

**Chemistry A**

Advanced GCE A2 H434

Advanced Subsidiary GCE AS H034

**Report on the Units**

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**January 2010**

**H034/H434/MS/R/10J**

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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.

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Advanced GCE Chemistry (H434)

Advanced Subsidiary GCE Chemistry (H034)

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# Chief Examiner's Report

## General comments

This series saw the second January sitting for OCR's revised Chemistry specifications.

Unit F321, *Atoms, Bonds and Groups*, was taken by over 24000 candidates, a considerable increase on the January 2009 entry of 19000 candidates. There were a significant number of re-sit candidates and the majority were able to improve on their previous performance.

Unit F322, *Chains, Energy and Resources*, was taken by well over 6000 candidates; almost exclusively re-sit candidates from the June 2009 series. Many centres had clearly chosen the January series for this re-sit whilst preparing candidates for the organically-based F324 A2 unit. As with F321, many were able to improve on their previous performance.

Unit F324, *Rings, Polymers and Analysis*, was taken by over 12000 candidates. This is the first unit exemplifying a new approach to assessment of A2 performance as part of the emphasis by the regulator on stretching and challenging candidates sitting the new GCE qualifications. By definition therefore, candidates may well find aspects of this assessment harder than they did with the previous GCE qualifications and the evidence from examiners marking the paper supports this finding.

## A\* for June 2010

Note that June 2010 will see the first award of the A\* grade for new GCEs (see page 70 of the specification). To achieve an A\* grade in their Advanced GCE, candidates must achieve 480 *uniform* marks (UMS) in their Advanced GCE, *i.e.* grade A, and also gain at least 270 *uniform* marks in their three A2 units. Two candidates with 480 UMS could have different grades depending on their AS and A2 performance, for example:

**Candidate 1** – 211 UMS at AS, 269 UMS at A2, 480 UMS overall, grade A

**Candidate 2** – 210 UMS at AS, 270 UMS at A2, 480 UMS overall, grade A\*

A good explanation is given in the recent open letter to centres from OfQual, see [www.ofqual.gov.uk/files/2010-02-11-open-letter-a-star-grade.pdf](http://www.ofqual.gov.uk/files/2010-02-11-open-letter-a-star-grade.pdf)

## F321 Atoms, Bonds and Groups

### General comments

The *Atoms, Bonds and Groups* paper is designed to be the first paper which candidates meet post-GCSE and is seen as part of the continuum of development throughout chemistry.

At the top end, performances were similar to those seen last January with several candidates achieving 60 marks out of 60. The performances at the lower end were slightly higher than last January, indicating a general trend of improved preparation for weaker candidates.

Responses given by candidates suggested they had been well prepared in familiar areas of the specification. Questions about chemistry introduced new to this specification proved difficult for many candidates. Conversely, it was also clear that many candidates are preparing well with familiar questions such as trends in ionisation energy, 'dot-and-cross' bonding diagrams, shapes of molecules and structure and bonding being answered very successfully.

Sadly, chemical literacy was often shaky for weaker candidates and it is disappointing to see formulae such as  $\text{Na}(\text{OH})_3$  appearing.

### Question 1

**1 (a)** This opening question was well answered. A common error to be avoided is comparison at the atomic level with the mole level. For example, '*The mass of an element compared to an atom of carbon-12*' would only secure the correct standard mark. Another way of failing to score the first marking point was to compare the mass of an atom of an isotope to 12 g of carbon-12.

**1 (b)** Most candidates were able to assemble the correct mathematical sum needed to calculate the answer but the correct outcome to the mathematical operation was not always achieved. Failure to use two decimal places and a rounding error to 152.05 were the commonest 'slips'.

A surprisingly large number of candidates made transcription errors, but the error was allowed to be carried forward provided that the final answer was shown to two decimal places and lay between 151 and 153, the relative masses of the two isotopes.

**1 (c) (i)** Many scored the mark here on this low-demand question.

**1 (c) (ii)** Many candidates scored this mark on what was seen as an equally low-demand question. Candidates opted to choose either electrons or protons, but not both.

**1 (d)** The trend in ionisation energies down a group is generally well understood and this often seen question was well answered and many 'stock' answers had been learned. Over half of the candidates scored three marks here. Where marks were lost, this was usually as a result of failure to use the comparative. '*...Xe has shielding...*' does not score the mark. '*...Xe has more shielding than Ne...*' will secure the mark. Candidates do need to be aware that (nuclear) 'charge' is not (nuclear) 'attraction'.

