



**GCE**  
**Chemistry A**

Advanced GCE H432

**OCR Report to Centres June 2017**

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This report on the examination provides information on the performance of candidates which it is hoped will be useful to teachers in their preparation of candidates for future examinations. It is intended to be constructive and informative and to promote better understanding of the specification content, of the operation of the scheme of assessment and of the application of assessment criteria.

Reports should be read in conjunction with the published question papers and mark schemes for the examination.

OCR will not enter into any discussion or correspondence in connection with this report.

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**Advanced Subsidiary GCE Chemistry A (H032)**

**Advanced GCE Chemistry A (H432)**

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## About this Examiner Report to Centres

This report on the 2017 Summer assessments aims to highlight:

- areas where students were more successful
- main areas where students may need additional support and some reflection
- points of advice for future examinations

It is intended to be constructive and informative and to promote better understanding of the specification content, of the operation of the scheme of assessment and of the application of assessment criteria.

Reports should be read in conjunction with the published question papers and mark schemes for the examination.

The report also includes:

- An invitation to get involved in Cambridge Assessment's research into **how current reforms are affecting schools and colleges**
- Links to important documents such as **grade boundaries**
- A reminder of our **post-results services** including Enquiries About Results
- **Further support that you can expect from OCR**, such as our Active Results service and CPD programme
- A link to our handy Teacher Guide on **Supporting the move to linear assessment** to support you with the ongoing transition

### **Understanding how current reforms are affecting schools and colleges**

Researchers at Cambridge Assessment<sup>1</sup> are undertaking a research study to better understand how the current reforms to AS and A levels are affecting schools and colleges.

If you are a Head of Department (including deputy and acting Heads), then we would be very grateful if you would take part in this research by completing their survey. If you have already completed the survey this spring/summer then you do not need to complete it again.

The questionnaire will take approximately 15 minutes and all responses will be anonymous.

To take part, please click on this link: <https://www.surveymonkey.co.uk/r/KP96LWB>

### **Enquiry About Results**

If any of your students' results are not as expected and University places are reliant on them, you may wish to consider one of our Enquiry About Results services. For full information about the options available visit: <http://ocr.org.uk/administration/stage-5-post-results-services/enquiries-about-results/>

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<sup>1</sup> Cambridge Assessment is a not-for-profit non-teaching department of the University of Cambridge, and the parent organisation of OCR, Cambridge International and Cambridge English

## Grade boundaries

Grade boundaries for this, and all other assessments, can be found on [Interchange](#).

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## Supporting the move to linear assessment

This was the first year that students were assessed in a linear structure. To help you navigate the changes and to support you with areas of difficulty, download our helpful Teacher guide: <http://www.ocr.org.uk/Images/345911-moving-from-modular-to-linear-science-qualifications-teachers-guide.pdf>

## Further support from OCR



Active Results offers a unique perspective on results data and greater opportunities to understand students' performance.

It allows you to:

- Review reports on the **performance of individual candidates**, cohorts of students and whole centres
- **Analyse results** at question and/or topic level
- **Compare your centre** with OCR national averages or similar OCR centres.
- Identify areas of the curriculum where students excel or struggle and help **pinpoint strengths and weaknesses** of students and teaching departments.

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<https://www.cpduhub.ocr.org.uk>

# H432/01 Periodic table, elements and physical chemistry

## General Comments:

This was the very first A level paper sat in the new chemistry A level. The paper contained questions from the AS part of the specification as well as the A level section.

Candidates found the new style of questions, including those with an extended response nature, straightforward and the majority managed to cope with the mathematical content.

There was evidence that many candidates were very confident and able with the part of the specification that would have traditionally been considered 'A2'. However, they were less confident and knowledgeable with the less demanding aspects of some questions which featured content from the AS part of the specification.

There was evidence that candidates wrote far more than was necessary in some responses. For example, Q20(a) was allotted a very generous 9 lines for an answer but unfortunately there was over half a page of blank space below these lines which many candidates felt obliged to use in providing rambling, repetitive responses. At best, they repeated themselves, at worst they contradicted themselves. Better candidates provided 4 or 5 line answers for full marks.

## Comments on Individual Questions:

### Section A

#### Multiple Choices Questions: Q1–Q15

Questions 2, 3 and 5 were the most successfully answered with each of these having a success rate of over 90%.

Question 11 was the most difficult with less than 50% of the candidates giving a correct response. Many opted for distractor B.

### Section B

#### Question 16

**16(a)** Most candidates secured the one mark available. Many weaker candidates opted for a diagram showing ionic bonding between  $\text{Al}^{3+}$  ions and 4  $\text{H}^-$  ions. Other types of incorrect diagrams had single electrons in covalent bonds, or failed to show one of the bonds as dative.

Centres should be advising candidates to ensure bonding diagrams are as large as possible in order to clearly illustrate different types of electron symbols.

**16(b)** The shape and bond angle of  $\text{NH}_4^+$  was invariably known, but  $\text{NH}_2^-$  proved more challenging.

**16(c)(i)** Most candidates recognised that  $\text{NH}_3$  had hydrogen bonding as its main intermolecular force and went on to describe hydrogen bonding as being stronger than the intermolecular force within  $\text{PH}_3$ .

Weaker candidates tried to relate boiling points to the atomic sizes of N and P or to different covalent bond strengths.

**16(c)(ii)** This question, based upon the AS part of the specification, proved challenging to many. More able candidates realised that  $\text{AsH}_3$  (or just As) had more electrons than  $\text{PH}_3$  (or P) and went on to correctly describe the London forces as being stronger. Alternative terminology for London forces were accepted such as ‘induced dipole-dipole attractions’ or ‘instantaneous – induced dipole interactions’, but loose phrases such as stronger induced dipoles or van der Waals’ forces were not accepted.

