this examination paper.

There was important information in the flowchart to aid candidates: the 'green solution' indicated that Cr^{3+} was one of the products, and the formation of a white precipitate with Ba^{2+}(aq) confirmed the presence of SO_4^{2-}(aq). The reacting ions were provided in the flowchart.

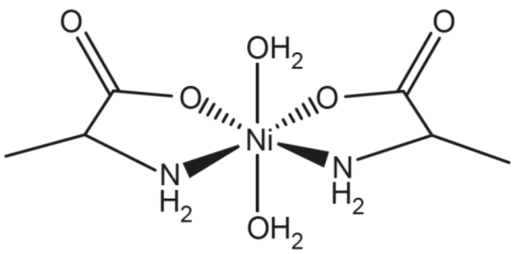
Together this information provided a framework for the equation:

SO_3^{2-}(aq) + $Cr_2O_7^{2-}$ $\rightarrow$ Cr^{3+} + SO_4^{2-}(aq). The equation then needed to be balanced, ideally using oxidation numbers, H_2O added as a product, and finally balancing.

Similar problems would be an ideal way of preparing candidates for writing equations for redox reactions.

Question 4 (b) (i)

(b) The structure of a neutral nickel(II) complex, **A**, is shown below.



Complex A

(i) What is the empirical formula of complex **A**?

.... **[1]**

Candidates produced a range of formulae, mainly from not counting H or C properly or omitting one of the elements, often Ni. A significant number of candidates wrote a structural formula rather than the empirical formula asked for in the question.

Question 4 (b) (ii)

(ii) Complex **A** can be prepared by reacting an aqueous solution of nickel(II) sulfate with amino acid **B** and potassium hydroxide.

Aqueous nickel(II) sulfate contains the octahedral hexaaquo complex ion **C**.

Draw the structure of amino acid **B** and the 3D structure, including the overall charge, of complex ion **C**.

Amino acid B	**Complex ion C**

[3]

The structure of the amino acid was usually drawn correctly.

The nickel complex ion provided problems with H_2O connectivity and superfluous use of SO_4. It was expected that bonds from Ni would be shown to the O atom, and that H_2O was shown correctly in all orientations. So $–H_2O$ and $–O_2H$ were not allowed.

Most candidates understood the importance of showing 3D bonds as wedges and the templates on the page will have helped in this respect. However, some candidates drew impossible 3D structures with bold wedges and dashed wedges shown opposite one another.

Despite the overall charge being asked for in the question, a significant number of candidates omitted the charge.

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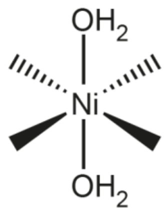
Question 4 (b) (iii)

(iii) Complete the 3D diagram below to show a stereoisomer of complex **A**.



[1]

Most candidates drew the correct *trans* isomer. The common incorrect response was to show the *cis* isomer rotated through 180º. As connectivity had been assessed already in 4(b)(ii) for the nickel complex ion, it was not penalised for NH_2 here or there would have been far more candidates who would not have been given this mark.

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Question 5 (a) (i)

5 This question is about two metal hydrides, lithium aluminium hydride, $LiAlH_4$, and sodium borohydride, $NaBH_4$. Both hydrides are used as reducing agents in organic chemistry.

(a) $LiAlH_4$, is a stronger reducing agent than $NaBH_4$, and can reduce esters to alcohols.

A student plans to use $LiAlH_4$ to reduce the liquid ester, ethyl phenylmethanoate, $C_6H_5COOC_2H_5$ (density = 1.05 g cm^{-3}) to the alcohol, $C_6H_5CH_2OH$ (M_r = 108).

The student uses $C_6H_5COOC_2H_5$ and $LiAlH_4$ (an excess) in a 1.0 : 2.5 molar ratio.

The student's method is outlined below.

Step 1 7.50 cm^3 of $C_6H_5COOC_2H_5$ is dissolved in an organic solvent.

Step 2 $LiAlH_4$ is added to the solution from **Step 1**. The reduction takes place.

Step 3 The mixture from **Step 2** is heated with dilute aqueous acid.

Step 4 The impure $C_6H_5CH_2OH$ is purified.

The student carries out this preparation and obtains 4.40 g of pure $C_6H_5CH_2OH$.

