

A LEVEL

Examiners' report

CHEMISTRY A

H432

For first teaching in 2015

H432/03 Autumn 2021 series

Introduction

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



Reports for the November 2021 series will provide a broad commentary about candidate performance, with the aim for them to be useful future teaching tools. As an exception for this series they will not contain any questions from the question paper nor examples of candidate responses.

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. 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.

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Paper 3 series overview

H432/03 is one of the three examination components for A Level Chemistry A. This component is aimed to link together different areas of chemistry within different scenarios; some practical, some familiar and some within novel contexts.

The paper is much more application based than the other two A Level units (H432/01 and H432/02), which emphasise knowledge and understanding of the assessment outcomes from the specification. H432/03 also contains more questions set in a practical context. Most candidates had prepared well for the examination and tackled all parts of the paper.

A small cohort of across a range of abilities, sat the examination. Although there were some high-scoring scripts from well-primed candidates, others did not perform as well, scoring very low marks. The standard of difficulty for this paper was appropriate and the paper discriminated very well.

There was no evidence that any time constraints had led to a candidate underperforming and scripts where there was no response or that sections of the paper had not been attempted.

<i>Candidates who did well on this paper generally did the following:</i>	<i>Candidates who did less well on this paper generally did the following:</i>
<ul style="list-style-type: none"> • Performed standard calculations following the required rubric (e.g. clear working, units, significant figures), e.g. Q1(a) Partial pressure calculation Q1(d) Formula determination from percentage composition by mass Q2(b) Converting mass and volume into moles Q3(b) Unstructured titration calculation Q5(a)(ii) Ideal gas calculation Q5(b)(i) Calculation of the pH of a weak acid • Produced clear and concise responses for a Level of Response question based on a familiar context i.e., Q4(b) rates by continuous monitoring and graphical analysis. 	<ul style="list-style-type: none"> • Had difficulty when answering questions requiring application of knowledge and understanding on questions set in novel and unfamiliar contexts, e.g. Q1(f) Outlining a mechanism for an unfamiliar reaction Q5(b)(iii) Predicting the equation for an unfamiliar organic reaction • Did not consider what a question is asking or read the information, e.g. Q2(c), Q2(d): Predicting the effect of modifications to an experiment Q5(c): Interpreting information in a Level of Response question provided in an unfamiliar contexts • Had difficulty when writing equations for unfamiliar reactions, e.g. Q1(d), Q1(e), Q5(a)(i) • Unclear drawing of diagrams and labelling of laboratory apparatus: Q2(a) • Had difficulty explaining chemical ideas, often repeating the same points several times, e.g. Q1(c) Intermolecular forces and electronegativity.

Comments on responses by question type

Structured questions

Question 1 comprised several short questions from different areas of chemistry.

Q1(a): Candidates were assessed on their understanding of partial pressure.

Most candidates worked out the number of moles of CO₂ and O₂ as 2.5 and 3.75 respectively and then multiplied the mole fraction by the total pressure as $2.5/6.25 \times 50$ to obtain the correct response of 20 atm.

A common error was to see a mass fraction multiplied by the pressure as $110/230 \times 50 = 23.9$ atm. Such candidates needed to develop more detailed knowledge of partial pressures, as per the specification.


Q1(b): Candidates were required to apply their understanding of K_c to a novel context requiring some mathematical awareness.

Most candidates wrote the correct K_c expression and were able to rearrange the expression to show that $[\text{PCl}_3][\text{Cl}_2] = 8.00 \times 10^{-3} \times 0.0500 = 4.00 \times 10^{-3}$. Candidates needed to realise that the concentrations of PCl₃ and Cl₂ would be the same and the correct concentrations would be obtained by taking the square root of 4.00×10^{-3} to obtain 0.0200 mol dm⁻³. While some candidates did this, many omitted this stage, choosing 4.00×10^{-3} as their response.

Q1(c): Candidates were required to use electronegativity and boiling point data to explain the difference in boiling points of CH₄, NH₃ and HF.