### Question 17

**17(a)** Most candidates were able choose hydrochloric acid as the reagent that would form  $\text{BaCl}_2$  as a product in a neutralisation reaction but a significant number were unable to balance this straightforward equation.

**17(b)** This question was another one based upon the AS part of the specification, and most candidates secured the first two marking points. The third mark, based upon the idea of less energy needed to remove electron(s) as the group is descended, was not scored by many. Instead, candidates loosely talked about an increasing ease of electron removal.

**17(c)(i)** The question asked candidates to state what disproportionation meant. Many candidates failed to give this statement, despite correctly identifying the change in oxidation number and correctly assigning the redox terms.

**17(c)(ii)** It was apparent that the idea of systematic naming of compounds was not known by many candidates. Of those who realised that Roman numerals were required, many showed uncertainty of the identity of the Roman numeral to be used or positioned the numeral at an inappropriate place within the name of the compound.

**17(d)(i)** Candidates who correctly identified barium sulfate as a solid product tended to realise that entropy had decreased, although a significant number failed to state that this decrease in entropy was as a result of less disorder being created.

**17(d)(ii)** Most candidates failed to produce a correct equation for the standard enthalpy change of atomisation of iodine. Of those who were able to produce the correct equation, a significant number failed to state that the increase in entropy was as a result of increased disorder being created.

**Question 18**

**18(a)** For the minority of candidates who recognised that the Gibbs' equation could be expressed in  $y = mx + c$  format, this question was very straightforward. For others, the realisation that  $Q$  was the point at which feasibility changed was the only mark scored.

**18(b)(i)** All but a few candidates realised that the term heterogeneous equilibrium could be applied because carbon monoxide was in a different physical state to the other reactants and products.

**18(b)(ii)** Marks were awarded for less than perfect versions of  $K_p = p(\text{CO(g)})^4$ . As long as a 'p' or a 'P' was seen and curved, rather than square, brackets, along with the correct power, the mark was awarded.

This was to differentiate between the candidates who knew that only the partial pressures of gaseous species should feature in a  $K_p$  expression from the candidates who used all four species to write the expression.

**18(b)(iii)** Candidates coped well with the calculation and, apart from a significant number of rounding errors, could provide a positive value of  $\Delta G$  and therefore could show the reaction to not be feasible.

Candidates were also able to calculate that the minimum temperature required for the reaction to be feasible was 962.023165 K which was sensibly rounded to 962 K. A significant number of candidates chose to give 963 K as the final answer despite showing a correct value to several decimal places in their working.

**18(b)(iv)** The general method of determining  $\Delta_f H(\text{CO})$  was known to most candidates, but many examples of avoidable errors were seen. For example, transcription errors in recording  $\Delta_f H$  values (-393 for -393.5 and -118.5 for -1118.5). Candidates should be advised to show every step in their calculation. This would allow method marks to be applied in the absence of a correct final answer.

**Question 19**

**19(a)** The majority of candidates were able to score the two marks for determining the volume of oxygen to be  $690 \text{ cm}^3$  (or  $0.690 \text{ dm}^3$ ). Only a very small proportion of candidates were able to suggest a suitably sized piece of apparatus.

**19(b)** The idea of measuring mass loss (over time) was frequently given as a correct response. The idea of titrating samples to determine the concentration of hydrogen peroxide during the course of the reaction was occasionally seen and given credit.

**19(c)** This was the first of the two extended response questions in which the candidates had to determine three values based initially upon the graph. Some of the workings on the graph were a little hard to follow.

Many candidates scored highly on this question, showing a good understanding of the chemistry involved. Weaker candidates sometimes struggled to express the link between the different values being calculated and were awarded a lower level mark.

### Question 20

**20(a)** The generous nine answer lines allowed for an answer to this question served to elicit many correct but rambling responses in which the candidates repeated the same point many times. Many candidates, after exhausting their thoughts upon simple equilibria shifts, completely forgot to suggest why operational conditions may be different.

**20(b)(i)** The expression and the units were almost universally known by the candidates.

**20(b)(ii)** There were three steps to this calculation:

- Conversion of molar quantities of  $\text{SO}_2$  and  $\text{O}_2$  to molar concentrations.
- Insertion into the  $K_c$  expression and determining of the molar concentration of  $\text{SO}_3$ .
- Conversion of the molar concentration of  $\text{SO}_3$  to a molar quantity including an appropriate number of significant figures.

Steps 1 and/or 3 of the calculation were occasionally omitted but as long as the calculation was presented in a coherent manner, partial credit was awarded.

### Question 21

**21(a)** Most candidates coped with this commonly seen type of calculation and were able to correctly calculate the concentration of the weak acid

**21(b)** For the able candidate, this question was quite straightforward but for the weaker candidate, there were many pitfalls. Candidates struggled with the idea that the equilibrium needed a positive ion and a negative ion on the product side. Others were unable to use  $K_a$  values in order to decide which of the two starting acids should become protonated. Finally, the assigning of the conjugate acid-base pairs was also challenging.

**21(c)(i)** This question caused difficulty for all but the more able. For many weaker candidates getting beyond a concentration of  $\text{CH}_3\text{COONa}$  was a problem. Once again, candidates should be advised to show every step in their calculation. This would allow method marks to be applied in the absence of a correct final answer.

**21(c)(ii)** Only the very able were able to explain that the ratio of concentrations of acid and salt would remain constant and as  $K_a$  is constant,  $[\text{H}^+]$  and therefore pH would remain constant.