(i) What is the systematic name of the alcohol $C_6H_5CH_2OH$?

.... **[1]**

This name caused problems for most candidates.

Phenyl methanol was expected, and unambiguous representations were allowed including 1-phenylmethanol, phenylmethan-1-ol and 1-phenylmethan-1-ol

Many candidates incorrectly based the name on methylphenol or hydroxymethylbenzene.

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Question 5 (a) (ii)

(ii) Calculate the mass of $LiAlH_4$ that the student should use in **Step 2** and the percentage yield of pure $C_6H_5CH_2OH$ obtained in **Step 4**.

Give the mass of $LiAlH_4$ and the percentage yield of pure $C_6H_5CH_2OH$ to **3** significant figures.

Mass of $LiAlH_4$ = ... g

Percentage yield of pure $C_6H_5CH_2OH$ = ...%

[4]

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Most candidates gave either the correct mass of $LiAlH_4$ or the correct percentage yield.

Provided that working was shown, it was possible to award some marks form a correct method. This allows ECF to be applied where a candidate had produced an incorrect number early in their calculation.

Common errors included: omission of the density, dividing instead of multiplying by the density.

This question discriminated well and the presence of $LiAlH_4$ in the problem introduced a harder feature to a convention percentage yield calculation.

At with the unstructured calculations elsewhere on the paper, often numbers were seen randomly placed in the answer space, making it difficult to see where errors had arisen. Candidates may be penalising themselves if they do not show clear working.

It was common to see the moles of $LiAlH_4$ being confused with the moles of the alcohol in the percentage yield calculation with moles of $LiAlH_4$.

This error is shown in Exemplar 2.

The candidate has calculated the moles of $C_6H_5COOC_2H_5$ and $C_6H_5CH_2OH$ correctly and has the determined the mass of $LiAlH_4$. This has allowed 3 of the 4 marks to be given.

For the percentage yield, the candidate has then used the moles of $LiAlH_4$ instead of $C_6H_5CH_2OH$.

Notice that the candidate has also given their percentage yield to 4 significant figures (SF) rather than the 3 SF asked for in the question. If the correct moles of $C_6H_5CH_2OH$ had been used, this error would also have prevented the mark for percentage yield from being given.

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Exemplar 2

(ii) Calculate the mass of $LiAlH_4$ that the student should use in **Step 2** and the percentage yield of pure $C_6H_5CH_2OH$ obtained in **Step 4**.

Give the mass of $LiAlH_4$ and the percentage yield of pure $C_6H_5CH_2OH$ to **3 significant figures.**

n(ethylphenylmethanoate)

Mass = 1.05 × 7.50

$= \frac{7.875g}{150}$

= 0.525 mol

× 2.5 = n(LiAlH4)

= 0.13125 × 37.9

= 4.974

n(C6H5CH2OH)

A = $\frac{4.40g}{108}$ = 0.0407 mol.

T = ~~...~~ 1:1 = 0.13125 mol

$\left(\frac{0.0407}{0.13125}\right) \times 100$ = 30.48%

Mass of $LiAlH_4$ = 4.97 g

Percentage yield of pure $C_6H_5CH_2OH$ = 30.48 %

[4]

3s.f

[redacted] © OCR 2025

Assessment for learning

In chemistry calculations, calculator values should be carried through all steps in a calculation. This is important to eliminate errors from rounding of intermediate values.

Any rounding should take place at the very end of the calculation.

Question 5 (a) (iii)

(iii) In the preparation, $LiAlH_4$ behaves as a nucleophile.

What is meant by the term **nucleophile**?

....

