

GCE

Chemistry A

Advanced GCE **A2 H434**

Advanced Subsidiary GCE **AS H034**

OCR Report to Centres June 2014

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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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CONTENTS

Advanced GCE Chemistry (H434)

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OCR REPORT TO CENTRES

Content	Page
F321 Atoms, Bonds and Groups	1
F322 Chains, Energy and Resources	5
F323 Practical skills in Chemistry 1	13
F324 Rings, Polymers and Analysis	18
F325 Equilibria, Energy and Elements	21
F326 Practical Skills in Chemistry 2	29

F321 Atoms, Bonds and Groups

Over 37,000 candidates sat this year's F321 paper and the range of marks suggested the questions provided good challenges for all candidates within the cohort.

As is often the case for this particular paper, a candidate's performance can be analysed first in terms of whether they have approached each topic with an aim to have excellent recall of the material, or whether they have gone beyond this and really understood what lies behind the facts that they have committed to memory. Thus it is not unreasonable to expect a well prepared candidate to score full marks for **1(c)(i)**, while the slightly different approach of questions such as **1(c)(ii)** and **6(b)** offered an opportunity to shine for those candidates who have worked to gain a deeper level of understanding.

Q1

1(a) Although virtually every candidate got off to a steady start with this opening question, it was perhaps not quite as secure an opening question as in previous years. Of the two parts, it was the identification of the Block that caused problems with some candidates giving the Group number.

1(b)(i) This question was well answered. The one common error made was to omit any reference to 'atoms' and so answers in terms of the same element having different number of neutrons received no credit. Candidates should be advised to avoid unnecessary references to isotopes having the same number of electrons.

1(b)(ii) The key reason why isotopes show similar chemical properties (ie because they have an identical numbers of electrons in the outer shell) was not always understood. Weaker candidates struggled and gave answers referring to the number of protons remaining the same. Even slightly improved answers referring to the total number of electrons remaining the same did not deliver the required level of detail.

1(b)(iii) This straightforward question saw virtually every candidate secure this mark.

1(c)(i) This familiar recall question was well answered by all candidates. In the past there have been problems with weaker candidates omitting reference to average or mean mass, or muddling comparisons by referring to a single atom of the element and then a mole of carbon-12. On this occasion, however, such errors were rare and the answers seen were extremely strong.

1(c)(ii) This question analysed the methodology of determining relative atomic mass in a more unusual way compared to the normal calculation from data about the constituent isotopes. As a result those candidates who had simply committed a method to memory without real understanding of what they were doing found themselves somewhat exposed here and consequently this question proved to be challenging for many. Stronger candidates scored well, however.

1(d)(i) This question was well answered. Many candidates approached this question in a systematic manner and consequently gained marks for stating the number of bonding and lone pairs around the nitrogen atom and used this to determine the molecular shape. Centres are advised to demonstrate this method of addressing this type of question,

1(d)(ii) This question was relatively challenging with the need for the candidate first to refer to the polar nature of the Sb–Cl bond and then to note that the shape of the molecule prevents these individual dipoles from cancelling out. It was rare for candidates picked up both marks.

Q2

2(a) Calculating empirical formulae is a skill which most candidates are familiar with and consequently the vast majority of candidates were awarded both marks.

2(b) This question proved more difficult than intended. The specification indicates the polyatomic ions which the candidates are expected to know the formulae of and it was little surprising that many candidates could not make the leap from the empirical formula given to the possible ions present. Weak answers came from candidates who took their lead from the empirical formula $\text{H}_4\text{N}_2\text{O}_3$ to suggest that the ions were H^+ and N_2O_3^- . Among stronger candidates it was more common to identify NO_3^- than NH_4^+ , although it remained rare to see both correct ions given.

2(c)(i) This question was well answered although it was common to see incorrect formulae such as HPO_4 from weaker candidates.

2(c)(ii) Nearly all candidates knew the answer to this question, but not all gained the mark here as many gave the formula of the base rather than its name, despite the question stressing the need for the name.

Q3

3(a) This question was very well answered. Where candidates did not gain the mark it was often because they forgot to discuss the oxidation of aluminium in terms of electron loss, but instead justified it in by using oxidation numbers.

3(b) Weaker candidates forgot to consider the stoichiometric ratio between Al and H_2 but were still able to gain credit for the correct use of the molar gas volume, leading to an answer of 1.92 cm^3 , rather than the expected 2.88 cm^3 .

3(c) This was a slightly easier calculation than **3(b)** and as a result many candidates scored both marks, with only a few forgetting to give the answer to three significant figures required.