**Question 22**

**22(a)(i)** A significant number of candidates handicapped themselves by failing to draw a simple circuit. Diagrams with electrodes not entering solutions, salt bridges not labelled or not entering solutions were frequently seen. Most candidates scored the mark for the Zn electrode but less scored the mark for the Pt electrode in the  $\text{Fe}^{2+}(\text{aq})/\text{Fe}^{3+}(\text{aq})$  mixture. The last mark, for the conditions (including concentrations of  $1.00 \text{ mol dm}^{-3}$ ), was almost universally scored even by those who omitted the solutions in their diagram.

**22(a)(ii)** This was the most successfully answered one mark question on the paper.

**22(b)** Most candidates were able to use the standard electrode potentials given in the question to work out that zinc (Zn(s)) was the strongest reducing agent and that manganate(VII) ions were the strongest oxidising agent.

**22(c)** This was successfully answered by the majority of candidates.

**Question 23**

**23(a)(i)** The identification and recall of transition element compounds and ions was not done well. Most candidates knew the yellow solution to be  $\text{CuCl}_4^{2-}$  and the majority suggested the brown solution was  $\text{I}_2$ . The formula of the blue precipitate  $\text{Cu}(\text{OH})_2$  was less well known and only a small minority were able to identify the deep blue solution and white solid as  $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$  and  $\text{CuI}$  respectively.

**23(a)(ii)** Ligand substitution was well known but redox was less frequently seen. However, as reaction 2 formed a precipitate, precipitation was accepted as an alternative answer.

**23(b)** This was the second extended response question. Most candidates were able to make a start on this response and found the formula of **B**. A significant number of candidates assumed the bidentate ligand **D** to be  $\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2$  and worked backwards to identify **C**. Having identified **C**, the drawing of optical isomers proved relatively straightforward.

Many strong candidates omitted to determine the formula of **A** or realised quite late on within their extended response that this was required.

# H432/02 Synthesis and analytical techniques

## General Comments:

H432-02 is one of the new examined units for the new revised A level specification. The synthesis and analytical techniques paper contains a number of multiple-choice questions, short answer questions and two longer questions where level of response marking replaces the traditional points based marking schemes. Within this paper candidates are tested on their knowledge and understanding of the principles and concepts found in organic chemistry, their mathematical ability through a range of familiar and unfamiliar calculations, and their ability to describe practical techniques.

Most candidates had prepared well for the examination and tackled all parts of the paper.

Candidates coped well with questions where reaction mechanisms were required, less well with some of the more descriptive questions, and poorly with questions that required the description of an experimental technique. Centres should note that practical work covered through the endorsement will be assessed through examination papers where this is possible and as such should ensure candidates are prepared to cope with such questions.

## Comments on Individual Questions:

### Section A

#### Multiple Choices Questions: Q1–Q15

- 1) This question was answered correctly by over 90% of candidates with the most common incorrect response, silver chloride being given by those who may have named a precipitate formed in the test rather than the reagent required.
- 2) This question was answered well by over 85% of candidates. Candidates failing to score a mark here often provided an answer which indicated that the compound was unsaturated rather than saturated.
- 3) The first question on the paper to require the application of some mathematical skills proved slightly more testing although the correct response C was given by a majority of candidates. The most common incorrect answer was B which has the same number of carbon and hydrogen atoms in its formula. This may have resulted from the question stating that an equal volume of both carbon dioxide and water was produced in the reaction, and the failure to consider the stoichiometry of the equation.
- 4) Those candidates who had clearly learned and understood the principles of the Cahn-Ingold-Prelog rules applied these successfully to this question arriving at the correct answer, B. All other answer options were equally distracting.
- 5) This was a fairly easy question and the vast majority of candidates knew that addition, with 100% atom economy based on only one product being formed, had the highest atom economy of the four reaction types listed. Candidates who failed to score this mark randomly choose one of the other distractors.

6) This question discriminated well between candidates, with the most able gaining the mark and the least able failing to apply their knowledge of shapes of molecules and bond angles to an organic structure. The theme of material potentially covered during the first year of the course being less well known than work taught traditionally in the second year is a recurring one throughout this report. Candidates here frequently opted for atom 4 rather than the correct atom 3. Where a candidate gave the number 3 rather than C in the answer box this was credited.

7) This question was answered correctly by over 80% of the candidates. The main distractor appeared to be B which was an amide rather than an amine.

8) This question was answered well. The correct answer C, was provided by just over 60% of candidates. Where incorrect responses were seen, it was frequently due to the candidate missing one of the chiral centres, typically the one nearest to the sulfur atom within the ring.

9) The vast majority of candidates were able to determine the molecular formula of the compound on what proved to be one of the easiest of the multiple choice questions.

10) In contrast to question 9, this proved to be the most difficult of the multiple choice questions for candidates who frequently gave B, ethanoic acid as their answer. The correct answer, D, an acyl chloride reacts with water to produce acidic fumes of HCl which are soluble in water and a carboxylic acid.

11) This was well answered on the whole, with some candidates failing to include the peak associated with the –COOH part of the molecule. The common incorrect answer was D.

12) Candidates across the whole ability range appeared to find the question equally challenging. The common incorrect answer B, resulted from a failure to use the information that equal moles of acid were reacted with equal moles of alkali to produce an equal number of moles of water.

13) Many Candidates scored well on this question having clearly learned that an acyl chloride will react with an amine to produce an amide. Where candidates failed to score this mark answers provided showed no pattern, with all distractors being seen equally.

