

GCE

Chemistry A

Advanced GCE **A2 H434**

Advanced Subsidiary GCE **AS H034**

OCR Report to Centres June 2016

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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 Subsidiary GCE Chemistry (H034)

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F321 Atoms, Bonds and Groups

General Comments:

The candidates sitting the paper were almost an entirely re-sit cohort who were seeking to improve upon the mark they obtained in June 2015. Consequently, scores were unusually high in comparison to previous sessions of F321. There was a noticeable lack of responses omitted and scores in single figures were extremely rare.

The paper was typical for a F321 paper in terms of difficulty. What was noticeable was that candidates did not stumble upon the molar calculation questions, a trait which a more 'normal' cohort would have shown.

Comments on Individual Questions:

Question 1

1(a) This was well-answered but it was evident that this basic material, usually covered very early in the syllabus had been forgotten by a few.

1(b)(i) Spherical was almost universally known as the shape of the s-orbital and this was mirrored in the responses for the shape of the p-orbital

1(b)(ii) This question asked about the simple concept of relative energies of the 2s orbital and the 2p orbitals. However, many candidates decided that the irrelevant details of the numbers of electrons should be given in their answer and further compounded their confusion by relating this fact to the relative energies of these orbitals.

This said, the better candidates were able to give concise, accurate responses for two marks.

1(c) Nearly all were able to draw an accurate 'dot-and-cross' diagram of a nitrogen molecule.

1(d) This proved to be one of the more difficult questions on the paper. A significant number of candidates were able to secure one mark by dividing by Avogadro's constant but failed to convert the number of molecules calculated into number of atoms present.

1(e)(i) The correct answer was almost universally known.

1(e)(ii) The correct answer was almost universally known with just the rare misspelling of disproportionation seen.

1(f)(i) Many candidates were successful in describing the term 'molecular formula' but weaker candidates gave answers which confused terms such as atoms and molecules. By far the most common erroneous response was 'The number of atoms in a molecule'.

1(f)(ii) Weaker candidates convinced themselves that the acid formed when water is added to nitrogen dioxide was HNO_3 . Better candidates were able to work out the product would have the formula $\text{H}_2\text{N}_2\text{O}_4$ but failed to convert this to its simplest form.

Question 2

2(a) Nearly all candidates understood that halogens consisted of simple molecular lattices.

2(b)(i) The explanation of how van der Waals' forces arise was well known. Some weaker candidates were unsure of the meaning of 'induced' and incorrectly assumed the induction process came before the formation of temporary dipoles.

2(b)(ii) Candidates were aware that the strength of van der Waals' forces was related to the number of electrons present in a molecule and secured both marks. Weaker candidates gave answers which lacked specific descriptions and loose phrases such as 'more energy is needed to break bonds' appeared from those who had not realised that bromine molecules also have covalent bonds.

2(c) Able candidates were able to provide full answers involving only two reactions, one ionic equation and correct colours of products in succinct form.

Some candidates answered the question correctly then ignored the instruction to keep the number of reactions to a minimum and gave an unnecessary third confirmatory reaction. This question distinguished well for many weaker candidates were unable to produce chemically coherent responses. Suggestions for 'impossible' reactions such as adding magnesium bromide to calcium iodide were frequently seen from such candidates.

Question 3

3(a) The term 'periodicity' was known to all but a very small minority of candidates.

3(b) The periodic properties of elements were not fully known. Most realised that sodium had the lowest first ionisation energy, less were aware that silicon had the lowest fourth ionisation energy and fewer still were unable to deduce that neon had the lowest boiling point.

3(c) The formula, Ga^{3+} , was almost universally known.

3(d) This question proved to be a good question in terms of distinguishing candidates. Good candidates were able to secure three marks with succinct, but well-explained answers. Weaker candidates were confused as to why the strength of metallic bonding increased from Na to Mg.

3(e) This seemingly difficult calculation was answered successfully by all but a relatively small handful of candidates.

3(f)(i) Nearly all candidates knew the formula of the molecule in question but some of these were less secure when it came to the name. Sulfur(IV) fluoride being the most common error.

3(f)(ii) Even weaker candidates coped well with the construction of this difficult equation. (Once again suggesting that having covered the A2 part of the specification, this had given candidates the experience that the normal AS candidate would not have met.)

3(g)(i) The application of dipoles to the molecule was done well.

3(g)(ii) Only a few candidates failed to realise that two bonding pairs and two non-bonding pairs would lead to the molecule being bent-shaped with an expected bond angle of 104.5° .

3(g)(iii) The question told candidates that fluorine was the most electronegative element which should have led them to realising that oxygen's oxidation state had to be a positive number. Many chose to ignore this despite allocating the oxygen atom a partial positive charge in part **(g)(i)**.

Question 4

4(a) The electron configuration of the d-block element zinc was extremely well known – once again suggesting that the knowledge gained from studying transition elements at A2 was of considerable benefit.

4(b)(i) This commonly asked for definition was well answered by all.

4(b)(ii) The vast majority were able to calculate the relative atomic mass of zinc to two decimal places.

4(c)(i) Most candidates realised that effervescence and dissolving would be seen.

4(c)(ii) Nearly all candidates were able to write the equation successfully – including those who had omitted effervescence in **4(c)(i)**.

4(d)(i) This type of question in the past has proved difficult but the current cohort found little difficulty. By far, the most common error was to use changes in oxidation numbers as the basis of the redox rather than using the number of electrons gained and lost for the explanation of the redox process.

4(d)(ii) The equation for the reaction between magnesium and water was well known – but many erroneously assumed MgO was formed.

4(e) This open style calculation would have usually proved difficult for the typical AS candidate but this year a significant majority of candidates were able to secure all four marks.

4(f)(i) The unusual equation involving P_4 molecules was answered well. Weaker candidates assumed that phosphorus was monatomic and consequentially lost credit.

4(f)(ii) This potentially difficult dot-and-cross diagram of the ions present was done well by candidates.

F322 Chains, Energy and Resources

General Comments:

The paper contained a good range of questions from each area of the specification providing candidates the opportunity to demonstrate their knowledge and understanding of a wide range of chemistry.