3(d) Nearly all candidates were able to convert the amount of hydrochloric acid into a volume and so the common error in this calculation, as in **3(b)**, occurred when the stoichiometric ratio between aluminium and the acid was not taken into account.

Q4

4(a)(i) Nearly all candidates answered this familiar question very well. Failure to show full dipoles on both molecules was the most common omission by some margin, whilst omitting to show a lone pair or not showing it involved in the hydrogen bond was seen comparatively more rarely.

4(a)(ii) This question proved to be one of the more challenging ones on this paper. Of the possible properties of ice, the fact that ice is less dense than water was quoted often and was then supported by the correct explanation.

It was when it came to discussing the anomalous melting point of water that candidates found it more difficult. Weaker candidates were content to give a very brief account, simply saying that ice's melting point was high (0°C is not a particularly high temperature) because hydrogen bonds are strong (a hydrogen bond is not a strong bond in comparison to a typical ionic bond). Such answers lacked the required comparison in terms of this property relative to other small molecules or of the strength of the hydrogen bonds in relation to other intermolecular forces.

4(b) The 'dot-and-cross' diagram of the bonding in CO_2 was well known.

4(c) This question allowed many candidates to achieve the mark but only the more succinct wrote the expected response of 'giant covalent'. Candidates unfamiliar with the concept of structure and bonding thought that the requirement to give the structure meant that they had to describe the geometry of the Si atom in SiO₂.

4(d) This extended writing question gave weaker candidates problems, often resulting from a weakness in the ability to arrange their answer in a cogent, non-repeating manner. The more able candidates were able to rattle off excellent answers but weaker candidates dropped marks by leaving out key points; in the worst cases failing to discuss the conductivity of sodium at all. Of the possible errors that candidates made, the most common remained the suggestion that conductivity in molten Na₂O relies on mobile electrons. Within the better answers it was common for candidates to say that the ions were unable to move in solid Na₂O, but not to give the required explanation of why they lacked mobility.

Centres are recommended to advise candidates, particularly weaker ones, that the use of bullet points often helps as a form of response that allows candidates to check that all aspects of the answer have been addressed.

Q5

5(a) Of the three marks on offer, the mark most commonly awarded was the one for the correct statement of the trend linked to an increase in each atom's nuclear charge. The next most popular mark was given for identifying that this increase in proton number would increase the attractive forces operating on the outer shell electrons, although a number of candidates did not get this as they rushed the answer and so just referred vaguely to increased attraction, without describing it in the required level of detail. The mark related to shielding, or the fact that each subsequent electron is being accommodated in the same shell was awarded the least of the three, with a significant number of candidates omitting to mention this at all. Candidates should be aware that using incorrect statements such as 'there is no shielding' could lead to correct statements being contradicted.

5(b)(i) Most candidates were awarded the mark available for the electron configuration of the bromide ion, but weaker responses included the electronic configuration of a bromine atom or of the ion, Br⁺.

5(b)(ii) Many candidates focused exclusively in their answers on the solubility of silver bromide in aqueous ammonia, writing as a result that the precipitate would remain, or that it would not dissolve and so not gaining the mark by omitting the colour of the precipitate.

5(b)(iii) The majority of candidates answered this question successfully with the only recurring error made being to omit some or all of the state symbols.

5(c)(i) This question was perhaps not as well answered as it might have been and although some candidates had memorised the equation that was needed here, many clearly had not and more alarmingly such candidates were then content to suggest equations which were chemical nonsense. It was very uncommon indeed to see candidates pick up the second mark for giving the correct conditions required to form bleach from chlorine, with few realising that as well as being cold, the NaOH(aq) needs to be dilute.

5(c)(ii) The concept of disproportionation has been tested before and candidates were able to address this part of the question successfully. Weaker candidates met problems in assigning the oxidation numbers and in particular the Cl in NaClO₃ was frequently misassigned as +1. Another frequent mistake was to identify that both oxidation and reduction had taken place, but not to say which changes in the oxidation numbers of which species corresponded to each of these processes. A large number of candidates relied for one of their marks on the examiner marking their working shown above the equation. It should be stressed that a complete answer should aim to restate these key assignments of oxidation numbers within the text.

Q6

6(a)(i) This question was well answered, with the vast majority of candidates able to recall a very familiar equation.

6(a)(ii) Most candidates realised that RaCO_3 would be the expected answer although in this instance BaCO_3 was also credited.