## Question 2

- 2 (a) (i) If 1d was very familiar, this part of the specification was less well known. This was targeted as a low demand question but very few candidates could provide the definition given in the specification.
- 2 (a) (ii) The formulae of three of the four species in this acid + alkali equation were given. This low-demand question required candidates to provide the fourth species, water. The balancing and the states were a little more difficult and so this proved with many achieving only one mark. Weaker candidates gave hydrogen as the fourth species but it was alarming that a relatively large number of candidates were unable to transcribe correct versions of the formulae given in the question.
- 2 (a) (iii) Once again, an unfamiliar question gave a higher level of difficulty than expected. Few candidates were able to convey the idea that a hydroxide ion acts as a base as it accepts protons.
- 2 (b) (i) The answer was correctly calculated by many candidates.
- 2 (b) (ii) Most scored the mark here, suggesting that many achieved this as a result of carrying an error forward from part (i).
- 2 (b) (iii) Many candidates were able to calculate a final answer. Once again many scored this mark as a result of carrying an error forward.
- 2 (c) (i) This was the first time this type of question had been seen and only a few candidates were able to state that the term required was water of crystallisation.
- 2 (c) (ii) This question discriminated very well. The more able tended to achieve both marks available. Mid-range candidates were able to score the first marking point as a result of correctly calculating the relative formula mass of  $\text{Na}_2\text{SO}_4$ . Many candidates calculated this value as 160.1 by including  $\text{H}_2\text{O}$  in the formula of the anhydrous sodium sulfate but they were able to process this number to achieve a value of 9 for x, thus earning one mark.

## Question 3

- 3 (a) (i) This question has been seen before. It is a standard description and is a specification learning outcome. However, many still do not emphasise that an ionic bond is an **attraction** between oppositely charged ions. Too many tended to write vaguely about a force between the ions rather than specifically about attraction. Others referred to atoms in place of ions.
- 3 (a) (ii) In general this 'dot-and-cross' diagram was well drawn with many scoring both marks. Pleasingly, few candidates suggested that MgS was covalently bonded. A more common error was to confuse sulfide with sulfate.
- 3 (b) (i) This was well answered with most candidates picking up both marks. The frequently seen error was the omission of non-bonding electrons on the two F atoms.
- 3 (b) (ii) This question discriminated particularly well. Weaker candidates could not appreciate the analogy with water and suggested a linear shape, presumably based upon the alignment of the 'dot-and-cross' diagram in part (i). Many candidates did spot the analogy and were able to quote  $104.5^\circ$  as the bond angle. However, they could only explain this by using the connection that each lone pair reduces the bond angle by  $2.5^\circ$  with no rationale as to why this reduction would happen.

Candidates who did apply the Valence Shell Electron Pair Repulsion theory usually scored the bond angle mark and were able to state that lone pairs repel more than bonded pairs. However, the numbers of lone pairs and bonding pairs were often omitted. Few candidates scored all three marks.

- 3 (c) (i)** The most common score seen for this question was three marks. The vast majority realised that the hydrogen bond exists between a nitrogen atom on one molecule and a hydrogen atom on an adjacent molecule. The role of the lone pair was less well appreciated.

A significant number of weaker candidates assumed liquid ammonia referred to aqueous ammonia and showed a hydrogen bond between an ammonia molecule and a water molecule. Some misread the question and drew hydrogen bonds between water molecules.

- 3 (c) (ii)** Candidates either opted to state that ice was less dense than water or that water had a relatively high boiling point. However, for those who chose the latter option, the key word was '*relatively*' as water does not have a *high* boiling point. Explanations of either property in terms of the hydrogen bonding were in general well handled with about half of candidates scoring both marks.

#### Question 4

- 4 (a)** About half of the candidates gained both marks. In the first part, the only common error was to suggest that chlorine cleaned the water. In the second part, a few candidates clearly recalled some link to carcinogens but suggested that chlorine itself was carcinogenic and so did not gain the mark.
- 4 (b)** Many scored the mark available for this electron configuration of one of the first 36 elements.
- 4 (c) (i)** This question discriminated well. Ionic equations are difficult for weaker candidates. A significant number relied upon producing a displacement of iodine – presumably as a result of revising last year's Mark Scheme.
- 4 (c) (ii)** A good proportion of candidates could describe the appearance of bromine within cyclohexane. Others guessed green or purple. Quite a few white precipitates were recorded.
- 4 (d) (i)** Another 'new' question on a well-known concept. The question discriminated well as more able candidates scored the mark.
- 4 (d) (ii)** This was meant as a top-level question. The first equation is taken directly from the specification although it is known to be a difficult equation. One has the feeling that some of the candidates had committed this equation to memory as reactants shown as correct in the first equation appeared incorrectly when shown in the second equation. The second equation was designed to test candidates' ability to construct an equation based upon redox predictions made from information given.