14) Once the Candidates had realised that hydrogen radicals do not appear in the mechanism for a radical substitution reaction of an alkane, the answer C was given. Almost 90% of candidates scored this mark.

15) This question proved accessible to the full range of abilities with many, having drawn all three structures out on their paper and converted these structures to molecular formulae, selecting the correct answer A.

**Section B****Question 16**

**16(a)** This question was less well answered than on the more traditional legacy papers with only 30% of candidates gaining both marking points. Common mistakes included the use of surface area without reference to points of contact, reference to van der Waal's forces previously accepted but not in the new specification and failing to mention more energy being required to break the intermolecular forces. For clarification on the use of van der Waal's forces please refer to page 20 of the current specification.

**16(b)(i)** Naming the organic molecule, hex-3-en-1-ol, proved difficult for all but the most able candidates. Candidates are not expected to know the priority of the alkene and hydroxyl groups in naming conventions so the answers given in the marking scheme were accepted to treat all candidates fairly.

**16(b)(ii)** Stereoisomers is one of a declining number of definitions candidates are expected to recall from the new specification. Surprisingly 35% of candidates failed to score this mark. The most common errors were the use of molecular formula rather than structural formula or giving the definition for structural isomerism.

**16 (b)(iii)** Even those candidates who were not able to define stereoisomerism, clearly understood how to draw the cis and trans isomers of hex-3-en-1-ol. Excellent structures were seen in the vast majority of cases. The most common error was the failure to place the –OH group on the correct carbon within the structure leading to only one mark being awarded. Candidates should be encouraged either to give displayed or structural formulae for cis and trans isomers rather than combining atoms, leading to groups such as  $-\text{C}_2\text{H}_5\text{O}$  or  $-\text{C}_2\text{H}_4\text{OH}$  being attached to the double bond. These were credited the second time they were given in the question but penalised on their first occurrence.

**16 (c)** Over half of candidates completing this question did not score a mark. The answer required the drawing of two p-orbitals on the left hand diagram and a pi-bond, a lobe of electron density above and below the plane of the carbon atoms, on the right hand diagram. Many candidates produced unexpected diagrams, some where the pi-bonds extended beyond even the remaining groups attached to the double bond. Others placed p-orbitals in the left hand diagram so that they were on the end of the molecule or showed four lobes merging in the right hand diagram. This clearly is an area for teachers' attention in the coming academic year.

**16(d)(i)** The specification states in learning outcome 4.1.3(g) that the definition and use of the term electrophile (an electron pair acceptor) is expected. This was tested in the context of electrophilic addition in alkenes. Half of the candidates gave a perfect answer, leaving half of candidates not gaining any credit. Answers indicating "accepting electrons" rather than an electron pair were not credited, neither did answers which discussed the attack of the alkene or an electrophile being electron loving or seeking.

**16 (d)(iii)** This was a well answered question with the vast majority of candidates displaying their knowledge of the addition of an unsymmetrical molecule to an unsymmetrical alkene and the production of two isomeric products. There were no common errors, rather those candidates who did not score a mark omitted the question or gave structures with an incorrect number of carbon atoms.

**16 (d)(iv)** On the whole candidates answered this question well, with many giving clear and accurate mechanisms to gain all three marks. In poorer scoring mechanisms, the main errors were around the drawing of arrows. Candidates must recognise that an arrow should start either at the negative charge or from the middle of a lone pair in the final step of an addition mechanism.

**16 (d)(iv)** Good answers to this question indicated the major organic product and related this to the intermediate being the most stable carbocation. Weaker answers discussed the stability of the product rather than the intermediate and did not include any comments about the carbocation.

**16 (e) (i)** The best answers first converted 204 mg into g and then divided this value by the molar mass of myrcene. Candidates then linked this to presence of three double bonds and calculated correctly the moles of hydrogen required to produce the saturated alkene. Finally the moles were multiplied by 24000 cm<sup>3</sup> to provide an answer in cm<sup>3</sup>. Candidates who worked in mg could not access the first mark however the subsequent mark was awarded as error carried forward.

Answer = 108 cm<sup>3</sup>

**16 (e)(ii)** The most common score on this question was two, with candidates being able to calculate the moles of hydrogen gas and relate this to the replacement of eleven double bonds. Frequently candidates calculated the formula of the saturated hydrocarbon to be C<sub>40</sub>H<sub>82</sub> by applying the general formula C<sub>n</sub>H<sub>2n+2</sub> to a compound containing 40 carbon atoms. The best Candidates were able to adjust this formula to account for the presence of the two rings and were then able to write the correct equation for the hydrogenation.

### Question 17

**17 (a)(i)** The majority of candidates were well prepared for this standard mechanism and frequently scored marks of four or five. Most were able to show equations to generate the electrophile and regenerate the catalyst. Candidates should note the importance of the correct placement of curly arrows and the horseshoe in the intermediate to show the remaining electrons present in the ring structure. These were often poorly represented, leading to marks not being awarded.

**17 (a) (ii)** This question tested some of the practical techniques covered as part of the practical endorsement as well as requiring candidates to calculate a percentage yield for the reaction. This proved to be quite a challenging question with some candidates giving little detail of how to

carry out a recrystallisation. Common answers included a statement that the solid should be allowed to dissolve in a solvent and then filtered to obtain crystals. This did not gain credit for the scientific content as there was no indication of the solid dissolving in a hot solvent and then being allowed to cool before carrying out filtration. High quality answers often went above and beyond the requirements of the marking scheme with some candidates discussing the importance of dissolving in the minimum amount of hot solvent to obtain a saturated solution, the need to wash and dry the crystals and provided detail of the apparatus and or method required.