6(b) Many of the more able candidates were able to give the correct formula here and did so with very clear working, which revealed that they understood the path that lay behind their calculations. Less able candidates converted the mass of the hydrate and the mass of water lost into the respective mol of substance (0.02 and 0.08). This is perhaps not surprising as these steps are common to the more familiar problem of working out the number of waters of crystallisation in a hydrated salt that is then fully dehydrated by the action of heat. However the degree of difficulty caused many to become unclear as to what to do with these numbers and hence $\text{SrCl}_2 \cdot 4\text{H}_2\text{O}$ was a common incorrect answer.

6(c)(i) Both equations were relatively challenging. Reaction 1 was a direct question about reactions of Group 2 elements. Reaction 2 demanded a higher level of application based upon information given. Many identified the alkaline gas as NH_3 , but then incorrectly assumed that the alkaline solution was BaO instead of Ba(OH)_2 . Weaker candidates suggested equations with hypothetical species that could not have born any relation to formulae that they might have encountered before.

6(c)(ii) This question was relatively well answered, although some candidates did negate the mark by referring to molecules of Ba_3N_2 either directly or by indirect reference to intermolecular forces.

6(c)(iii) This question was designed to be difficult, but many candidates rose to the challenge. Weaker candidates simply drew a 'dot-and-cross' diagram for BaO_2 in which they treated each oxygen species as an oxide ion each having a single negative charge. Many stronger candidates did realise from the structure given in the question that there was only a single bond between the two oxygen atoms, as was clear from their suggested diagram. Only the stronger candidates managed to incorporate correctly the electrons from barium, to arrive at a correct version of the bonding of BaO_2 .

F322 Chains, Energy and Resources

General Comments:

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

In general candidates were able to answer questions that required recall and basic explanations well, e.g. 1(d)(ii), 3(d)(iii), 4(b)(i), 6(a)(i) and 7(c)(ii). It was clear from responses to these questions that the majority of candidates had prepared well for the examination.

The longer response questions towards the end of the paper allowed the more able candidates to apply their knowledge and problem solving skills. There were many excellent examples of clear and logically presented work and the responses provided in 7(d) and 8 suggested that most candidates had sufficient time to complete the exam.

The questions that candidates found demanding were those that assessed their ability to apply knowledge to unfamiliar contexts and analyse information provided in the question.

These parts included

- Analysis of information: 1(c), 1(e)(ii), 2(d), 5(b)(i), 7(c)(iii) and 8.
- Application of knowledge: 1(g)(i), 2(b), 3(c), and 7(a)
- Equations: 4(b)(ii) and 7(d).

Overall the standard of responses was impressive, although candidates should be advised to label diagrams clearly in black ink. Candidates should also be reminded to cross out any answers that they do not want the examiner to consider, to avoid answers having contradictions.

Comments on Individual Questions:

Question 1

1(a)(i) Many candidates were able to score both marks by specifying 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 CH_2 group.

1(a)(ii) Most candidates were able to state the general formula for the cycloalkanes.

1(a)(iii) This was a well answered question and many candidates could relate the difference in boiling point to the increase in points of contact and stronger van der Waals' forces. A significant number of candidates referred to the breaking of bonds rather than intermolecular forces.

1(b) Most candidates were able to state the shape required. Explanations for the bond angle often focused on the four bond pairs around the carbon atom, however candidates did not always refer to repulsion between these electron pairs.

1(c) Candidates generally struggled with this question which required application of knowledge. Common incorrect responses included products of a substitution reaction e.g. 1,2-dibromocyclopropane.

1(d)(i) Most candidates were able to provide the correct equation.

1(d)(ii) The importance of cyclohexane to the petroleum industry was well known.

1(e)(i) Although many candidates were able to provide the correct definition, some responses did not state that stereoisomers have the same structural formula.

1(e)(ii) This question required candidates to identify isomers of cyclobutane that would exhibit stereoisomerism and proved challenging for some. The more able candidates were able to provide two correct structures. A significant number of candidates suggested cyclic alkenes, which were not isomers of cyclobutane.

1(f)(i) This question required candidates to apply their knowledge of the radical substitution mechanism and those who had prepared well scored full marks. A common misconception was to have hydrogen radicals being formed and reacted in propagation and termination steps.

1(f)(ii) This question was better attempted than in previous sessions. Although many candidates were able to identify that radicals were formed, a significant number did not refer to the breaking of the covalent bond in Br₂.