Overall the standard of responses was impressive and it was clear that the majority of candidates had prepared well for the examination. Questions requiring numerical problem solving, such as questions **2(e)(ii)**, **3a(i)**, **3(c)(ii)** and **5(e)**, were approached logically and on the whole the working shown was clear and easy to follow.

There were many excellent examples of precisely drawn mechanisms in questions **1(b)(iii)** and **2(f)(ii)**, but the work of some candidates was untidy. Candidates should be made aware that scanned images of diagrams first drawn in pencil and overwritten in ink often caused problems for examiners.

Many candidates found the questions requiring accurately written responses demanding. These included **4(b)**, **5(b)** and **6(b)(ii)** and provided opportunity for the strongest candidates to demonstrate their high level of understanding.

It should be noted that some candidates did not use the information given in the question sufficiently to provide a full response. This was particularly the case in **4(a)(i)** and **(ii)**, where candidates often failed to describe the appearance of the equilibrium mixture. Many candidates did not refer to the information regarding the relative molecular mass of the two isomers in their responses to **7(a)**. Candidates should be encouraged to read each question carefully before finalising their response.

Comments on Individual Questions:

Question 1

1(a) The majority of candidates were able to state the molecular formula of compound **A** correctly.

1(b)(i) Most of the candidates were able to show correct structures for all four organic products. The majority of these candidates used skeletal formulae. A small proportion of responses included incomplete structures. These included a missing Br atom on the product from the reaction of compound **A** with Br₂ or a missing methyl group. Candidates should be advised to check structures carefully, especially when using skeletal formulae.

1(b)(ii) Most candidates were able to state that an acid catalyst was required for the reaction of compound **A** with H₂O. However, although many candidates recognised the need for the reaction to be heated only the strongest responses referred to temperatures above 100 °C. It was not uncommon to see vague responses that simply referred to a high temperature. Candidates should be encouraged to give precise conditions for the hydration reaction of an alkene.

1(b)(iii) The mechanism of the reaction of compound **A** with Br₂ was well known and consequently the majority of candidates scored all three marks. A common reason for scoring only two marks was inaccurate placement of the curly arrow from the bromide ion to the carbocation intermediate. This arrow should start from either a lone pair or the minus sign of the bromide ion.

1(b)(iv) Most of the candidates were able to name the mechanism correctly. However it was not uncommon to see incorrect responses which included electrophilic substitution and nucleophilic addition.

Question 22(a) Many candidates were able to score both marks by specifying that compounds from a homologous series possess the same functional group and that each successive member varies by a CH_2 group. Some responses were imprecise and referred to just members differing by a CH_2 group, but this was less common compared to previous sessions.

2(b) Many candidates identified the process as fermentation and were able to provide a correctly balanced equation. Most candidates attempted to provide the conditions but it was often the case that either an appropriate temperature or anaerobic was suggested. Only the strongest responses contained both.

2(c) Many candidates attributed the difference in boiling point between alkanes and alcohols to the relative strength of hydrogen bonds compared with van der Waals' forces. Weaker responses simply identified alcohols as being able to form hydrogen bonds, but failed to compare these with van der Waals' forces.

2(d) Most candidates recognised that 2-methylpropan-1-ol is branched and communicated both marking points succinctly. Weaker responses identified that 2-methylpropan-1-ol would have weaker intermolecular forces, but failed to specify these as van der Waals' forces.

2(e)(i) Many candidates correctly named the type of reaction. There were a significant number of incorrect responses, the most common of which included hydrolysis, dehydrogenation and condensation.

2(e)(ii) Candidates coped well with this calculation based on percentage yield. Most were able to calculate the moles of cyclopentene produced and the strongest scaled this correctly to give the moles of cyclopentanol required. A common mistake was to scale by a factor of 45/100, rather than 100/45. However, error carried forward marks were awarded and the majority of candidates scored two or three marks. Answer: 14.1 g

2(f)(i) Most candidates were able to identify the correct chloroalkane required to produce 2,2-dimethylpropan-1-ol and provided a correctly balanced equation. A small but significant proportion of candidates failed to show the inorganic product in their equation. Candidates are encouraged to check equations carefully to ensure the correct formulae appear on both sides.

2(f)(ii) The mechanism of the hydrolysis of a primary halogenoalkane was well known and consequently most candidates scored both marks. A small, but significant, proportion of candidates started their curly arrow from the H atom of the hydroxide ion. Candidates should be advised to take care when drawing mechanisms to ensure curly arrows are used accurately.

Question 3

3(a)(i) Almost all candidates recognised the first step of this unstructured calculation was to use the $mc\Delta T$ expression to determine the energy change. The majority of the cohort subsequently divided this by the moles of CuSO_4 to obtain a value for ΔH_r . A significant proportion of responses did not include a sign for the enthalpy change and so only scored three marks. A small number of candidates gave incomplete responses, often rounding the energy change to three significant figures, rather than processing it further.
Answer: -347 kJ mol^{-1}

3(a)(ii) The majority of candidates were able to link the moles of CuSO_4 with the balanced equation to determine the moles of Mg reacting and hence suggest a mass. However, only the strongest candidates were able to scale the quantity required to take into account the excess.

3(b)(i) This definition is well known by candidates and the majority scored all three marks. A significant proportion of the cohort only scored two as the standard conditions were often omitted. Candidates should be encouraged to read questions carefully to ensure they include all the required information in their responses.

3(b)(ii) In general candidates approached this calculation confidently and applied Hess' law accurately. Some candidates failed to take into account the mole ratios, but subsequently processed their values correctly. Consequently the majority of candidates scored one or two marks.

Answer: -281 kJ mol^{-1}

3(c)(i) Most candidates were able to recall that bond enthalpy referred to the energy change occurring when bonds are broken, but weaker responses included contradictions by also mentioning bond formation. The strongest candidates were able to state that bond enthalpy referred to one mole of bonds but a significant proportion of candidates incorrectly referred to one mole of molecules or made no reference to this quantity.

3(c)(ii) Almost all candidates were able to process the bond enthalpy data and mole ratios to arrive at values for the energy required to break bonds in the reactants and the energy released by the formation of H–H bonds in the products. The most able candidates processed these values alongside the enthalpy change provided in the question to arrive at the correct answer. Common incorrect responses included $+1482 \text{ kJ mol}^{-1}$ and $+1272 \text{ kJ mol}^{-1}$, the latter of which was caused by failure to use the ΔH value provided.