Most candidates discussed that purity could be determined by taking the melting point of the product and comparing this to a value obtained from data book. The most comprehensive answers gave an indication of the apparatus required to carry out the melting point determination and discussed how the melting point becomes higher and sharper as impurities are removed. Common errors included comments about carrying out a boiling point determination.

When carrying out a percentage yield calculation, it is important to round answers only at the last stage of the calculation. Early rounding frequently led candidates to obtain answers, which did not gain credit. Weaker Candidates divided the mass of 3-nitrobenzoic acid by the mass of benzoic acid and obtained an answer of 97.6%.

Answer = 71.3%

**17 (b) (i)** The vast majority of candidates gave a good answer to indicate that it was easier to carry out the nitration of phenol than benzene and that benzene would undergo nitration easier than benzoic acid.

**17 (b) (ii)** The most able candidates scored well on what proved a difficult question for many. Although the vast majority of candidates knew about the reasons behind phenol's increased reactivity many were unable to express themselves clearly to gain credit. Often answers lacked the specific detail about the lone pair on the oxygen atom in the –OH group being delocalised into the ring. Weaker answers discussed electrons being supplied to the ring, the -OH group providing the electrons to the ring or just that –OH is an activator. Good answers expressed the increase in electron density and the subsequent increase in phenol's susceptibility to electrophilic attack. The most able candidates were able to interpret the information given in the question to establish that the –COOH group must be electron withdrawing leading to decreased electron density of the ring structure and reduced ability to react with electrophiles.

**17(c)(i)** Candidates were able, in the main, to provide the reagents for bromination and reduction. The structure of the intermediate compound in the preparation of 3-bromophenylamine proved to be straightforward, however common errors involved the omission of the halogen carrier catalyst for bromination or stating names rather than formulae as indicated in the question.

**17(c)(ii)** The most able candidates completed this question with a clear statement that the –NH<sub>2</sub> group was 2,4 directing and provided two clearly drawn structures of 2-bromophenylamine and 4-bromophenylamine. The most common errors observed included drawing two structures that were identical and explaining the two structures in terms of electron donation from the –NH<sub>2</sub>

without any indication of positioning. Candidates using the terms ortho and para directing were awarded full marks for their answers.

### Question 18

**18(a)(i)** The mechanism for the reaction of 1-chloropropane was well done with the majority of candidates scoring two or three of the marks. Marks were not awarded when candidates used a negative charge or a lone pair sited on the nitrogen as the starting point for a curly arrow in the first stage of the reaction mechanism. The final marking point was awarded for the production of a  $\text{Cl}^-$  ion. The placing of curly arrows, dipoles and lone pairs of electrons are important when communicating by mechanisms.

**18(a)(ii)** Although many candidates were able to provide the structure of methanol as the starting material for this synthesis, the structures of chloromethanol, bromomethanol and iodomethanol were accepted as suitable alternatives. It should be noted that hydrolysis is carried out using aqueous acid and that dilute acid is not a suitable alternative.

**18 (a)(iii)** Only 20% of candidates were awarded both marks for this question. The commonest error was a failure to state that the N atom has a lone pair of electrons that can gain a proton. Answers stating that amines accept protons or that a salt is produced when an acid reacts with a base were not credited. Where a full displayed structure is given the positive charge must be shown on the nitrogen atom, although  $-\text{NH}_3^+$  is acceptable. As the question required the formula of the salt, the  $\text{Cl}^-$  had to be included.

**18 (a) (vi)** The most common mark for this question was two out of the three marks available, with candidates giving a correct structure of the polymer but failing to express that the polymer was biodegradable due the ability of the ester functional group to undergo hydrolysis.

**18 (b) (i)** All but the weakest candidates scored two marks for the two monomers that could be used to produce Nylon 6,6.

**18 (b) (ii)** This was a fairly simple calculation where candidates were expected to divide the relative molecular mass of the polymer by the relative molecular mass of a single repeat unit (226) to establish the number of repeat units present in the polymer. Many candidates obtained the correct answer. Those that did not gain credit made a simple error in their calculation of the relative molecular mass of the repeat unit.

Answer 95

### Question 19

**19 (a)** The more able candidates were able to balance this combustion equation. Those who failed to be awarded the mark either used the molecular formula of a saturated alcohol or did not consider the presence of the oxygen atom in the alcohol when balancing the equation.

**19 (b)(i)** The examiners were surprised that more of the candidates did not achieve both marks on a question that many would have experienced before from legacy past papers. Candidates often failed to include dipoles and lone pairs even though this was indicated in the stem of the question. Candidates should recognise the involvement of the lone pair in any hydrogen bonds drawn. Where candidates gave more than one hydrogen bond in their diagrams they had to be correct for a mark to be awarded.

**19 (b) (ii)** The best answers here stated that hexane-1,6-diol had more OH groups than hexan-1-ol and so more hydrogen bonds could be formed with water molecules. Weaker answers did not compare the two compounds simply stating that hexan-1,6-diol had two OH groups or that it formed two hydrogen bonds with water. Candidates who did include a comparison frequently failed to state that solubility was due to hydrogen bonds being formed with water.

**19 (c)(i)** There were many good answers to this synthesis question with about 40% of the cohort scoring full marks. The structure of the carbonyl and the reagent needed for reduction were well known by a majority of candidates however some reacted the alcohol group with sodium bromide to obtain  $\text{O}^-\text{Na}^+$  for the second structure. Weaker candidates did not realise that an alcohol could be dehydrated and thus failed to be awarded the final two marks.