Higher-attaining candidates responded concisely, explaining in terms of the different strengths of intermolecular forces and the electronegativity. Such responses linked the different electronegativities to the boiling points and compared the strengths of London forces in CH₄ with hydrogen bonds in NH₃ and HF.

Many candidates did not explain it concisely. This resulted in long responses that repeated the same points and omitted some of the question entirely. Candidates did not always state the intermolecular forces involved, particularly hydrogen bonding, and many explained the different boiling points in terms of the different strengths of the covalent bonds within the molecules.

	AfL	Candidates would benefit by underlining the key features being asked for in the question. This would help in addressing the requirements of the question.
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Q1(d) Candidates were required to analyse provided information to identify three unknown compounds and to write an equation.

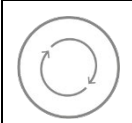
Most candidates knew how to derive a formula from percentage compositions by mass and were able to identify **A** as Ca₃N₂. Candidates found it difficult to apply their knowledge and understanding to the information to identify **B** as NH₃ and **C** as Ca(OH)₂. Some candidates did identify **B** and **C** but did not state which was which, costing a mark. Identification of **A**, **B** and **C** usually led to a correctly balanced equation.

A common mistake was identification of **C** as CaO and a 'correct' equation using CaO was allowed.

Candidates are recommended to use the 'hints' in the provided information to obtain realistic possibilities for unknown substances. A reaction of H_2O with a compound containing Ca and N can only form a limited number of alkalis. Common formulae seen included H_2 , NOH , NO_2 , NH_4 , NH_2 and these should have been instantly rejected as not being alkalis.

Q1(e): Candidates needed to use their knowledge of reactions of carboxylic acids to construct two equations.

Most candidates obtained 1 mark for each equation by identifying CO_2 and H_2O for the reaction with Na_2CO_3 and H_2 for the reaction with Al. The second mark for each equation was much more elusive. Common errors included sodium carbonate shown as NaCO_3 , reaction of the alcohol OH to form $-\text{O}^-\text{Na}^+$ and unbalanced equations.

	AfL	Candidates are advised to take much more care when writing formulae and equations. Knowledge of the charge on common ions (such as Na^+ and CO_3^{2-}) is essential.
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Q1(f): Candidates were required to apply their knowledge of nucleophilic substitution of haloalkanes to outline a similar mechanism for an unfamiliar nucleophile.

Most candidates were able to show a correct curly arrow for breaking the C–X bond, with a dipole shown. The role of the unfamiliar ethanoate ion proved to be much more difficult, with curly arrows not starting from either a lone pair or the – charge. A mark was given for the correct products but the halide ion was often omitted.

This question discriminated extremely well. Higher-attaining candidates provided clear mechanisms and were commonly given all 3 marks. Many candidates could not work out where to start, beyond breaking the C–X bond. It was common to see reactants and products with the wrong number of carbon atoms, and the structure of ethyl methanoate instead of methyl ethanoate being shown as the product.

When confronted with a question set in a novel context, candidates are advised to apply knowledge and understanding from reactions that they have studied – here the reaction of a haloalkane with a OH^- ion.

Question 2 required candidates to interpret the results of a practical experiment that would be similar to experiments they would have carried out.

Q2(a): Candidates were asked to draw a labelled diagram for a familiar practical set up. The first mark was available for an unlabelled diagram of a closed system that would work. Most candidates were given this mark. The second mark required labels of key pieces of apparatus and some candidates did not name these correctly, with conical flasks sometimes being labelled as beakers.

Many diagrams were unclear, suggesting that candidates need to take much more care and time when drawing them.

Q2(b): Candidates were required to analyse the experimental results to obtain a conclusion. Most candidates calculated the moles of Eu and H_2 correctly. Candidates were then expected to conclude that Equation 2 was correct using the 1:1 ratio. Overall, this question was answered well, though some candidates omitted to show the ratio evidence.

Q2(c): Candidates needed to evaluate the effect on the results and conclusion of the apparatus getting hot. Most candidates did realise that the gas volume would increase but the reason was usually in terms of a faster reaction with more successful collisions rather than expansion of gas as temperature increases. Candidates then needed to realise that the $H_2 : Eu$ ratio would increase leading to Equation 3 to be the most likely. This conclusion proved to be elusive for most candidates.