The examiners were not expecting to necessarily see a correct equation but any version which had chlorine being oxidised to +5 in  $\text{NaClO}_3$  and reduced to -1 in  $\text{NaCl}$  was credited. If the other species balanced then further credit was awarded.

- 4 (d) (iii)** Clearly many candidates are unfamiliar with 1.1.4 '*Redox*' in the specification as very few scored this mark.

### Question 5

- 5 (a) (i)** This question was designed to be one of the easiest on the paper but candidates found it surprisingly difficult. Incorrect responses were based around hydrogen and helium or cobalt and nickel.
- 5 (a) (ii)** The examiners were expecting responses based upon the reactive metal, potassium, not being an inert gas or *vice versa*. However, many candidates opted for the easiest answer here and simply pointed out that the modern Periodic Table is arranged in order of increasing atomic number.
- 5 (b) (i)** Many candidates correctly wrote the equation for the combustion of magnesium.
- 5 (b) (ii)** Very few failed to score here. A significant number scored a single mark often by only providing one observation. Candidates are advised to consider the number of marks available when planning the level of response required for a question.
- 5 (b) (iii)** This low demand question did not behave as predicted with just over half providing a correct response.
- 5 (c)** This question discriminated very well. High ability candidates scored 5 or 6 marks whereas grade 'e' candidates tended to score 2 marks.

There were some impressive answers to this question on structure and bonding. Many candidates wrote correct descriptions but full marks were often not awarded because of the omission that magnesium has a *giant* structure or a description of the particles involved in the metallic bond. ('Nuclei' was often seen in place of 'positive ions'.) Weaker candidates often contradicted correct statements. Describing the 'ionic bonding' shown in the metallic structure of magnesium or referring to the intermolecular attraction in metallic bonding were typical examples of such contradictions.

Other failures to gain credit came as a result of describing 'molecules of magnesium' or describing the breaking of the covalent bond in chlorine as requiring less energy.

- 5 (d) (i)** This question discriminated well amongst the higher ability candidates. Candidates had difficulty correctly assigning oxidation numbers to the reactant. The product proved to be less difficult.

The commonest mark scored was the oxidation number change of oxygen. The hardest mark appeared to be realising that nitrogen was reduced from +5 to +4.

Many candidates erroneously gave oxygen an oxidation state of -6 in the nitrate ion, presumably as a result of multiplying -2 by three. This then led to nitrogen being given an oxidation state of +6 in the reactant. However, these candidates were able to salvage a mark by correctly assigning terms to the numerically wrong redox changes from reactant to products.

- 5 (d) (ii)** This was the last question and, to aid candidates, the molar mass of  $\text{Sr}(\text{NO}_3)_2$  was given. However, a significant majority chose to ignore this value and proceeded to calculate their own values, frequently without success. The stoichiometry was difficult and a mark was given for processing the 0.250 mol of reactant into a value for the number of moles of gas formed. The third mark was dependent upon the second mark and was awarded for multiplying the number of moles of gas by 24. Some calculated the volume of only one of the two gases formed.

## F322 Chains, Energy and Resources

### General comments

The examination included a significant proportion of questions that assessed topics new to the AS specification. There was some evidence that the candidates found these questions more demanding than traditional questions. There was little evidence that candidates did not have time to finish the examination.

The average mark for the examination was 61 and candidates were awarded marks that covered the whole mark range. Statistics show that all of the questions and the paper as a whole differentiated well. The paper allowed candidates of all abilities to demonstrate positive achievement.

A significant proportion of candidates wrote incorrect equations and did not check that they were balanced. Many candidates also found the questions that involved long answers were demanding. These candidates often did not organise their answers by using information in the stem of the questions. Good answers to these types of questions were well organised and concise.

Candidates often were not awarded marks because their answers lacked detail and precision.

### Question 1

This question focussed on the use and environmental impact of using kerosene as an aviation fuel.

In **(a)** most candidates could recall that fractional distillation is used to separate kerosene from crude oil and that this process depends on the different boiling points of each fraction.