**19 (c) (ii)** Just over half of candidates managed to name the structure as 3-methylcyclohexanol. The most common errors included 3-methylphenol, 3-methylcyclichexanol and 3-methylhexanol.

**19 (d)** A very well answered question. Candidates had obviously been well prepared as even the weakest candidates gained a number of marks here. The most common mark lost was a failure to include  $\text{H}_2\text{O}$  in the balanced equations. In the preparation of the carboxylic acid, a number of Candidates balanced the equation with  $2\text{H}_2\text{O}$ .

## Question 20

**20 (a)** The empirical formula was correctly calculated by all but the weakest candidates. The final mark was more difficult to obtain as it required evidence that the molar mass had been determined from the mass spectrum and used in establishing the molecular formula.

**20 (b)** Many candidates were able to suggest that the compound contained a ketone but found it more difficult to indicate the presence of phenol. Approximately 20% of the entry obtained all three marks. When explaining the presence of the ketone some failed to indicate that the 2,4-DNP test indicated that the compound must contain a carbonyl and just focused on the lack of reactivity with Tollens'. Answers suggesting the molecule contained a ketone as no reaction was observed with Tollens' did not gain credit when no reference to carbonyl was seen. Those who recognised the presence of a phenol explained that the only acidic functional group that does not react with sodium carbonate is a phenol.

**20 (c)** When interpreting a carbon-13 NMR spectrum, candidates should be advised to fully label any peaks. Many candidates failed to indicate the presence of four aromatic peaks yet produced a structure containing a benzene ring. In some cases candidates did not link their answer to part (a) of the question giving structures that did not match their molecular formula.

### Question 21

**21** The final question on the paper was a six mark level of response question which required candidates to identify a molecule from a range of spectral data. Most candidates were able to process the information from the infra-red spectra to suggest the presence of a carboxylic acid in M and an alcohol in N. Candidates then linked these two product molecules to acid hydrolysis and suggested that L must have been an ester. Level of response questions require a degree of detail and candidates should indicate the presence of the –OH and C=O bonds and link this to the carboxyl functional group rather than just stating that the peaks show a carboxylic acid.

The best candidates were able to fully explain the evidence from the  $^1\text{H}$  NMR spectrum to identify the structure of L. Use of specialist terminology to describe the peaks as singlet, quartet and triplet was expected. An indication of how these peaks could be interpreted to indicate adjacent protons and the link between the integration (peak height) and the number of hydrogens in each environment was also required for a full answer. Some answers were unstructured and disorganised, and candidates should be encouraged when analysing spectra to organise their answers by discussing each spectra in turn.

# H432/03 Unified chemistry

## General Comments:

H432-03 is one of the three examination units for the new revised A level examination for GCE Chemistry A. This unit is aimed to link together different areas of chemistry within different contexts, some practical, some familiar and some within novel contexts. The paper is much more application based than the other two A level components, 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 than H432-01 and H432-02.

Most candidates had prepared well for the examination and tackled all parts of the paper.

The standard of difficulty was appropriate and the paper discriminated very well.

There were some difficult, challenging and novel questions and candidates should be congratulated on the ways in which they tackled these.

However, one part deserves a special mention, Q4(a)(i). Candidates were asked to record titration results from diagrams showing burettes at different stages during a titration. The responses were extremely disappointing with numbers sometimes sprayed onto the page or squeezed next to the diagrams. Often there were no units to be seen. Only about half the candidates made any effort to tabulate the results into what should be a conventional titration table. It is hoped that the standard of recording results improves in future sessions.

There was no evidence that any time constraints had led to a candidate underperforming.

## Comments on Individual Questions:

### Question 1

**1(a)** Able candidates showed a good working knowledge of hydrogen bonds and electron pair repulsion. However, it was common for candidates to become diverted from the question, instead describing the open lattice structure of ice and the comparison of bond angles was often omitted entirely. Consequently, many candidates were awarded only one mark for mentioning hydrogen bonding in ice. For gaseous water, many candidates did state that lone pairs repelled more than bonded pairs but the number of bonded and lone pairs involved was seen more rarely. A common error was that a molecular shape is determined by lone pairs repelling atoms, instead of electron pairs.

**1(b)** Most candidates were awarded this straightforward mark for stating that methane is a greenhouse gas. A common error was depletion of the ozone layer.

**1(c)** This part applied candidate's understanding of formula determination in a novel context. Although candidates were asked to show their value for x to two decimal places, many rounded their value to a whole number. Most candidates were awarded both marks for 5.74, but one mark for 6 was fairly common.

Answer  $\text{CH}_4 \cdot 5.74\text{H}_2\text{O}$

**1(d)** The majority of candidates recognised that this problem involved the ideal gas equation, which was well known. Candidates usually rearranged the equation to make  $n$  the subject and substituted correct values into the equation. The examiners allowed error carried forwards from the answer in 1(c) or an incorrectly calculated value for  $n$ . Common errors included an incorrect calculation of the amount of  $\text{CH}_4$ ,  $n$ , or incorrect conversion into  $\text{dm}^3$  for the final answer.

A small number of candidates used 100 for 101 or 298 for 273.

Instead of using the ideal gas equation, some weaker candidates resorted to use of  $24.0 \text{ dm}^3$  or  $22.4 \text{ dm}^3$ , an approach that could still obtain two of the four available marks.

Overall, the examiners were impressed with the responses seen to this part.

Answer:  $188 \text{ dm}^3$

**1(e)** Most candidates correctly identified that industry might use methane as a fuel or for production of energy. Credit was also allowed for use as a chemical feedstock. A small number effectively rewrote the question without stating how industry could use the methane.