Q2(d): Candidates found it much more difficult to evaluate the unfamiliar scenarios in Q2(c) and Q2(d) than the stock mole calculation in Q2(b). Candidates found this question very difficult with many stating that the equation could be determined from the molar ratio of Eu to the precipitate, despite these being the same.

Question 3 required candidates to explain how a standard solution can be prepared and to analyse titration results.

Q3(a): Candidates were required to describe how they would prepare 250 cm^3 of a 0.150 mol dm^{-3} standard solution. Most candidates were able to calculate the mass of $Ba(OH)_2$ required by stock mole calculations. Candidates found it more difficult to describe the practical procedure without omissions. Examples included transferring the solution to a volumetric flask but not transferring washings; making the solution up to the graduation mark but not then inverting the flask. Some candidates described how to carry out a titration, rather than preparing the standard solution.

Q3(b): As with Question 2, candidates had more success with the mole calculation in Q3(b) than the descriptive response in Q3(a).

Most candidates followed a set procedure to show that the molar mass of the acid was 114, and to then show that the formula must be C_5H_9COOH . Correct *cis* stereoisomers were seen more rarely. One structure was often repeated in both boxes and the structures seen sometimes had C or H atoms missing.

When errors were made with the calculation, these usually stemmed from the scaling up by a factor of 4 in going from 25 cm^3 to 100 cm^3 . Some candidates omitted this stage, obtaining a molar mass value of 456. Others scaled up by a factor of 10 to 250 cm^3 , obtaining a molar mass of 45.6. Both errors made it very difficult to make further progress. If candidates get into this situation, they are advised to check back through their calculation – it should be obvious that there is a critical error somewhere in the working.

Question 4 required candidates to analyse and evaluate information and results of a rates experiment.

Q4(a) required candidates to identify that pent-1-ene was in great excess. Candidates generally answered this well.

Q4(b) is a Level of Response question which is commented on after this section.

Q4(c)(i) required candidates to suggest equations for a two-step mechanism. Most candidates correctly showed the slow step must start with pent-1-ene and I_2 in a 1:1 ratio. Higher-attaining candidates then went on to construct two equations that added up to give the overall equation.

Marks were not given for various reasons, including unbalanced charges, missing CH_2 groups and missing H atoms. Candidates are advised to carefully check all species in equations, especially those involving structural organic formulae. See also comments made for Q1(e) and Q3(b).

Q4(c)(ii) Candidates needed to suggest monitoring the change in rate with changing pent-1-ene concentration while keeping the iodine concentration constant. Most candidates identified one of these two points.

Question 5 was about nitrogen and its compounds, some parts familiar and some novel, from different areas of the specification.

Q5(a)(i) required candidates to write half equations for a redox reaction. Many candidates wrote a correct equation for the reduction of Na^+ to Na . The oxidation of the unfamiliar N_3^- ion was much more difficult, and candidates struggled. Some clearly saw that this was an anion based on nitrogen and wrote the more familiar N^{3-} ion in their attempted equation. Candidates should check carefully that they have not changed any formulae when copying information from the question.

Q5(a)(ii): As with earlier quantitative questions, candidates are very comfortable in tackling stock mole-based calculations, here involving the ideal gas equation. Candidates have improved with converting units in the gas equation and very many were able to show that 0.796 mol of gas were present. Candidates needed to convert this value to moles of Na_3N using $2/3$ and then multiplying by its molar mass of 65. The correct value of 34.5 g of Na_3N gained all 5 marks. Most candidates did not use $2/3$ and obtained either 51.7 or 51.8 g, which could be given 4 or 5 marks.

Very few candidates were unable to rearrange the ideal gas equation and used its inverse. Marks were still available by ECF for using a correct method for subsequent steps.

Q5(b)(i): Most candidates found this pH calculation easy and most obtained a pH of 2.75 for both marks.

Q5(b)(ii): This unfamiliar acid–base pair question was answered comparatively well. Most candidates identified one correctly labelled acid–base pair, usually H_3O^+ and H_2O . The higher-attaining candidates were able to write the correct equation and to identify both acid–base pairs.