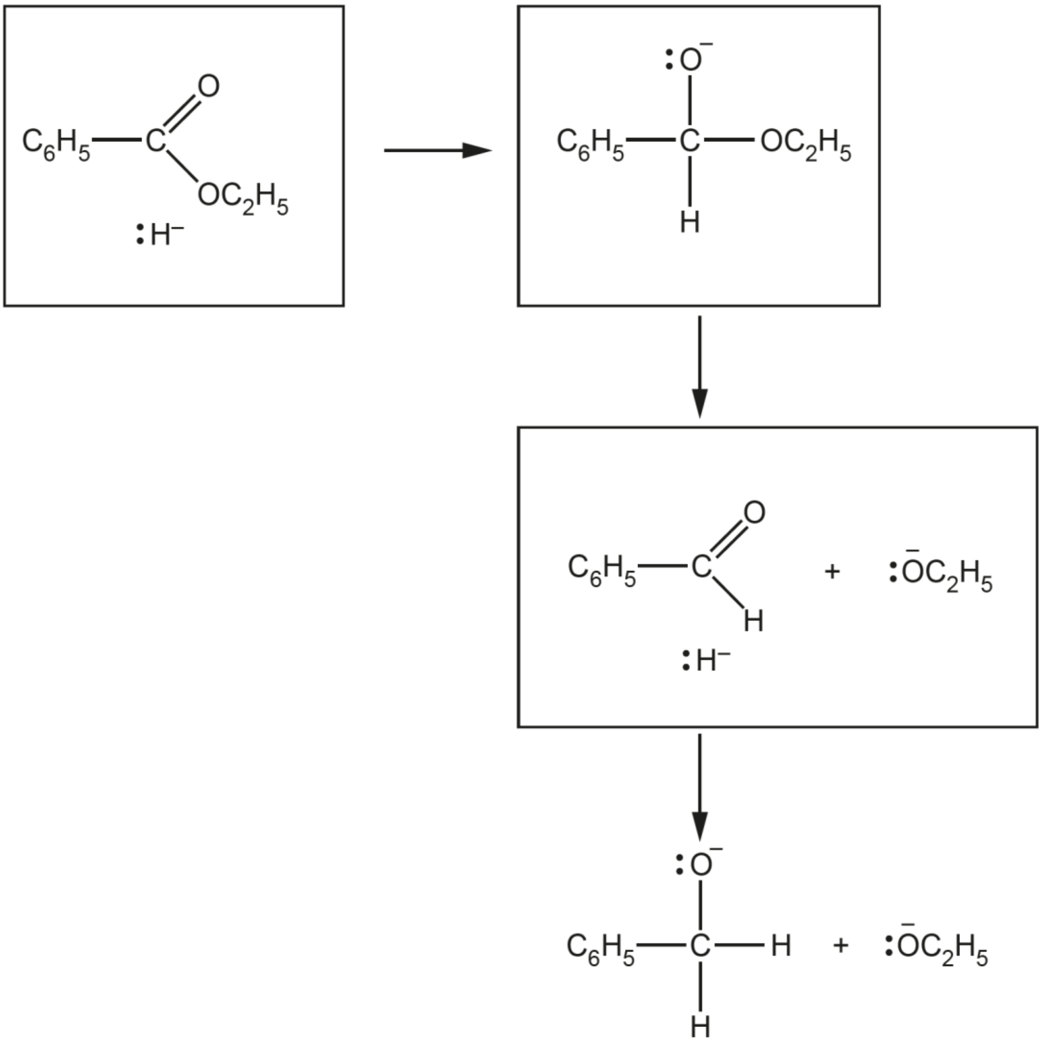
.... **[1]**

This question was answered correctly by most candidates, the most common error being the omission of 'pair' in the term. Lower attaining candidates often used incorrect terms such as 'proton donor' and 'electron acceptor'.

Question 5 (a) (iv)

(iv) The mechanism for **Step 2** in the reduction of $C_6H_5COOC_2H_5$ is shown below.
In the mechanism, $LiAlH_4$ can be represented as H^-.

Complete the mechanism by adding curly arrows to the three boxes.



[4]

Candidates showed a good understanding of how to position curly arrows within an unknown mechanism.

Incorrect responses were mainly in the second box. Some arrows were shown from O^- to C atom instead of to the bond. It was rare for additional arrows to be added.

From the responses, there was clear evidence that most candidates are becoming more confident in the accurate use of curly arrows in a mechanism and the role of lone pairs. The positioning of both ends of a curly arrow were often accurate.

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Question 5 (a) (v)

(v) Suggest why the student heated the mixture from **Step 2** with dilute aqueous acid in **Step 3**.

....

....

.... **[1]**

Most candidates found this question difficult with only higher attaining candidates being able to synthesise the information provided in the method and the mechanism.