Answer: $+1062 \text{ kJ mol}^{-1}$.

Question 4

4(a)(i) The effect of pressure on the position of an equilibrium is well known by candidates. Most were able to apply le Chatelier's principle accurately stating the equilibrium shifted to the right as that was the side with fewest moles of gas. However a significant proportion of the cohort did not comment on the effect on the appearance of the equilibrium mixture.

4(a)(ii) As with part **(a)(i)**, candidates demonstrated an excellent grasp of le Chatelier's principle but it was only the most able candidates who referred to the appearance of the equilibrium mixture. Candidates should be encouraged to read questions carefully to ensure they include all the required information in their responses.

4(b) This question discriminated well and the strongest candidates provided succinct responses with the correct level of scientific content. The first mark was awarded for recognition that adding an acid would increase the concentration of H^+ ions, causing the equilibrium to shift to the right. Most candidates realised this was the case. However, it was not uncommon to see vague responses that simply re-stated the information in the question, rather than focussing on the effect it would have on the species in the equilibrium equation. The second mark proved more difficult. The strongest candidates identified that the added alkali would remove H^+ ions from the equilibrium mixture, and some supported this statement with an equation. Many however, simply stated that the equilibrium would shift left to reduce the concentration of the alkali without attempting to relate it to the equation provided. Candidates are advised to consider the chemical equations provided with a question as they will help form the basis from which to build a response.

4(c)(i) Many candidates are well-prepared for this type of question however there are still some issues regarding the use of double headed arrows to indicate an enthalpy change. Whilst allowed by the examiners for showing activation energies, a correct single headed arrow was required to illustrate ΔH . A small proportion of candidates omitted hydrogen as a product, despite it being stated in the question.

4(c)(ii) Candidates are very familiar with the Boltzmann distribution curve and there were many examples of excellent diagrams. The majority of candidates scored maximum marks in this part. Failure to identify that more molecules have an energy greater than the activation energy when a catalyst is used, was a common reason why only three marks were scored.

4(d)(i) Most candidates were able to provide an equation for an industrial process with a suitable catalyst. The most frequent correct response was the use of Fe in the Haber process. Other common responses included the use of an acid catalyst for the preparation ethanol from ethene and Ni for the hydrogenation of an alkene.

4(d)(ii) The majority of candidates were able to provide two suitable examples of how catalysts increase the sustainability of chemical processes. The mark scheme allowed a variety of different responses that reflected the specification statements being assessed. The strongest responses focussed on the use of lower temperatures and reduced CO₂ emissions. Reference to alternative processes with a better atom economy was also frequently seen.

4(e)(i) This question required candidates to state two sources of nitrogen oxides in the stratosphere. Whilst most candidates identified one, this was often accompanied by vague or irrelevant statements such as 'car engines' or 'the burning of fossil fuels'. Consequently only the strongest candidates scored in this part.

4(e)(ii) The majority of candidates were able to provide the two equations that describe the catalytic role of NO in ozone depletion. A small but, significant proportion, of candidates provided equations involving N atoms.

Question 5

5(a) Almost all candidates were able to state the general formula of an alkane correctly.

5(b) This question linked together the formation of CO and NO within in an internal combustion engine and the use of a catalytic converter to reduce the emission of these gases. Almost all candidates explained the CO was produced by incomplete combustion and most provided an equation for its formation. However, many candidates failed to give an equation for the formation of NO. The role of a catalytic converter is well known by candidates and, as with previous sessions, examiners expected more than the basic 'adsorption, bonds weaken, desorption' that some candidates mentioned. The strongest responses made clear reference to the adsorption of CO and NO onto the surface of the catalyst and the bonds in these reactants being weakened. Weaker responses simply stated 'gases are adsorbed' and 'gases are desorbed' but made no attempt to identify which gases were present at each step. A small, but significant number of responses confused adsorption with absorption.

5(c) The majority of candidates were able to provide appropriate structures to represent a branched and cyclic alkane. Perhaps unsurprisingly, the most common responses were 2- or 3-methylheptane and cyclooctane. However, a wide range of responses was seen. In general candidates demonstrated a clear understanding of organic nomenclature and provided appropriate names for their chosen compounds. In some cases incorrect locant numbers were used. For example 2,3-dimethylcyclohexane rather than 1,2-dimethylcyclohexane.

5(d) This question was answered well and most candidates were able to recall at least one factor that affects the contribution of a gas to the greenhouse effect. Many candidates scored both marks. A few candidates incorrectly referred to the absorption of UV radiation, rather than IR.

5(e) In general candidates coped well with this unstructured calculation. The majority chose to convert the mass of CO₂ into moles and use the balanced equation to determine the mass of octane, before obtaining the reduction in petrol consumption. However, alternative approaches were also seen and awarded full credit where due. Error carried forward marks were awarded,

and most candidates scored three or four marks. Weaker candidates often divided the mass of CO_2 by 700 and failed to achieve a meaningful answer. Candidates should be encouraged to start multistep calculations by considering amounts in moles, rather than just experimenting with the data provided in the question.

Answer: 259 litres

Question 6

6(a)(i) This question required candidates to use the m/z value for the molecular ion peak and the mass of the empirical formula to confirm the molecular formula of the alkene as C_6H_{12} . The most common method employed was to divide 84 by 14 to show that the molecular formula contained 6 empirical formula units. Although many candidates scored this mark, a significant proportion neglected to use the empirical formula and simply showed that the M_r of C_6H_{12} was equal to 84. Candidates should be encouraged to take note of all the supplementary information provided with a question, as it is likely to be required in the response.

6(a)(ii) In general the attempts at this question were good, and the majority of candidates chose to show the fragments as displayed formulae. A common incorrect response for the fragment that gave rise to peak I was $\text{CH}_3\text{CH}_2\text{C}$. Some candidates failed to show the positive charge on each fragment, although this was less common than in previous sessions.