Most candidates could identify decane in **b(i)**. In **b(i)** a large proportion of candidates could draw the skeletal formula of a branched chain isomer. The most common error was to draw decane rather than include a branched chain formula with more than ten carbon atoms per molecule. The most popular skeletal formula was that of one of the methylnonanes. In **b(iii)** many candidates realised that the difference in boiling point was as a result of the straight chain isomer being able to get closer to or have more surface contact with neighbouring molecules. Some candidates did not refer to greater or stronger van der Waals' forces with the straight chain isomer but instead used intermolecular forces; this was not given credit. In **b(iv)** many candidates referred to smoother burning or less knocking with branch chain isomers; however it was not sufficient to refer to just a better fuel.

A large proportion of candidates in **c(i)** could write the equation for the complete combustion of decane. Almost all of these candidates used one mole of octane in the equation. The most common misconception was to use O rather than O<sub>2</sub> in the equation. In **c(ii)** the mark was awarded for a correct equation involving molecular oxygen and nitrogen reacting together to make nitrogen monoxide. Often candidates did not include an equation or they used atomic nitrogen in the equation. This part question was the least accessible in Question 1 and a significant proportion of the candidates did not attempt **c(ii)**.

Many candidates in **d(i)** could recall the definition for a radical, although a small proportion of candidates referred to a radical as a species with a single electron and this was not given credit. Another misconception was that a radical was an unpaired electron. In **b(ii)** many candidates recognised that NO was a catalyst but other incorrect answers included as a nucleophile or as an oxidising agent. In **b(iii)** most candidates who obtained full marks used the equilibrium process involving O reacting with O<sub>2</sub> to make O<sub>3</sub>, only a small number of candidates referred to

the rate of formation of ozone being the same as the rate of decomposition. Candidates who gave the equation involving  $3\text{O}_2 \rightarrow 2\text{O}_3$  were not given credit. A small but significant proportion of candidates did not attempt this question. In **b(iv)** a significant proportion forgot to refer to the absorption of ultraviolet radiation and so were not given credit.

## Question 2

This question focussed on the decomposition and manufacture of hydrogen peroxide.

In **a(i)** many candidates could construct the equation for the decomposition of hydrogen peroxide. The most common misconception was that hydrogen and oxygen were produced rather than water and oxygen. In **a(ii)** candidates were often imprecise and only referred to more collisions between particles. The Mark Scheme required reference to more molecules per unit volume and so more collisions per second. Acceptable alternatives to these marking points included '...the molecules were closer to one another...' and '...there were collisions more often...'. The action of a catalyst in lowering the activation energy by providing an alternative pathway was well known by candidates in **c(iii)**. A small proportion of candidates gave an alternative answer referring to lowering the activation energy so more molecules had a kinetic energy at or above the activation energy. This answer was given full credit. An even smaller proportion of candidates gave an explanation based on the surface action of the  $\text{MnO}_2$  catalyst and this approach could also be awarded full marks. Many candidates could draw the Boltzmann distribution at a higher temperature in **a(iv)** but less could explain why this would give rise to a greater rate of reaction. Candidates often forgot to label the activation energy. Only a very small proportion of candidates gave two different activation energies.

In **b(i)** many candidates could calculate the atom economy as 12.7%. Candidates who rounded up to 13% were also given full credit. One mark was awarded to candidates who did not get the correct answer but realised that the expression for atom economy needed 264.4 at the bottom of the fraction. A small proportion of the candidates worked out the atom economy for  $\text{BaSO}_4$  which is not a useful product. Candidates were able to interpret the information in **b(i)** and **(ii)** to explain the advantage of making  $\text{H}_2\text{O}_2$  from  $\text{H}_2$  and  $\text{O}_2$ . Most candidates compared the atom economy and appreciated that anthraquinone could be recycled and was thus acting as a catalyst. Slightly fewer candidates explained that oxygen was readily available from the air since this was not in the given information.

Candidates found **(c)** very difficult and many gave confused and conflicting answers. The best answers were set out as bullet points.

- Bond breaking absorbs energy
- Bond breaking releases energy
- More energy is released than absorbed

A common misconception involved taking more energy to make a bond than to break a bond. No credit was allowed about the number of bonds made or broken since it is overall energy change that is important. Correct reference to bond enthalpy changes could be given full marks so long as it was clear that it was the sum of the bond enthalpies of the reactants and of the products that were being considered.

## Question 3

This question focussed on the enthalpy change of combustion of glucose.

Respiration was well known in **(a)**.