In 5(a)(iv), the last step in the mechanism for **Step 2** gave a clue with the two products shown with a negative charge on both O atoms. The mark scheme required an understanding that an H^+ ion was involved in **Step 3**.

With the preparation involving H^- ions, responses referring to a 'hydrogen ion' were ambiguous and imprecise. A common incorrect response referred to hydrolysis of the ester.

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Question 5 (b)

(b) $NaBH_4$ contains Na^+ and BH_4^- ions.

Draw a 'dot-and-cross' diagram for $NaBH_4$.

Use a different symbol for the electrons from each element.

Show outer electrons only.

[2]

This question looked straightforward but produced a large range of responses.

The best answers were clearly communicated with different symbols being used for B, H and Na electrons in the two ions, Na^+ and BH_4^-, from the information provided in the question.

Most candidates showed BH_4^- with 4 covalent bonds. The expectation was that candidates would draw 3 B–H bonds using x• and a one B–H bond using a different symbol to represent a Na electron, following the requirement in the question.

A dative covalent bond was often shown as the fourth B–H bond, usually as ••. The charges were often omitted and there were a number of attempts to covalently bond the Na in a single covalent molecule.

Many candidates drew very small diagrams, and it was often difficult to decipher the symbols being used to represent electrons.

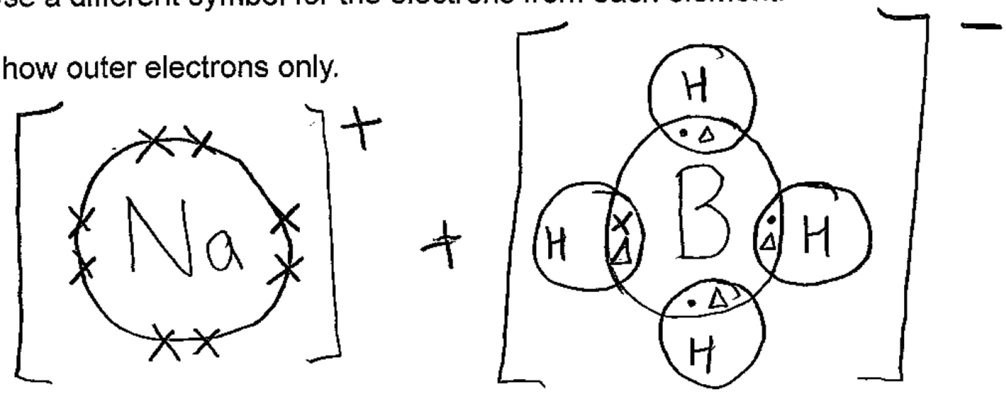
Candidates are well-advised to adhere to the requirements and information given in the question.

Exemplar 3 is shown as a clear diagram. The diagram is large enough so that electrons can be seen clearly. The candidate has used dots for B electrons, triangles for H electrons and a cross for Na electrons. Notice that this candidate has shown the full second shell of Na electrons using the same cross symbol of in the BH_4^- ion. Na^+ was allowed showing either the full inner shell or an empty outer shell.

Exemplar 3

Use a different symbol for the electrons from each element.

Show outer electrons only.



[2]

Question 5 (c) (i)

(c) $NaBH_4/O_2$ cells are being investigated as potential fuel cells.

- The positive electrode contains O_2.
- The negative electrode contains $NaBH_4$.

The reaction at the positive electrode and the overall cell reaction for a $NaBH_4/O_2$ fuel cell are shown below.

Reaction at positive electrode: $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$ $E^{\ominus} = +0.40\,V$

Overall cell reaction: $NaBH_4 + 2O_2 \rightarrow NaBO_2 + 2H_2O$ $E^{\ominus}_{cell} = 1.64\,V$

(i) What is the standard electrode potential of the negative electrode in this cell?

Standard electrode potential = ... V **[1]**

This question was answered well. Incorrect answers mainly resulted from the wrong sign for –1.24 or for 2.04 V, by adding rather than subtracting the 2 values given.

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Question 5 (c) (ii)

(ii) Construct the equation for the reaction at the negative electrode of this cell.

.... **[2]**

Candidates found this question difficult with few being given 2 marks.