6(b)(i) It was anticipated that most candidates would be able to provide the skeletal formulae for the *E* and *Z* isomers of hex-2-ene but this proved not to be the case. A large number of responses displayed the $\text{C}=\text{C}$ group and gave structural formulae for the side chains, while others confused *E* and *Z*, placing the isomers in the incorrect columns. A number of candidates opted to use an ambiguous formula and it was not uncommon to see C_3H_7 attached to a $\text{C}=\text{C}$ group. Candidates should be made aware of the importance of showing each C atom when a question requires structural detail.

6(b)(ii) Most candidates recognised that the $\text{C}=\text{C}$ group had restricted rotation which resulted in *E/Z* isomerism. However, many struggled to explain that each C atom in the $\text{C}=\text{C}$ group was bonded to different groups with sufficient clarity.

6(c)(i) The majority of candidates were able to use brackets to show the repeat of the polymer shown. A number of candidates placed brackets inaccurately, often intersecting carbon atoms in the backbone.

6(c)(ii) Candidates found this part more difficult than part **(c)(i)**. Many candidates correctly drew the structure of pent-2-ene as hydrocarbon **B** but a wide range of other responses was seen. Two common incorrect responses were the structures of either 2-methylpent-2-ene or 2-methylpentane.

6(c)(iii) Many candidates were able to use the repeat unit identified in **(c)(i)** or the monomer in **(c)(ii)** to determine the number of monomer molecules in the polymer.

Question 7

7(a) Calculation of empirical formula has always been a strength of candidates at this level. Consequently the vast majority were able to deduce the structures of the two isomers correctly. A significant number of candidates failed to secure full marks as they did not link the M_r of the empirical formula with the information about the M_r of the isomers being less than 150. Some candidates tried to use the value of 150 to determine the formula of **C** and **D**, ultimately ending up with an incorrect answer. However, error carried forward marks were allowed through subsequent parts of question 7 where appropriate.

7(b)(i) Candidates were well prepared for a structural determination question and examiners were encouraged by the number of high quality of responses to this question. Most candidates were able to interpret the key peaks in the IR spectrum and identified the O-H bond of a carboxylic

acid and C=O bond accurately. Most candidates identified all three structures correctly. Only the strongest responses included a correct equation for the formation of **G** by oxidation of **E**. Many responses failed to include this and others often had H₂ as the inorganic product. Candidates are advised to revise oxidation reactions of alcohols thoroughly as it is often the case that incorrect equations are frequently seen in responses to exam questions.

7(b)(ii) Most candidates were able to show the structure of the ester formed from propanoic acid (**G** and propan-2-ol (**F**) correctly. Some candidates used the incorrect alcohol, propan-1-ol (**E**) and such responses received only one of the two marks available.

F323 Practical skills in Chemistry 1

General Comments:

The majority of candidates presenting coursework for an award in 2016 were retaking one or more tasks from 2015. A small number of Centres completing the course linearly were entering candidates for the first time using the 2015 tasks.

Due to the curriculum reforms introduced in 2015 the number of candidates entered for this unit decreased significantly from approximately 36,000 in June 2015 to 2800 in June 2016. The number of Centres presenting candidates was about half the number of previous years reflecting those Centres where candidates required a retake.

This year, most Centres provided work which was accurately marked against the OCR marking schemes. This work was clearly annotated so that Moderators were able in most part to agree with the marks submitted. As all of the Centres had entered candidates for the unit in previous sessions, it was clear that the teachers administering the coursework in Centres understood the requirements of the scheme of assessment and awarded marks accordingly. The best Centres had retained candidates' work from previous sessions along with Centre results and were able to provide moderators with all three assessed tasks covering the set experimental work from 2015 and 2016. These Centres are thanked for their efforts as this makes the moderation of work straightforward and efficient.

However, even after several years, the sample for moderation provided by some Centres still required remedial action in order for moderation to take place. In some cases marks awarded in Centres cannot be confirmed when the marking schemes have not been followed rigorously or when the submitted sample has been over-valued. In this case Moderators have to apply a downwards adjustment to bring marks in line with the national standard. In some cases marks have been adjusted upwards where Centres have not understood clearly the principle of error carried forward when assessing quantitative and evaluative exercises involving multi-stage calculations.

When resubmitting candidates marks for this unit as part of a retake, a requirement of the scheme is that at least one new task is submitted to make up the overall mark. Where a candidate is retaking Tasks but does not improve their overall score, no entry should be made. Where entries were made, Moderators have instructed Centres to withdraw the entry. This was one of the main issues for Moderators in June 2016 along with those Centres who had not retained the Centre results for the 2015 Tasks.

Some Centres interpreted the retake rules as if candidates had to take three new tasks in 2016 to be awarded a mark. In some cases this resulted in candidates being awarded fewer marks than last year. Centres should submit the best mark for each of the quantitative, qualitative and evaluative tasks completed over the two year period of the course, not just the marks for 2016. Finally, some Centres submitted marks which contained clerical errors whether from the addition of marks within an individual task or in the adding of the three Task marks together. This issue was dealt with using the OCR clerical error process and marks were corrected accordingly.

Although these errors are picked up by Moderators for work in the sample provided for moderation, errors in work not requested can lead to candidates being awarded a grade which does not reflect their attainment. This was less of an issue this year as in most cases all of the Centre work was requested as part of a much smaller sample. Centres are reminded however that the responsibility for checking marks rests within the Centre.

Candidates continue to perform well in all of the Task areas and in some cases display outstanding skill in observing, recording, analysing and evaluating. On the whole this year, due to the nature of the entry and the ability of candidates to select their best mark from potentially 12 tasks, the marks submitted were higher than in previous years.

Comments on Individual Tasks:

Qualitative Tasks

This year, Moderators saw equal numbers of the four Qualitative Tasks. These provided adequate discrimination with the most able candidates being able to access full marks.

Candidates should be aware of the requirement to give the colour and physical state in the recording of their observations. When writing equations, state symbols must be given if required in the stem of a question. Where a marking point requires multiple observations Centres must ensure that all observations required are recorded before a mark is awarded. In some questions, formulae or names of species are required. It is important that Centres only award marks when the question is answered in the way it has been designed.