1(g)(i) This question proved quite difficult for the vast majority of candidates who failed to apply their knowledge of radical substitution to an unfamiliar example. The most common incorrect answer was $C_6H_{12} + Br_2 \longrightarrow C_6H_{10}Br_2 + H_2$.

1(g)(ii) Candidates were required to name one of the dibromocyclohexane compounds that could be formed from cyclohexane and the more able candidates were able to apply their understanding of nomenclature successfully. Common incorrect responses included straight chain dibromo compounds e.g. 1,2-dibromohexane and incorrect use of locant numbers e.g. 2,3-dibromocyclohexane.

Question 2

2(a) Most candidates were able to state that the methoxide ion acted as an electron pair donor. In some cases imprecise responses such as 'donates electrons' were seen. Candidates should be encouraged to give specific answers when asked to explain scientific terms.

2(b) This question required candidates to apply their knowledge of the nucleophilic substitution mechanism in an unfamiliar context.

The first mark was awarded for showing the dipole on the C-Br bond and the curly arrow to demonstrate the heterolytic fission of the bond. This proved to be the most accessible mark and most candidates scored it.

The second mark was awarded for the curly arrow from the methoxide ion to the C atom of the C-Br bond. The more able candidates were able to show their understanding and provided accurately drawn arrows. A common misconception was to start the curly arrow from a lone pair on the C atom of the methoxide ion.

The third mark was awarded for the correct organic product and was often scored by the stronger candidates. As a consequence of showing nucleophilic attack from the C atom of the CH₃O⁻ ion, a significant number of responses showed the incorrect connectivity, as the nucleophile was joined via the C atom rather than the O atom.

Unfortunately a number of candidates attempted to show the mechanism using OH⁻ ions as the nucleophile rather than CH₃O⁻. Although they were able to score the first mark no other marks were awarded.

A very small proportion of candidates chose to show the S_N1 mechanism rather than the expected S_N2 and full credit was allowed if the response was correct.

2(c) Many candidates were able to predict that the rate of the reaction would increase. In addition to this the Mark Scheme required candidates to explain this by referring to the effect of the different C-halogen bond. Most candidates were able to identify that the C-I bond would be weaker. Some candidates often referred to 1-iodobutane having weaker bonds but failed to specify which bond. Other candidates referred to the reactivity of iodine and bromine.

2(d) This question required candidates to interpret the information and deduce that an ester would be produced. Many candidates found this challenging but the strongest candidates were able to provide a correct skeletal formula and name for the product. Common incorrect responses showed carboxylic acid structures and names.

2(e)(i) This was a very well answered question and most candidates were able to calculate to the atom economy for the reaction.

Answer: 47%

2(e)(ii) This novel question required candidates to suggest a way of increasing the atom economy by using an alternative reactant. The most able correctly identified that either sodium or lithium bromide would be an appropriate replacement for potassium bromide. The most common response was HBr which was not credited as the question specified a chemical other than an acid should be suggested.

2(e)(iii) This was a very well answered question and the majority of responses were clearly laid out. Consequently most of the candidates scored two or three marks. Some candidates gave their final answer to more than three significant figures, despite the prompt in the question. Other candidates decided to over-round the actual yield of 1-bromobutane to one significant figure which led to a yield of 87.5%.

Answer: 88.8%

Question 3

3(a) Many candidates are well-rehearsed 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 E_a , a correct single headed arrow was required to illustrate ΔH .

3(b) Most candidates were able to correctly process the E_a and ΔH values provided to calculate the activation energy of the reverse reaction. Some candidates subtracted ΔH from the E_a value to give an answer of 164 kJ mol^{-1} . Other candidates reversed the sign of the activation energy provided to give -173 kJ mol^{-1} .

Answer: $+182 \text{ kJ mol}^{-1}$

3(c) Many candidates were able to tackle the first part of this question confidently to obtain the correct value for the moles of hydrogen iodide that decomposed. The second marking point proved more difficult, and candidates were expected to scale the enthalpy change given, in addition to providing the correct sign for this process, which is the reverse reaction of the equilibrium shown. The very best candidates were able to achieve the second mark. Common errors included incorrect scaling, to give the enthalpy change as $+126 \text{ kJ mol}^{-1}$, or showing the incorrect sign, -63 kJ mol^{-1} or not providing the sign, 63 kJ mol^{-1} .

Answer: $+63 \text{ kJ mol}^{-1}$

3(d)(i) A good proportion of candidates recognised the need to provide one of the key features of a dynamic equilibrium as outlined in the specification.