1 mark was available for showing an equation with BH_4^- and OH^- as reactants and $NaBO_2$ and H_2O as products. The equation often included O_2 as a reactant and $4e^-$. Only higher attaining candidates were able to combine the equation successfully. This question was a very good discriminator.

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Question 6*

6* The enthalpy change of **Reaction 6.1**, ΔH_1, shown below, is difficult to measure directly by experiment.

$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(l) + CO_2(g)$ ΔH_1 **Reaction 6.1**

The enthalpy changes of reaction for the reactions of Na_2CO_3 and $NaHCO_3$ with excess $HNO_3(aq)$ can be measured by experiment.

The reactions are shown below as **Reaction 6.2** and **Reaction 6.3**.

$Na_2CO_3(s) + 2HNO_3(aq) \rightarrow 2NaNO_3(aq) + H_2O(l) + CO_2(g)$ ΔH_2 **Reaction 6.2**

$NaHCO_3(s) + HNO_3(aq) \rightarrow NaNO_3(aq) + H_2O(l) + CO_2(g)$ ΔH_3 **Reaction 6.3**

A student reacts $Na_2CO_3(s)$ with $HNO_3(aq)$ to find ΔH_2 for **Reaction 6.2**.

Student's method

Weigh a bottle containing $Na_2CO_3(s)$ and weigh a polystyrene cup.
Add about 30 cm^3 of 1.00 $mol\,dm^{-3}$ $HNO_3(aq)$ to the polystyrene cup and measure its temperature.
Add the $Na_2CO_3(s)$, stir the mixture, and measure the maximum temperature reached.
Weigh the empty bottle and weigh the polystyrene cup with the final solution.

Mass readings

Mass of bottle + $Na_2CO_3(s)$ / g	3.26
Mass of empty bottle / g	1.29
Mass of polystyrene cup / g	21.08
Mass of polystyrene cup + final solution / g	54.58

Temperature readings

Initial temperature of $HNO_3(aq)$ / °C	20.0
Maximum temperature of final solution / °C	24.0

The student follows a similar method and reacts $NaHCO_3(s)$ with $HNO_3(aq)$ to find ΔH_3 for **Reaction 6.3**.

The student calculates ΔH_3 for **Reaction 6.3** as $+19.8\,kJ\,mol^{-1}$.

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Calculate ΔH_2 for **Reaction 6.2** and determine the enthalpy change of **Reaction 6.1**, ΔH_1.

Assume that the density and specific heat capacity, c, of the final solution are the same as for water.

Show your working, including an energy cycle linking the enthalpy changes.

....

....

....

....

....

.... **[6]**

As with the other Level of Response (LoR) question (Question 3(a)), most candidates were able to gain some marks for this question, with very few obtaining no marks.

Overall fewer candidates were given Level 3 for Q6 than for Q3(a).

To achieve Level 1, candidates needed to calculate a value for the energy change q from $mc\Delta T$ using at least two of m, c and ΔT. Candidates needed to first process the raw experimental results provided to extract the required values for the calculation.

In the $mc\Delta T$ calculation, the most common incorrect values used were 1.97 (the mass of Na_2CO_3) for m, 8.314 (the gas constant) for c and 277 (Kelvin) for ΔT. Only the lowest attaining candidates were unable to carry out this task.

For Level 2, candidates were expected to determine the energy change per mole using the correct $mc\Delta T$ value. Most candidates reached Level 2.

A Level 3 response proved to be more elusive, requiring candidates to use an energy cycle to determine an enthalpy change. This task was far more testing than the requirements for Level 2.

Some leeway was allowed for values used within the response. For m, a value in the range of 30 – 33.5 was allowed to take into account either HNO_3(aq) or the mass of solution.

Responses calculated per mole of Na_2CO_3 or HNO_3 were allowed. This allowed for the fact that, even though the question described an excess of HNO_3 being used in the reaction, the volume and concentration specified (30 cm^3 of 1.00 dm^3 HNO_3) is short of being an excess. The approach taken is fully outlined in the mark scheme for this question and ensured no students were disadvantaged.

The communication strand for this LoR question was given for responses that were arranged in a cohesive way. Unfortunately, a significant number of candidates produced responses that were difficult to follow with unlabelled quantities and numbers spread randomly across the page.

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