## Question 2

**2(a)** In this part, candidates were presented with the results of an enthalpy experiment and other related data. They were then required to determine two enthalpy changes, one directly from the experimental results, the other indirectly using Hess' Law. No guidance was supplied about how to carry out this analysis.

The examiners were impressed with the many superb responses that linked all the information together to determine correct values for the two enthalpy changes.

Most candidates attempted all aspects of the problem but often made mistakes, particularly with the Hess' Law extension or with incorrect signs.

From the raw experimental data, most candidates calculated the two masses, even if they did not subsequently use both masses, and the temperature change. A common error was to use the wrong mass in the initial  $mc\Delta T$  calculation with 25.0, 1.24 or  $(25.75 + 1.24)$  commonly seen. A small number tried to convert the temperature change to Kelvin by adding 273 and using 308 instead of 35 in the calculation.

Many calculated the amount of  $\text{Na}_2\text{O}$  correctly and used 0.0200 appropriately to determine the enthalpy change of reaction. It was not uncommon for candidates to omit this step or to use 0.0400 instead of 0.0200, although it was difficult to see why.

In the Hess' Law extension, it was common to see an incorrect cycle, using incorrect signs, or  $-57.6$  being used rather than  $2 \times -57.6$ .

Generally, candidates need to improve the use of signs, units and in the quality how their answers are communicated. Too many responses comprised a mass of unsubstantiated numbers.

Answers:  $-188 \text{ kJ mol}^{-1}$ ;

$-303$  to  $-304 \text{ kJ mol}^{-1}$  (depending on extent of intermediate rounding)

**2(b)** Virtually all candidates realised the need to calculate percentage uncertainties, but less than half were awarded both marks. Some based their calculations on the readings rather than the difference, and others did not take into account that two readings had two uncertainties, doubling the overall uncertainty.

Answers: mass: 0.81%; temperature change: 0.57%

**2(c)** Many candidates did not consider reducing percentage uncertainties in the measurements (stated in the question), instead repeating readings and taking an average. Despite the question stating that the same apparatus was to be used, many suggested using a more accurate balance or thermometer, or using a lid with some form of insulation.

The most common creditworthy answer was to increase the mass of  $\text{Na}_2\text{O}$  to reduce the percentage uncertainty in mass. The best candidates realised that an increased mass of  $\text{Na}_2\text{O}$  would produce a larger temperature change, reducing also the percentage uncertainty in  $\Delta T$ . Some candidates suggested increasing the volume of the water but this would have decreased the temperature change and increased its percentage uncertainty.

**2(d)(i)** This part was very poorly answered, the most common answer being sodium nitrate. The examiners were expecting sodium nitrate(III) but the mark scheme was extended to also allow sodium nitrite.

Sodium(III) nitrate was sometimes seen, indicating that candidates are not fully conversant with rules for showing oxidation states in names.

**2(d)(ii)** This part was generally answered well although a significant number of candidates managed to get one of the oxidation numbers wrong, usually for N. It was rare to see the sign for an oxidation number omitted.

**2(d)(iii)** The examiners were impressed with the responses for this part with just over half the candidates producing a correct balanced equation for this unfamiliar reaction. Most used whole numbers for balancing but it was common to also see the half-multiple version including  $\frac{1}{2}\text{N}_2$ .

### Question 3

**3(a)(i)** This rates calculation was generally well answered. Surprisingly, some candidates did not write the rate equation, despite being part of the question. A common mistake was omission of  $\times 10^{-6}$ .

Most candidates find determination of orders from initial rates data a straightforward task. Despite this, many obtained an incorrect rate equation, the most common being  $\text{rate} = k[\text{I}]$ . The mark scheme allowed error carried forward from an incorrect rate equation for both the calculated value of  $k$  and its units.

**3(a)(ii)** Most candidates used the logarithmic form of the Arrhenius equation from the Data Sheet and recognised that a graph of  $\ln k$  against  $1/T$  would produce a gradient of  $-E_a/R$ . Errors were sometimes made with the graph itself with many opting for  $\ln k$  against  $T$  or  $k$  against  $T$ . A

significant number of candidates seemed muddled by the term ‘against’ in describing their graph. A safer option is to state the axes for each variable.

**3(b)** Many candidates found this part challenging and there was a wide variety of answers and marks awarded. There were two equations to construct showing how  $\text{MnO}_2$ , and  $\text{Mn}^{2+}$  react with  $\text{H}_2\text{O}_2$ . Many combined the two equations involving  $\text{H}_2\text{O}_2$  to obtain the overall equation for the decomposition of  $\text{H}_2\text{O}_2$  which was given at the top of the paper. Of the equations seen, many had species uncancelled. Many candidates only tackled one of the equations.

Candidates were expected to provide evidence for their equations based on the electrode potentials provided. Use of this data was patchy and only the best candidates linked the relative  $E$  values to the direction of movement or redox details. A significant number gave cell potentials.

Regeneration of  $\text{MnO}_2$  was well understood but often just stated with no reference to the equations. This part discriminated very well.

**3(c)(i)** This part was attempted well, with many providing a structure containing the correct  $\text{COOOH}$  functional group. The mark scheme did allow alternatives provided that the three O atoms were bonded to the C atom, e.g.  $\text{H}_3\text{C}-\text{O}-\text{COOH}$

**3(c)(ii)** Many candidates obtained the correct answer but water was often seen in the  $K_c$  expression. Candidates then assigned arbitrary values to the concentration of the water, often the same as  $\text{CH}_3\text{COOH}$ , unity, or even 55.6 from 1000/18. The mark scheme allowed some credit by use of error carried forwards.