In **(b)** many candidates were able to get to the correct numerical answer in **(iii)** but failed to include the negative sign or quote the answer to three significant figures. Full marks were given for an answer of either  $-1560$  or  $-1570 \text{ kJ mol}^{-1}$  depending on previous rounding. In **(i)** candidates had to get  $7.23 \text{ kJ}$  but a small proportion of candidates forgot to convert joules to kilojoules. The answer had to be quoted to at least two significant figures with correct rounding. Another misconception was to use the mass of  $0.831 \text{ g}$  (the glucose) rather than  $100 \text{ g}$  (the water). Most candidates were able to calculate the number of moles in **(ii)** as  $0.00462$ . Again this answer had to be quoted to at least two significant figures with correct rounding. Only a very small proportion of candidates was awarded one mark as an error carried forward from an incorrect  $M_r$ . A significant proportion of candidates did not attempt **b(iii)**.

In **(c)** a large proportion of candidates was able to cope with this calculation obtaining  $-2830 \text{ kJ mol}^{-1}$ , or  $+2830 \text{ kJ mol}^{-1}$  if they had the cycle the wrong way around. A variety of error carried forward marks were available for candidates who did not use the correct mole ratios and/or had the cycle the wrong way around.

Many candidates in **(d)** referred to incomplete combustion or that heat was lost to the surroundings but a much lower proportion of candidates referred to non-standard conditions. Some candidates referred to the idea that the theoretical value is based on average bond enthalpy values but this was not relevant to the question that was set.

#### Question 4

This question focussed on two reaction mechanisms. Only a very small proportion of candidates failed to attempt to describe the reaction mechanisms.

In **a(i)** many candidates could write the equation but in **(ii)** some candidates used carbon position numbers in their name. The use of '1-' as a position number was allowed but not examples such as 1,2-dichloromethane. A small proportion of candidates gave answers such as dichloroethane. Other candidates gave a non-organic product and a significant proportion of the candidates left **(ii)** blank.

Only a very small proportion of the candidates did not attempt the radical substitution mechanism in **a(ii)**. The names of the steps were well known and generally they were linked to the correct equations. This linkage contributed to the quality of written communication mark. A small fraction of the candidates described the mechanism in words rather than equations. These answers could be awarded full marks but it was easier for candidates to write the equations for each step. The most common errors involved using the wrong formula for the free radical formed in the propagation steps. Some candidates used hydrogen atoms instead of a methyl radical or a chlorine atom. The termination steps were well known and credit was given for the reaction  $\text{CH}_3 + \text{CH}_3 \rightarrow \text{C}_2\text{H}_6$  without any further written explanation. Only a very small proportion of candidates attempted a mechanism using 'curly arrows'.

In **(b)** most candidates chose to describe electrophilic addition or nucleophilic substitution. Only a very small proportion of the candidates chose a mechanism from the A2 specification, the most popular being electrophilic substitution. A common misconception was to give a good description of a mechanism including the example but give it an incorrect name e.g. describing the reaction of bromine with an alkene but describing it as nucleophilic addition. Such examples could score a maximum of five out of six marks. The use of 'curly arrows' was well understood by many candidates and many candidates drew curly arrows from a lone pair in  $\text{OH}^-$  or  $\text{Br}^-$ . The Mark Scheme allowed the curly arrow to go from a negative charge or a lone pair.

With electrophilic addition two common misconceptions were to use a partial charge on the carbocation or on the halide ion rather than  $+$  or  $-$ , respectively. Only a small proportion of the

candidates had the curly arrow attacking the double bond. With nucleophilic substitution a common error was to miss off the partial charges on the C–Hal bond.

### Question 5

This question focussed on the chemistry of alkenes and the disposal of polymers.

In **(a)**, cracking was well known by most candidates.

In **b(i)**, either the type of catalyst or the name of the catalyst was allowed in the Mark Scheme. A large proportion of candidates were awarded a mark. In **b(ii)** Le Chatelier's principle was well known by most candidates but a much lower proportion of candidates could use the principle to predict the conditions in **(iii)**. Some candidates gave the correct conditions but did not link these answers to the correct information, e.g. low temperature because the (forward) reaction is exothermic and high pressure because there are less moles of gas on the product side of the reaction. Part **(iv)** was difficult for candidates who had the conditions incorrect but most candidates were able to link high pressure with either cost or danger. Candidates found it much more difficult to explain the compromise conditions of the temperature to ensure that the reaction was sufficiently fast without shifting too far to the left. Many candidates only really focused on the rate side of the compromise. It was also clear from some answers that some candidates did not realise that 60 atmospheres is a high pressure.