Quantitative Tasks

The Quantitative marks were much higher on the whole than in previous years with many candidates presenting the titration as their Task with the highest mark. This is not surprising given that all candidates would have developed both the practical skills and methods of calculation required over the two years that they had been studying this subject to A2 level. The main areas of concern were the same this year as in previous years. The inability of candidates to correctly round their answers or to give answers to nearest whole number or specified number of significant figures frequently results in the loss of marks. Candidates often fail to appreciate the degree of accuracy specific apparatus can be read to and provide temperature readings as whole numbers or titration values to one decimal place. Calculations that do not fully meet the requirements of the marking scheme should not be credited by Centres as this often leads to a reduction of marks in moderation.

Evaluative Tasks

A full range of Evaluative Tasks were presented for moderation. These Tasks continue to discriminate between candidates with the best candidates being able to score marks in the range thirteen to fifteen. In marking these Tasks credit should only be given where the explanations provided satisfy the full demands of the marking scheme. Typical errors include the misuse of energy change and enthalpy change in Evaluative Task 3, from 2015 and the explanations provided for the shape of the graph in Task 3 for 2016.

F324 Rings, Polymers and Analysis

General Comments

This was a high scoring paper and the majority of candidates had been well prepared for the examination. There were few blank spaces and no evidence that candidates had insufficient time to complete the paper. The questions on reaction mechanisms, Q2(b)(iii) and Q3(a), were particularly well answered and many candidates were able to construct an accurate response to the final analysis question, Q6. Questions that required candidates to apply their knowledge to unfamiliar situations, e.g. Q3(c)(iii) and Q4(c), enabled the most able candidates to earn the highest marks.

Questions that required the drawing of the structures of organic molecules, e.g. Q1(c) and Q1(d), were often well answered. Many used skeletal structures, drawing them with assurance. Those who drew fully displayed formulae were occasionally penalised for omitting part of the structure. Other common errors included adding too many carbon atoms or putting the double bond in the wrong position.

Structures and formulae were usually clear but scanned images of diagrams first drawn in pencil and overwritten in ink again caused problems for examiners. Also, it was occasionally difficult to distinguish between answers that were intended to be marked and the rough work alongside the answer. Candidates should avoid drawing several different structures when just one is required for the answer and they should cross out all work other than the answer which they wish to have marked.

There seemed to be quite a number of candidates who used additional sheets in spite of the availability of two pages of additional answer space at the end of the paper. When used, the two pages provided ample space for any additional responses.

Comments on individual questions

Question 1

1(a) Poorly answered. Incorrect answers often tried to link the naturally occurring fatty acids listed in the table to trans unsaturated fats thought to be responsible for increases in 'bad' cholesterol and LDL.

1(b) Very well answered. Most candidates could write the correct equation.

1(c) A variety of well-drawn triglyceride structures gained both marks. Some candidates opted to draw out the alkyl chains as a skeletal or even as a displayed formula and this could easily result in a minor error in the structure.

1(d)(i) Well answered by the majority of candidates. Incorrect chain length and putting the double bond in the wrong position were the most common errors.

1(d)(ii) Many candidates failed to score the mark for this simple definition with reference to the carbon atoms in the double bond a common omission.

Question 2

2(a)(i) Very well answered. The vast majority of candidates scored full marks on this question.

2(a)(ii) Generally well answered but many incorrect answers referred to Kevlar or the uses of Kevlar.

2(b)(i) The structure of ethanoic anhydride was well known and most candidates gave the correct structure for the other organic product of the reaction.

2(b)(ii) Once again it was clear that candidates had been well prepared for this type of percentage yield question. It was well answered with almost all candidates scoring some marks here and a high proportion gaining all three marks for the calculation.

2(b)(iii) Although some lost marks through minor errors on the details, most candidates scored well on this question.

2(c) A range of marks was seen but a good knowledge of the reagents and conditions for diazotisation and coupling was shown by the majority of candidates.

Question 3

3(a) Some candidates lost a mark for the incorrect positioning of the curly arrow from the hydroxide ion. The mark scheme specifies that it should start at either the lone pair on the oxygen atom or the negative charge on the oxygen atom.

3(b) This question discriminated well with relatively few candidates able to score all three marks. Some candidates attempted to explain how the technique separates components between a mobile phase and a stationary phase which was not required by the question. There was some confusion with gas chromatography and retention times. Vague answers about all amino acids having similar structures did not score the final marking point to explain why only two spots appeared on the chromatogram.

3(c)(i) This definition had been learned by the majority of candidates.

3(c)(ii) Generally well answered but structures with only one carboxylate group were quite common and some candidates showed aspartic acid being protonated at high pH.

3(c)(iii) A more challenging question with relatively few candidates able to show the position of all three chiral centres on a correct tripeptide structure. Most candidates identified the chiral centres in the amino acid backbone of aspartic acid and isoleucine and realised that glycine was not chiral, but many missed the second chiral centre in isoleucine.

Question 4

4(a) Although named correctly by the majority, errors such as 2-hydroxyl were not uncommon.

4(b) No mention of optical isomers or enantiomers and statements regarding atom economy or the use of anaerobic conditions were common features of the answers that did not score a mark on this question.

4(c) A good discriminator. Many failed to produce the correct cyclic structure.

4(d)(i) Although many incorrect structures and structures with two repeat units were seen, this question was well answered by the majority of candidates.

4(d)(ii) The question discriminated well and relatively few candidates were able to score full marks despite there being several alternative scoring points listed in the mark scheme. Many based their answer on an explanation of the polymer dissolving in water rather than the dissolving process taking place after hydrolysis of the polymer chain.

Question 5

5(a)(i) Although it could be argued that this question tested the same skill three times, the full range of marks was awarded and errors were seen in the chemical shift, relative peak area and

splitting pattern. Fully correct responses included either a chemical shift value within the range specified on the data sheet or a range that matched the one given on the data sheet.

5(a)(ii) Although peak 2 was often correct, the species responsible for the M^+ peak was often missing a positive charge. Possibly students have learned that the particles become charged as part of the fragmentation process and don't realise that only charged particles can be detected by a mass spectrometer.

5(b)(i) A well answered question. Some candidates forgot to use a solvent or suggested the use of aqueous ammonia.

5(b)(ii) This question discriminated well. Although there were very few blank pages, many incorrect structures were seen.

5(c)(i) Generally well answered but incorrect functional groups included carbonyl and amine.