Answer: 0.023 mol

#### Question 4

**4(a)(i)** This question should have been four straightforward marks, but it was actually found very challenging by candidates. Most read the scales correctly but then did not present their findings clearly, often scattering unlabelled numbers around, omitting units with absence of any heading linking them to the burettes.

0.60 was very often shown as 0.6 and 22.80 as 22.8.

Candidates were expected to take the mean of their closest titres but a significant number took an average of all three titres instead. The mark scheme allowed for a mean titre obtained from incorrect titres.

Candidates need to appreciate the importance of communicating their results in a clear and comprehensive way with headings and units, and showing numerical values to the accuracy of the apparatus used.

**4(a)(ii)** Most candidates made some headway with this problem. Candidates were expected to process their mean titre from 4(a)(i) in a conventional titration calculation to arrive at a molar mass of  $132 \text{ g mol}^{-1}$ . From there, candidates could determine a  $\text{C}_4\text{H}_9$  alkyl group and draw the structure of compound A with two chiral carbon atoms.

Most candidates scored some marks but processing beyond the molar mass proved to be difficult for weaker candidates. Some candidates showed a structure with a linear  $C_4H_9$  group which contains one chiral carbon atom.

A common error was use of  $25.0\text{ cm}^3$ , instead of the titre, as the volume of  $NaOH$ , obtaining an initial value of  $2.10 \times 10^{-3}\text{ mol}$ . The mark scheme allowed processing of this value to be credited using error carried forwards. Some candidates omitted to scale their initial value by a factor of  $\times 10$ , obtaining a molar mass of over  $1000\text{ g mol}^{-1}$ , e.g. 1320 instead of 132. A large range of marks was seen and the question discriminated extremely well.

**4(b)(i)** Candidates found this part difficult and the problem presented many opportunities for errors. Many candidates tried to show charges for the salt formed but often the  $2+$  charge was missing on  $Mg^{2+}$  or  $Mg^+$  was shown. The balanced equation required a balancing 2 before compound A but this was often omitted. Candidates using skeletal formulae fared better than attempts to show structural formulae such as  $HOCHRCOOH$ , with many omitting the H atom from CHR. Few candidates identified the reaction as redox, with many giving neutralisation instead.

**4(b)(ii)** As with 4(b)(i), candidates found this question difficult. It was not often that the dimer was seen but, when it was, the structure was usually correct. Balancing required  $2H_2O$  and the balancing 2 was often omitted.

In contrast with 4(b)(i), many more candidates identified the type of reaction, here condensation or esterification.

**4(c)(i)** Most candidates identified the skeleton of the ligand. However, this was often drawn without the minus sign on the  $COO^-$  or with an additional minus sign on the nitrogen.

**4(c)(ii)** Most candidates calculated the amount of chromium correctly as  $3.85 \times 10^{-6}\text{ mol}$ . The second mark required this value to be multiplied by the molar mass of the complex. Success here was dependent on obtaining the correct molar mass of  $418\text{ g mol}^{-1}$ . Candidates scored better here than in 4(c)(i).

Answer:  $1.61 \times 10^{-3}\text{ g}$

## Question 5

**5(a)(i)** This part was very well answered. Candidates responded with either near molecular formulae, such as  $C_4H_9SH$ , structural formulae or with skeletal formulae. Some candidates made careless errors such as omitting the negative charge or showing  $[H^+]^2$  as numerator rather than  $[C_4H_9S^-][H^+]$ .

**5(a)(ii)** In this part, candidates were expected to apply their knowledge and understanding of esterification to thiols and thioesters. Over half the candidates obtained a correct structure of the thioester. Most of these candidates constructed a balanced equation although some omitted the water product. Common errors included formation of a conventional ester and  $H_2S$ , and retaining

the O atom from the OH in the carboxyl group to form –COOS–. As with 4(b)(i), structural and skeletal formulae were used. Candidates are less likely to omit H atoms if the skeletal formula is used.

**5(a)(iii)** Just over half the candidates drew the correct structure, displaying a good understanding of interpreting organic nomenclature when drawing a structure.

Common errors included omission of the CH<sub>2</sub> adjacent to the terminal –SH group and placing the branch or double bond in wrong positions. Some candidates spoilt an otherwise good response by showing a structural formula or a mixture of skeletal and structural formulae.

**5(a)(iv)** In this part, candidates were expected to apply their knowledge and understanding of condensation to an entirely new context. One mark was allocated for the reactants and this was usually scored. The second mark for the novel cyclic compound and water was much more difficult, aimed at stretch and challenge. A significant number of candidates interpreted the information to obtain a correct cyclic structure but this mark was the domain of the most able candidates.

**5(b)** This question required candidates to apply their knowledge of functional group tests for several naturally occurring organic compounds. Candidates were free to plan a series of chemical tests and there were many different solutions. The best responses planned to identify compounds by using tests that eliminated compounds one by one for further tests. These were often concise and very clear. Unfortunately, many responses were excessive in length with confusing plans that sometimes broke down partway through. Some candidates gave chemical tests for the functional groups in each compound in turn. They then didn't link the tests together to show how the compounds could be distinguished. Weaker candidates sometimes wrote down chemical tests for the different functional groups without linking these to the compounds. Poorly prepared candidates sometimes had the wrong observations for the tests. A significant number of candidates thought that the cyclic alcohol F was a phenol.

Despite these difficulties, there were many candidates who scored all six marks by a variety of methods.

**OCR (Oxford Cambridge and RSA Examinations)**  
1 Hills Road  
Cambridge  
CB1 2EU

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Facsimile: 01223 552627  
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