3(d)(ii) This question required candidates to apply le Chatelier's Principle to the equilibrium and in addition predict the effect it would have on the composition of the mixture. Most candidates were able to predict and explain the shift in the position of equilibrium and the most able stated the effect on the composition of the mixture. Candidates should be encouraged to read questions carefully to ensure they address all aspects in their response.

3(d)(iii) This question was answered very well and most candidates picked up this mark.

3(e) This question required candidates to process the bond enthalpy data and value for ΔH to obtain a value of the bond enthalpy of H–I. In general the responses were much better than for a similar question asked in the January 2012 session and most candidates were able to score at least one mark. The most common error was a failure to divide by two, resulting in an answer of $+596 \text{ kJ mol}^{-1}$. Another common incorrect response included the incorrect subtraction of ΔH from the bond enthalpy to give a value of $+289 \text{ kJ mol}^{-1}$. Some candidates neglected to use ΔH and arrived at a value of $+293.5 \text{ kJ mol}^{-1}$. All these responses received one mark.

This question discriminated well and the most able candidates scored both marks.

Answer: $+298 \text{ kJ mol}^{-1}$.

Question 4

4(a) Candidates coped well with this unstructured calculation. Almost all candidates recognised the first step was to use the $mc\Delta T$ expression to determine the energy change and subsequently divided this by the moles of Na_2CO_3 to obtain a value for ΔH_r .

A significant proportion of responses across the whole ability range did not include a sign for the enthalpy change. Candidates should be encouraged to quote all enthalpy changes with the appropriate sign, so that they receive the credit they deserve.

Common incorrect responses included using the mass of the carbonate rather than the volume of acid as m in the $mc\Delta T$ expression. Some candidates used the moles of HCl rather than Na_2CO_3 when calculating ΔH_r . Error carried forward marks were awarded, where appropriate, in each of these cases. Consequently the majority of candidates scored in this part. The most common marks were 3 and 4, which were awarded in roughly equal proportions.

Answer: $-38.3 \text{ kJ mol}^{-1}$

4(b)(i) Candidates were well prepared to quote this definition and many candidates scored full marks. Some candidates neglected to give the standard conditions or quoted incorrect values.

4(b)(ii) This question required candidates to apply the knowledge of the definition given in the previous part and provide an equation for the formation of ammonium chlorate(VII). Stronger candidates were able to do this, but some balanced the equation incorrectly and formed two moles of the compound. It was common to see incorrect formulae and weaker candidates were unable to state the formula of chlorine, which was given as Cl . Nitrogen was also shown as N . Candidates should be aware that being able to state formulae of elements is required at this level.

4(b)(iii) The majority of candidates made a good attempt at this question and provided structured responses. The most common approach adopted by candidates was to use the ΔH_f data given in the table and the stoichiometry ratios from the equation to calculate the difference between the reactants and products, $-2497 \text{ kJ mol}^{-1}$. This value was then subtracted from the enthalpy

change of the reaction to give $+270 \text{ kJ mol}^{-1}$. The strongest candidates recognised the need to divide this by three to obtain the enthalpy change of formation of NO.

Some candidates carried out their subtractions in the intermediate stages incorrectly and consequently arrived at a value of -90 kJ mol^{-1} . This response received two marks.

Error carried forward credit was awarded to candidates who incorrectly processed ΔH_f data, stoichiometric ratios and the enthalpy change of the reaction provided their final answer was divided by three. Consequently the majority of candidates scored at least one mark in this question.

Answer: $+90 \text{ kJ mol}^{-1}$

Question 5

5(a) The majority of candidates were able to show the displayed formula for the correct polymer. Surprisingly, many candidates failed to score the second mark because they did not consider balancing the equation on the left-hand side by inserting an n before the chloroethene monomer.

5(b)(i) The stronger candidates were able identify that the other non-toxic product was water and therefore could provide a suitable equation for this unfamiliar question. A significant number of candidates found this question difficult and it was common to see equations where hydrogen had been stated as the other product. A smaller proportion of candidates attempted to balance the equation using only the three products stated in the question.

5(b)(ii) The examiners expected candidates to recognise that sodium hydrogencarbonate would neutralise the acidic gas and most candidates communicated this well. Responses such as 'sodium hydrogencarbonate is a base' and 'NaHCO₃ forms a salt' were accepted. Weaker candidates often used less precise language and responses such as 'NaHCO₃ reacts with the HCl' did not receive credit.