Q5(b)(iii) Candidates were expected to interpret information for an unfamiliar organic reaction and to write a balanced question. The information included important clues which were sometimes ignored, showing the importance of using any information provided. The structure of 2-methylbutanoic acid was usually correct although many candidates did show 3-methylbutanoic acid instead, numbering from the wrong end of the chain. The amine structure proved to be more difficult with many showing an amide instead. Even when an amine was shown, it often included four C atoms instead of three. Finally, candidates were told that the two gases (N_2 and CO_2) are present in the atmosphere. Many candidates clearly did not use this clue, included substances that are not atmospheric gases such as H_2 , H_2O and NH_3 . As always, the advice is to use the information provided – it often includes hints to help candidates.

Q5(c) is a Level of Response question which is commented on after this section

Level of response questions

Q4(b): Candidates were required to analyse the graphical results of a rates investigation to determine the reaction order, rate and rate constant. There have been several similar questions in previous sessions and many candidates were well prepared to tackle this question. So many candidates were given Level 2 or Level 3. The Level was determined from the extent of the candidate's conclusions. T communication mark in each level was judged by the clarity of the evidence, including annotations on the graph in support of half-life or initial rate.


Q5(c): Candidates were supplied with information about two reactions, supported by numerical data and an IR spectrum. The reactions were novel, meaning that candidates needed to apply their knowledge and understanding to unfamiliar contexts. This is an area in which many candidates have difficulty. Candidates were required to identify six unknown substances, with Levels being determined from the number identified. The communication mark in each level was given on the clarity of the analysis of the evidence.

Overall, candidates found this question difficult. For reaction 1, many identified **F** and **G** as H_2 and N_2


respectively. Identification of **E** as Cu proved to be more problematic, with $\text{Cu}(\text{OH})_2$ and copper(II) complexes with ammonia being seen often. This was despite the mass of **E** in the supplied data being less than the mass of copper(II) oxide.

For reaction 2, many identified the N–H and C=O peaks in the IR spectrum but candidates often listed all the possible peaks from the Data Sheet. The supplied clues showed that **H**, **I** and **J** were linked by the reaction of an acyl chloride with ammonia. The chloride salt **J** as NH_4Cl was seen very rarely. There were attempts at constructing equations. The equation for reaction 1 was seen by high-attaining candidates, mostly those achieving Level 3.

Common misconceptions

	Misconception	<p>“A simple molecular substance has a low boiling point because the covalent bonds within the molecules are weak.”</p> <p>The correct explanation is that the forces between molecules are weak.</p>
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Structure and bonding are amongst the most difficult concepts encountered at chemistry A Level. In Q1(c), candidates were expected to use data on electronegativity to help explain differences in boiling points of three simple molecular compounds, CH_4 , NH_3 and HF . Although most candidates identified that the larger the difference in electronegativity, the higher the boiling point, this was often explained in terms of increasing **strength of the covalent bonds** within the molecules rather than increased **strength of intermolecular forces**. The difficulty is enhanced when explaining that giant covalent structures have high different boiling points because of strong covalent bonds and **not** intermolecular forces.

	Misconception	<p>Branched and substituted carboxylic acids are named counting from the start of the main stem, e.g. In Q5(b)(iii), 2-methylbutanoic acid is $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{COOH}$.</p> <p>The correct name is obtained by starting from the carbon atom with the functional group. i.e. The COOH carbon in number 1: 2-methylbutanoic acid is $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{COOH}$.</p>
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The same rule is used for all organic compounds, e.g. 2-methylbutanal is $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CHO}$ and **not** $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CHO}$

Key teaching and learning points – comments on improving performance

Candidates would benefit by tackling questions set in an unfamiliar context, particularly unstructured long questions where candidates are required to develop strategies for their response.

Guidance on using this paper as a mock

The paper would offer candidates an excellent flavour of a truly synoptic paper that incorporates more questions set in a practical context than the more content-based papers (H432/01 and H432/02). It would be best used after all specification content has been covered. If used partway through the course, some questions would need to be removed.

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