Candidates found naming the monomer in **(c)** much more difficult than drawing the structure of the monomer. A common misconception was to name the monomer as methylethene rather than as propene.

Many candidates could balance the equation in **d(i)** and almost all answers used the equation with a fraction rather than double up to get integers. A small but significant number of candidates did not attempt **(ii)** and many who did stated an alkene rather than an alkali or a base.

Candidates were often awarded one mark in **(e)** by referring to the use of biodegradable polymers. Candidates referring to recycling also had to mention sorting to be awarded a mark. The development of photodegradable polymers, developing polymers from plant materials and cracking were all mentioned by candidates.

### Question 6

This question focussed on the chemistry of alcohols.

In **(a)** many candidates could deduce which isomer was a tertiary alcohol but a significant proportion of candidates chose 2-methylpentan-3-ol rather than 2-methylpropan-2-ol.

Many candidates could draw the skeletal formula for 2-methylpentan-3-ol in **(b)** but a small proportion of candidates did not show a bond to the OH group and so reduced the number of carbon atoms in the skeleton.

The definition of structural isomer in **c(i)** was well known but a common misconception was to refer to structural isomers having a different arrangement of atoms in space which referred to stereoisomerism rather than structural isomerism. In **(ii)** candidates could get marks by drawing a structural formula, displayed formula or a skeletal formula. Only a very small proportion of candidates drew the OH bond with the hydrogen attached to the carbon atom.

In **(d)** many candidates appreciated the importance of the hydroxyl group but did not always clearly indicate that as a result there were hydrogen bonds between ethane-1,2-diol and water molecules. A few candidates referred to hydroxide groups and this was not given credit.

Candidates found **(e)** very difficult and even if they appreciated that an ester was made, often the ester drawn was based on ethanedioic acid rather than the diol.

Many candidates ignored the fact that the compounds **B**, **C** and **D** were alkanes and drew structures that included an OH group. Any structures that were not alkenes that could be formed from dehydrating butan-2-ol were not given credit. In **f(i)** only *E*- and *Z*-but-2-ene were given credit. Either structural formulae, displayed formulae or skeletal formulae were allowed in the Mark Scheme. Candidates did not have to identify the *E* and *Z* isomer. Even if the wrong structures were drawn in **f(i)** most candidates were able to state that the stereoisomerism was *E/Z* or *cis-trans*. A significant proportion of candidates did not attempt **(iii)**.

In part **(g)** one mark was available for the quality of written communication by linking the evidence with the possible structure of alcohol **E** or organic product **F**. Only a small proportion of the candidates actually linked the *m/z* peak of 60 with the molecular ion and the relative formula mass. Many candidates made the link but did not show this link as a written explanation. One more mark was available for identifying the fragment ion at *m/z* = 45 and suggesting a possible fragment responsible for the ion. Because the infrared spectrum had a possible O–H stretching frequency candidates were allowed to deduce that **F** was either a carboxylic acid or a ketone (if the candidate assumed there was no broad O–H absorption). Many candidates identified **F** as a carboxylic acid as a result of the peaks between 1300 and 1000  $\text{cm}^{-1}$  although there were no marks for this deduction. Some candidates used the oxidation data to eliminate the possibility of **F** being propanal but those who did not could only be awarded a maximum of six marks for the question. Many candidates could not write a balanced equation for the oxidation; in particular the  $\text{H}_2\text{O}$  product was often missed out.

## Question 7

This question involved the concern about increasing amounts of greenhouse gases in the atmosphere. This was the most demanding question in the examination paper.

In **a(i)** a significant proportion of candidates referred to the absorption of ultraviolet rather than infrared radiation. Often candidates neglected to state that the result of this infrared absorption was that bonds vibrate. In **a(ii)** candidates often appreciated that there is more carbon dioxide in the atmosphere or that more carbon dioxide was produced. Candidates were allowed to suggest that carbon dioxide is a more effective greenhouse gas than methane even though this is untrue since this knowledge is beyond the AS specification content.

Candidates often focused on Carbon Capture and Storage (CCS) in **(b)** and the Mark Scheme allowed the idea of CCS and two examples. Other candidates took a more broad view and talked about reporting to governments or the contributions of chemists to world-wide protocols, or the development of alternative fuels that do not produce carbon dioxide. Candidates had to link the idea of carbon-neutrality to be awarded a mark about developing biofuels. One common misconception was that catalytic converters could be developed to remove carbon dioxide.