5(c)(ii) Many candidates were able to score one mark for this question but the amine group was often not protonated and it was surprisingly common to see the amine group as NH_2^+ .

Question 6

6(a) Very well answered. The most common error was an incorrect formula for the aldehyde.

6(b) A high scoring question with many candidates gaining full marks. Although most realised that Compound F was a secondary alcohol, fewer candidates combined this knowledge with the information provided by carbon-13 NMR to deduce the correct structure of the secondary alcohol.

6(c) A good discriminator but many correct structures were seen.

F325 Equilibria, Energy and Elements

General Comments:

Most candidates had prepared well for the examination, but many found it quite difficult to apply what they had learnt to unfamiliar situations.

The standard of difficulty was appropriate, with most candidates achieving over 40% and the most able achieving percentages in the 80s or 90s. There were some stretch and challenge questions for the most able, but a sufficient number of straightforward questions for the weaker candidates to access.

Many candidates had revised from much practising of past exam questions. This did mean that questions presenting new and different information, or questions that presented a new slant on the assessment of learning outcomes, proved to be more difficult. Sometimes candidates answered using rehearsed answers for different questions.

General quality of communication

- Working in calculations was often very difficult to follow. In the worst cases, examiners were presented with numbers sprayed across the answer space with no indication of what they applied to. Where final answers are incorrect, it is difficult for marks to be awarded for intermediate working if the response cannot be followed. This was especially apparent in the pH calculations in Question 5.
- Diagrams were often very poor, such as in Question 6(b)(i).

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

Comments on Individual Questions:

Question 1

This question assessed complex ions of transition elements. Although a relatively gentle introduction to the paper, the question discriminated well.

1(a) This question required knowledge and understanding of complex ions formed in ligand substitution reactions of aqueous Cu^{2+} ions. Well-prepared candidates usually collected the three marks with comparative ease. For the complex ions, common errors included $[\text{Cu}(\text{NH}_3)_6]^{2+}$ instead of $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$ and incorrect charges (e.g. CuCl_4^-). The observations were well known although green, rather than yellow, was often seen for CuCl_4^{2-} .

1(b)(i) Most candidates obtained this mark in terms of donation by two electron pairs to a metal ion to form two coordinate or dative covalent bonds. Some candidates omitted donation, reference to a metal ion, or the formation of coordinate bonds.

1(b)(ii) Candidates were required to draw accurate diagrams of stereoisomers of $[\text{Cu}(\text{COO})_2(\text{H}_2\text{O})_2]^{2-}$ and to classify these. The examiners were impressed with the accuracy of the diagrams seen. The inclusion of a 3D template and structure of one of the stereoisomers gave candidates a good indication of what was required. Unfortunately, marks were lost by showing the same stereoisomer twice, omitting O atoms from the COO^{2-} ligands or poor connectivity of the H_2O ligands. Many candidates did not identify one of the stereoisomers as being both *cis* and optical.

1(c) In the formula, the majority of candidates showed the correct 2– charge but many failed to show an empirical formula. The main problem was use of a structural formula instead of the

empirical formula: $\text{CuC}_4\text{H}_4\text{O}_{10}$. Candidates showing an empirical formula often omitted one of the ligand atoms, with C the commonest omission. The number of each atom also proved problematic, especially the O atoms.

Question 2

This question assessed different aspects of reaction rates, based around the reaction of hydrogen peroxide with hydrogen and iodide ions.

2(a) This part required candidates to show that the experimental results provided evidence for a provided rate equation. Most candidates were able to link concentration changes within the experiments with rate for H_2O_2 and H^+ . For I^- , there were two concentration changes but weaker candidates often ignored the H_2O_2 change. The best answers were well-structured and succinct. Many longer, less focussed responses were seen which often omitted important detail.

The rate constant was usually calculated correctly but many candidates did not show their calculated answer in standard form or to two significant figures. Candidates are advised to look carefully at the requirements of the question.

Answer: $k = 2.9 \times 10^{-2} \text{ dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$.

2(b) This part was answered well, with most candidates recognising that H^+ was used up in the overall equation. Some candidates were distracted by the absence of H^+ in the rate equation.

2(c)(i) Almost all candidates were aware that the rate-determining step is the slowest step in a multi-step mechanism.

2(c)(ii) This part was attempted very well, the majority identifying that the reactants of the rate-determining step (Step 1) are obtained from the rate equation. Various possible equations were allowed for the remaining steps. Some otherwise correct equations could not be credited as charges had been omitted. Candidates are advised to check that charges, as well as species, balance on each side of any equation.

Question 3

This question assessed enthalpy changes in aqueous solutions.

3(a) Most candidates were awarded both marks for a clear definition stating that 1 mole of gaseous ions formed 1 mole of aqueous ions. Some candidates instead gave a definition for enthalpy change of solution.

3(b)(i) Many candidates successfully completed the energy cycle to obtain all marks. Correct species and state symbols are essential in such cycles and marks could not be awarded for species such as $\text{K}^-(\text{g})$ or $\text{SO}_4^-(\text{g})$. Poorly-prepared candidates often scored no marks at all, having shown random species on the energy levels. Candidates are advised to ensure that the state symbols (s) and (g) are clearly distinguished.

3(b)(ii) Although many candidates correctly calculated the lattice enthalpy, errors were common. A common error was use of -320 (instead of 2×-320) giving -1419 .

Answer = $-1099 \text{ kJ mol}^{-1}$

3(c)(i) In this part, candidates needed to recognise that solid particles are forming aqueous particles with an increase in disorder. Many candidates incorrectly used 'liquid' instead of aqueous and others started from gaseous particles, perhaps confusing enthalpy change of solution with hydration.

3(c)(ii) The majority of candidates recognised that the Gibbs' equation was required. Usually the correct enthalpy change of $+24 \text{ kJ mol}^{-1}$ was used to obtain a negative value for ΔG . The majority then went on to link the negative value to feasibility for the dissolving process. A

significant number of candidates used the wrong enthalpy change (or no enthalpy change at all) or mixed units of J and kJ.

Answer: $\Delta G = -43 \text{ kJ mol}^{-1}$

Question 4

This question was about equilibrium, set in the context of the solubility of iodine.

4(a) Candidates were expected to recognise that I_2 molecules are non-polar and do not form hydrogen bonds with water. Many candidates instead discussed molecular size, electronegativity or answers in terms of van der Waals' forces.

4(b) Most candidates are comfortable with calculations of equilibrium constants. The correct numerical answer of 104 and units of $\text{dm}^3 \text{ mol}^{-1}$ were seen often. The commonest calculation error was use of the equilibrium moles, rather than concentrations, giving 521.

This question asked for the final value to be expressed to the most appropriate number of significant figures. Candidates should use the least significant number of significant figures in the provided data, in this case 3. Many candidates lost a mark by using more than 3 significant figures (e.g. 104.2 and 104.21).

Answer: $K_c = 104 \text{ dm}^3 \text{ mol}^{-1}$

4(c) This part required candidates to apply their knowledge and understanding of equilibria to a novel situation. Candidates were expected to predict that $\text{Ag}^+(\text{aq})$ and $\text{I}^-(\text{aq})$ ions would react together to form $\text{AgI}(\text{s})$, a yellow precipitate, shifting equilibrium 2 to the left. Equilibrium 1 would then shift to the left forming solid iodine. Responses in terms of equilibrium 2 were seen far more often than for Equilibrium 1.

4(d) This part required candidates to interpret unfamiliar information to construct reactions for redox reactions of iodine. Candidates were far more successful with the first equation than the more demanding second equation.

For the second equation, the key difficulty was the formula of the iodate(V) ion, IO_3^- , with I^{5+} or the formula of I_2O_5 often being shown.

The most difficult skill was balancing the second redox equation, suggesting that many candidates need more practice in this area.

Question 5

5(a) Almost all candidates successfully wrote the expression for K_a . Responses using $[\text{H}^+(\text{aq})]^2$ were not credited. Rarely, the expression was shown inverted or square brackets were omitted from one or more of the terms. For most candidates, this was an easy mark.

5(b) Most candidates calculated $[\text{H}^+]$ as the square root of $K_a \times [\text{HNO}_2]$, and then the correct pH value. The commonest errors were incorrect rounding of the pH value (e.g. 2.13) and missing out the square root (giving 4.25).

Answer: pH = 2.12

5(c)(i) This buffer calculation was easier than some on recent papers as the equilibrium moles had been provided. Some candidates tried to mimic the approach for a more complex calculation, introducing errors where there were none.

The simpler problem allowed more candidates to obtain the correct value for the pH of the buffer solution than in recent examinations.

Answer: pH = 3.43

5(c)(ii) The role of buffers in controlling pH is a common question and most candidates had prepared their rehearsed answers. Consequently these candidates could obtain the four marks easily. As always, candidates who had not learnt the work produced muddled responses that made little sense and could not be credited.

5(d)(i) Candidates were expected to predict the type of energy change using the provided information. Credit was given for responses linking an endothermic change with the increase of K_w with temperature or breaking bonds during dissociation.

5(d)(ii) Most candidates calculated a value for $[H^+]$ using the K_w value at 60°C. Many recognised that $[OH^-] > [H^+]$ giving an alkaline solution. An alternative and equally valid method seen was to calculate the pH of a neutral solution at 60°C as 6.52 and then to relate water at a pH of 7 as being alkaline. Many using this approach thought that water would be acidic rather than alkaline, presumably because $6.52 < 7.00$.

5(d)(iii) Despite the novel context, almost all candidates obtained the correct pK_w value of 13.03.

5(e) The majority of candidates correctly calculated the pH via K_w but many had problems in initially deriving the concentration of the diluted solution of NaOH. Some candidates did not consider the dilution at all; others produced long calculations of this simple dilution, obtaining an array of concentrations. Provided that this concentration was then converted to a pH by a correct method, credit could still be given for the second part of the problem.

Answer: pH = 10.76

Question 6

6(a) This definition was well known with most candidates achieving both marks. An error was more likely for the units of the standard conditions, usually 1 mol and 1 mol dm³ for concentration. A less common error was comparison with a hydrogen fuel cell.

6(b)(i) Most candidates drew a full circuit with half cells containing the correct species in a suitably labelled diagram. The signs of the electrodes were usually correct but the charge carriers were omitted much more often than they were included. The overall quality of the diagrams was poor, usually resembling drawings or even rough sketches.

6(b)(ii) This part was answered correctly by almost all candidates.

Answer: standard cell potential = 0.60 V

6(c) Although most candidates produced lengthy answers to this part, there was often little that could be rewarded. The terms oxidising agent and reducing agent were usually described but the expected response needed to be in terms of electrons or oxidation number. An alarming number of candidates claimed that an oxidising agent is oxidised and a reducing agent reduced.

Many candidates went on to discuss the role of Cr^{3+} ions in oxidising aluminium, with a correct equation. The expected explanation in terms of electrode potentials was seen more rarely.

The role of Cr^{3+} in reducing FeO_4^{2-} was seen much more rarely. The commonest responses showed a list of equations, all showing reactions of Cr^{2+} rather than Cr^{3+} .

The best candidates produced superb answers demonstrating excellent understanding of electrode potentials.

When comparing electrode potentials, candidates are advised to use terms such 'more negative' or 'more positive, rather than 'greater' or 'higher', which are ambiguous when comparing negative numbers. An alternative approach in terms of positive cell potentials were seen and credited, although the positive sign was required.

Question 7

7(a)(i) The majority of candidates obtained all three marks. Where marks were lost, it was often for missing or incorrect charges (e.g. $[\text{Ni}(\text{CN})_4]^{2+}$), and poor use of brackets (e.g. $\text{Ni}(\text{OH}_2)$ and $[\text{NiCN}_4]^{2+}$). $\text{Ni}(\text{OH})_2(\text{H}_2\text{O})_4$ was often seen and was credited.

7(a)(ii) Provided that correct formulae had been obtained in (a)(i), correct equations often followed, although marks were again lost by careless uses of charge and brackets, and unbalanced equations. The types of reaction were usually correct.

7(b)(i) Most candidates identified the shape as linear.

7(b)(ii) Although most identified correct oxidation numbers, a significant number thought that the CN^- ion was reduced. Overall though, candidates demonstrated a good understanding of basic redox.