There was no mark for yes or no in **(c)**, all the marks were about the explanations. Most candidates were able to state that when the  $\text{CO}_2$  concentration goes up so does the temperature. Good answers appreciated that other factors could be involved in global warming.

# F324 Rings, Polymers & Analysis

## General comments

This is the first examination of this unit and the paper produced an excellent spread of marks with marks ranging from 0 to 59. Very few scored below 15 marks, equally the top 5 or 6 marks proved to be very elusive.

All candidates were sitting this examination for the first time and there were no re-sit candidates. Each of the five questions was accessible to all candidates but each question contained parts that stretched the most able candidates. The majority of candidates seem to have been well prepared.

Candidates displayed good examination technique in most of the questions but a substantial number of candidates struggled on the questions directed in **1b(ii)**, **1c**, **3d**, **4a**, **4b** and **5c**.

## Question 1

- 1(a)** This part was generally well answered but a substantial number of candidates failed to score the mark by either writing out the mechanism in full or in part or by writing an equation for a reaction between benzene and chlorine.
- 1(b)(i)** It was disappointing that few candidates scored both marks. Most correctly identify the organic product for one mark but only a minority recorded the correct observation.
- 1(b)(ii)** Many candidates displayed a lack of precision in naming 1,2-dibromocyclohexane with well over half scoring no marks. It was common to see errors such as either omitting the numbers or the 'di' or the 'cyclo' as well as seeing hexene instead of hexane. A surprising number named the product as 2,4,6-tribromophenol which related back to the product in **1b(i)**.
- 1(b)(iii)** This was generally well answered. A substantial number failed to score full marks by confusing electronegativity with electron density or by not referring to one of the three chemicals in the question.
- 1(c)** The preparation of an azo dye was well answered with over 30% scoring 5/5. It was apparent that this reaction sequence was well known but many failed to score maximum marks by carelessly forgetting the methyl group or by moving the methyl group from the '3' position. A substantial number of responses started with phenylamine and produced the azo dye formed when phenol couples with benzenediazonium chloride. The initial error prohibited full marks but the rest was marked consequentially.

## Question 2

- 2(a)(i)** This was an easy start for one mark and most scored this. Those that didn't score the mark often confused Tollens' with 2,4-dinitrophenylhydrazine.
- 2(a)(ii)** This was well answered with most candidates realising that the aldehyde was oxidised to a carboxylic acid. It was, however, common to see Ag covalently bonded to an organic molecule. A number of candidates also identified the product as CH<sub>3</sub>COOH, forgetting that the starting material was hydroxyethanal and not ethanal.

- 2(b)** This proved to be one of the hardest sections on the paper with very few scoring 2/2. The key to the question was the realisation that reflux results in complete oxidation of both the alcohol and the aldehyde. Many scored half marks by writing an equation that correctly described one of the possible partial oxidations. The most common product was hydroxyethanoic acid but it was disappointing to see so many equations that were not balanced.
- 2(c)(i)** This was well answered with most correctly identifying the reduction product.
- 2(c)(ii)** A substantial number of candidates knew the mechanism well and were able to apply their knowledge to this reaction; however a small number scored no marks at all. In general, candidates showed the movement of electron pairs by drawing curly arrows correctly but a substantial number failed to score full marks by forgetting one or more dipoles. It was not uncommon to see the intermediate with either a  $\delta^-$  charge or no charge at all. A surprising number also started with ethanal rather than with hydroxyethanal.

### Question 3

- 3(a)** All three parts were well answered but a substantial number confused retention times and  $R_f$  values whilst others, in part **(ii)**, linked TLC to a mass spectrometer to identify the three amino acids. Few, if any, described an experiment that they might have done in class. It was disappointing not to see any descriptions of running a TLC of the mixture alongside a range of known amino acids.
- 3(b)(i)** This was a straightforward question and an easy mark for most candidates.
- 3(b)(ii)** This was a difficult question but it was well answered by a substantial number of candidates. It was pleasing to see the logical approach of many candidates. However, a substantial number confused stereoisomers and structural isomers whilst others drew the same stereoisomer two or three times.
- 3(c)** This proved to be a difficult exercise in that candidates had first to identify the correct R-group and then to determine ions at different pH values. Most scored the first mark for the zwitterion formed by alanine. Very many recognised that glutamic acid would form an anion at pH 10, whilst lysine would form a cation at pH 2. However, most failed to spot that in each case the R groups would also be ionised resulting in a di-anion and a di-cation, respectively.
- 3(d)** This was poorly answered with less than one third of candidates scoring the mark. Many candidates named only one amino acid, usually valine, and perhaps were unsure what was required by the word 'sequence'.
- 3(e)** There were two easy marks available here for almost all candidates. Some candidates lost marks by drawing fully displayed monomers and miscounting the number of  $\text{CH}_2\text{s}$  in each monomer.