7(b)(iii) Almost all candidates wrote the correct species but balancing the equation was much more demanding. It was often balanced by species but not by charge and oxidation number. This weakness was also seen in **4(d)** and **8(c)**.

7(b)(iv) Compared with the equation in **(b)(iv)**, candidates found it much easier to derive the correct half equation.

Question 8

8(a) The responses seen were very mixed. Able candidates scored the two marks easily but many errors were seen, particularly by removal of 3d electrons rather than 4s electrons from copper atoms to give the electron configurations of the ions (especially for Cu^+ in CuI).

8(b) Most candidates attempted an equation using CuO , $\text{Cu}(\text{OH})_2$ or CuCO_3 . Marks were then sometimes lost by not balancing the equation. It was not uncommon to see equations using CuSO_4 or CuCl_2 as reactant and consequently this mark was often not awarded.

8(c) This equation proved to be much more difficult than in **8(b)**, with only the best candidates producing a correctly balanced equation. As with **4(c)** and **7(b)(iii)**, equations were often unbalanced in terms of charge and oxidation number.

8(d) Most candidates seemed unaware that starch is used to identify the end point in iodine–thiosulfate titrations. Even when starch was given, the colour change was often incorrect. Random responses were seen to this part, e.g. methyl orange, phenolphthalein, potassium manganate and sodium thiosulfate.

8(e) Many candidates were on firm territory with a redox titration problem. The majority went through a well-rehearsed sequence of steps to obtain all five marks for showing that x was 4.

Where '4' had not been obtained, marks could still be awarded for intermediate working if correct.

Answer: $x = 4$

F326 Practical Skills in Chemistry 2

General Comments:

This scheme of assessment continues to be popular with Centres mainly due to its ease of operation and the in-built flexibility which allows centres to choose appropriate Practical Tasks to fit in with their teaching schemes. Once more, Centres have prepared candidates well for the demands of the Tasks with many Centres submitting marks covering the full range of advanced level grades.

Most Centres provide accurately marked work with suitable annotation making it clear to the Moderator why a particular mark has been given. The best Centres arrange their work by candidate, attach a coursework cover sheet (not a requirement) detailing the marks awarded for each skill, ensure that Centre results are provided and complete the required CCS160. These Centres are thanked for the time and effort that goes in to ensuring that the sample submitted to their Moderator can be dealt with quickly and effectively.

It was very unusual for centres to forget to include the Centre Authentication Form (CCS160) with their candidates' work but is an essential form to include with the package sent to the Moderator.

Moderation can be delayed for centres where clerical or transcription errors are found in the submitted marks. Clerical errors are often found within individual Tasks where marks have not been added up correctly often as a result of marking not being clear. It is suggested that Centres should give a tick for each marking point awarded and then the number of ticks on the Task should be equal to the number of marks awarded.

Clerical errors also are found in the adding up of marks for the three Tasks. OCR provides a spread sheet on Interchange which selects the best scoring Task for each Task type and adds these up to give the total for each candidate. This can serve as a suitable checking process especially for centres with large entries.

Finally, Centres sometimes transpose marks incorrectly onto Interchange or the MS1. It must be emphasised that it is the Centre's responsibility to ensure that the marks submitted reflect accurately the work of their candidates. A number of Centres corrected the paper version of the MS1 but had not passed those corrections on to OCR.

Candidates continue to perform well in all of the Task areas and in some cases display outstanding skill in observing, recording, analysing and evaluating. Calculations are carried out competently, however some candidates fail to give their answers to the specified number of significant figures, decimal places or even to the nearest whole number when required. However, over-rounding of answers too early in multi-stage calculations appears to have improved this year.

Comments on Individual Tasks:

Qualitative Tasks

The quality of the work received was generally good with Tasks 2 and 3 being seen by the Moderators slightly more often than Task 1 and overall the marks were usually high.

When the marks awarded for some of the observations were generous it was because the marking points from the published Mark Scheme had not been matched due to incomplete or inaccurate observations. The use of 'benefit of the doubt' is not always appropriate as the Mark Scheme is usually explicit as to what is acceptable. In particular, where the Mark Scheme

requires two or more observations to be made, a mark cannot be awarded if all have not been recorded correctly.

Centres must trial all of the Tasks carefully and check that the centre results agree with the Mark Schemes before allowing candidates to attempt a Task. Tasks have been trialled extensively prior to publication and it is unlikely that the results provided cannot be obtained. However, in exceptional circumstances the advice below should be followed.

If teachers are unable to obtain all of the marking points themselves with their trial results (having checked the solutions have been made up correctly), their observations should be submitted by e-mail to OCR for advice to GCEScienceTasks@ocr.org.uk. If a Centre then changes the expected observations from the Mark Scheme and these have been approved by OCR, candidates can only gain credit if their results then match the Centre-agreed observations.

Quantitative Tasks

Marks for the Quantitative Tasks are generally much higher than for the evaluative tasks. Candidates performed these Tasks to a high standard and were able to manipulate their results with confidence.

Centres are reminded that the sample provided should include results obtained by the teacher and/or a technician. For Centres with more than one teaching group, it is essential that it is clear which Centre results have been used to assess the accuracy marks for each candidate. To aid this process, the use of the look-up tables supplied with the Quantitative Tasks is to be encouraged. There were a number of instances where centres had incorrectly awarded accuracy marks as no allowance had been made for the difference between candidate and teacher masses.

When difficulties do arise they are mainly the recording of results to the correct number of decimal places or significant figures. The guidance in both the question and Mark Scheme must be followed.

Graphs were often drawn well but occasionally points were not always plotted correctly. More frequently, points were not then taken from the line of best fit or used to calculate the gradient correctly. Some centres chose to replace the graph paper on the tasks with their own paper. The tasks should not be altered as this may change the standard required. This also applies to the Evaluative Tasks.

Evaluative Tasks

The generous use of 'benefit of the doubt' was less of an issue where alternative wording was credited for explanations. When equations are asked for, the only alternatives allowed, other than multiples, are those given in the Mark Scheme and care must be taken that the correct species are used.

Even more care must be taken at this level with correct terminology being used in explanations. For example, the use of mass in place of moles, and volume instead of concentration, are common issues but seem to have improved from last year.

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