#### Question 4

- 4(a)** Very few scored all three marks and many failed to follow the guidance given in the question. Many listed the presence of absorptions for the C=O, C–O and the O–H bonds in the infrared spectra without recognising that C=O and C–O bonds would also be present in the esters. The use of  $^{13}\text{C}$  NMR was answered in either a very general way or by reference to chemical shift data. Part credit was given if candidates stated that  $^{13}\text{C}$  NMR detected different C environments but full credit was only given if this was directly related to the number of peaks that would be detected in each of the carboxylic acids.
- 4(b)** This was much better answered than **4a** with the majority of candidates scoring four or more marks out of six. Over 30% of candidates scored 6/6 indicating that  $^1\text{H}$  NMR is better understood than  $^{13}\text{C}$  NMR. It is appreciated that the correct ester could be identified in a number of different ways but candidates were instructed to ‘...analyse the splitting patterns and the chemical shifts...’ and the Mark Scheme gave credit for following these instructions.

#### Question 5

- 5(a)** This was generally well answered with about half the candidates scoring the mark but a surprising number identified the reagent as either phenol or as benzoic acid.
- 5(b)(i)** This part differentiated well with approximately a third of the candidates scoring 0, 1 or 2 marks. Many candidates deduced the correct reagents but only the most able correctly balanced the equation. It was common to see  $\text{H}_2\text{O}$  as one of the products rather than  $\text{CH}_3\text{COOH}$ .
- 5(b)(ii)** This was the most demanding question in the paper but it was pleasing that very able candidates deduced one of the possible products and scored the mark. Many simply made up random chemicals that met the formula  $\text{C}_{10}\text{H}_{11}\text{NO}_3$ . Many nitrates were seen.
- 5(b)(iii)** This was a very easy mark and almost all candidates scored the mark.
- 5(c)** This question was poorly answered and many candidates listed three or four functional groups for aspirin and for paracetamol. Others listed only one functional group for each. It was disappointing to see so many candidates misinterpret the amide in paracetamol as a ketone and an amine, and the phenol in aspirin as an alcohol.
- 5(d)** This was generally poorly answered. Many of the answers related back to **(c)** and used reagents that would react with ketones or alcohols. The key to the question was recognising that both aspirin and paracetamol reacted with either Na or with NaOH or could be hydrolysed. The carboxyl group in aspirin meant that it would react with either a carbonate or with an alcohol, whilst paracetamol would react with neither. The phenol in paracetamol meant that it, and not aspirin, would react with either bromine or with a diazonium compound.

# Grade Thresholds

Advanced GCE Chemistry A (H034/H434)  
January 2010 Examination Series

## Unit Threshold Marks

| Unit |     | Maximum Mark | a   | b   | c  | d  | e  | u |
|------|-----|--------------|-----|-----|----|----|----|---|
| F321 | Raw | 60           | 46  | 40  | 35 | 30 | 25 | 0 |
|      | UMS | 90           | 72  | 63  | 54 | 45 | 36 | 0 |
| F322 | Raw | 100          | 77  | 68  | 59 | 51 | 43 | 0 |
|      | UMS | 150          | 120 | 105 | 90 | 75 | 60 | 0 |
| F324 | Raw | 60           | 43  | 38  | 33 | 29 | 25 | 0 |
|      | UMS | 90           | 72  | 63  | 54 | 45 | 36 | 0 |

## Specification Aggregation Results

Overall threshold marks in UMS (i.e. after conversion of raw marks to uniform marks)

|      | Maximum Mark | A   | B   | C   | D   | E   | U |
|------|--------------|-----|-----|-----|-----|-----|---|
| H034 | 300          | 240 | 210 | 180 | 150 | 120 | 0 |

The cumulative percentage of candidates awarded each grade was as follows:

|      | A    | B    | C    | D    | E    | U   | Total Number of Candidates |
|------|------|------|------|------|------|-----|----------------------------|
| H034 | 12.9 | 37.5 | 62.7 | 83.1 | 96.2 | 100 | 1415                       |

**1415 candidates aggregated this series.**

For a description of how UMS marks are calculated see:  
<http://www.ocr.org.uk/learners/ums/index.html>

Statistics are correct at the time of publication.

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