5(c) This question was answered well and most candidates were able to recall at least one factor that affects the contribution of CO₂ to the greenhouse effect. Many candidates scored both marks. Some candidates gave imprecise responses referring to radiation rather than specifying the ability of CO₂ to absorb IR.

5(d)(i) The majority of candidates scored a mark in this question and most used a Group II oxide to show an appropriate equation. Some candidates adopted a more general approach and used MO which was also credited. Candidates should be advised to check formulae when giving equations. A small but significant number of responses contained incorrect formulae such as NaO and NaCO₃. If such formulae had been correct, candidates would have achieved a mark for their equations.

5(d)(ii) The majority of candidates were able to given a suitable example of Carbon Capture and Storage in this question.

Question 6

6(a)(i) Candidates are very familiar with the Boltzmann distribution curve and there were many examples of excellent diagrams to illustrate the effect of increasing the temperature on the rate of reaction. Occasionally curves that did not start at the origin and/or ended up touching the x-axis were seen, but these were less common than in previous sessions. Candidates should be aware that, when two curves are required, each curve should be clearly labelled. Unlabelled curves was a common reason why candidates only scored three marks and not four.

6(a)(ii) Most candidates recognised that a decrease in pressure would lower the concentration of the particles resulting in a decreased rate of reaction. The examiners were encouraged that a significant proportion of the cohort scored the second mark by relating the decreased rate with the frequency of collisions, rather than vaguer responses just in terms of collisions.

6(b)(i) Many candidates were able to provide the equation for the fermentation of glucose. The conditions proved a little trickier and although many candidates were able to suggest an appropriate temperature not all referred to anaerobic. It was common to see yeast mentioned but since this was provided in the question it did not score. A small number of candidates gave the equation and/or conditions for the hydration of ethene. These responses received no credit.

6(b)(ii) The equation for the reaction within a catalytic converter was well known. Although some candidates failed to balance the equation correctly.

Question 7

7(a) and (b) Part (a) of this question required candidates to interpret the reaction scheme and suggest an intermediate compound that could be formed from 2-methylbut-2-ene that could be also hydrolysed to give the diol shown. The most able candidates demonstrated their understanding of this scheme and often suggested the correct dihalo compound. Most candidate favoured the dibromo compound however some chose to show the dichloro or diiodo compound. All of these responses received credit.

A large proportion of structures suggested were obtainable from 2-methylbut-2-ene but could not be hydrolysed. These included the products of hydrogenation e.g. 2-methylbutane, or hydration e.g. 2-methylbutan-2-ol.

Consequently only the most able candidates achieved a mark in part (b), as this was essentially dependant on part (a).

7(c)(i) One would expect the majority of candidates to do well in a question which required them to state the reagents and conditions required for the hydration of alkenes; however this was not the case. The most able candidates provided accurate responses which referred to both steam and the acid catalyst, which was often shown to be H_3PO_4 .

Other candidates stated only one of the two required responses and it was common to see the acid catalyst stated alongside a temperature and pressure but with no reference to steam. Some candidates stated the reagent as H_2O instead of steam and this was allowed if accompanied by a temperature of over $100\text{ }^\circ\text{C}$.

Candidates should be encouraged to learn reagents and conditions required for organic reactions.

7(c)(ii) The majority of candidates were able to explain the term structural isomers.

7(c)(iii) Many candidates found this question difficult and a large number of candidates showed structures of alcohols with the molecular formula $\text{C}_5\text{H}_{12}\text{O}$, but that could not be formed from 2-methylbut-2-ene. Examples of these incorrect responses included 2-methylbutan-1-ol, pentan-1-ol, pentan-2-ol and pentan-3-ol. Only the most able could show the structures of both alcohols produced by the hydration of 2-methylbut-2-ene.

Candidates should be reminded to check that any structures they suggest are consistent with the context of the question.

7(c)(iv) The majority of candidates were able to recognise that the key to the solubility of the isomers in water is that they contain the OH group whereas 2-methylbut-2-ene does not. Most candidates scored the second mark by accurately explaining that the OH group could form hydrogen bonds with water.

7(d) This question differentiated well with some very good answers but also some weak responses. The most able candidates provided succinct and well-structured responses which demonstrated a good understanding of the oxidation of primary alcohols. Frequently, good candidates picked up five or six marks.

The most common approach was to state the oxidising agent first and whilst most candidates were able recall that potassium dichromate was required, a significant proportion failed to state that an acid was also needed. Many candidates were able to give the colour change but a large number did not mention this.

Candidates often referred to the production of the aldehyde and then the carboxylic acid and the majority of candidates were able to provide the correct conditions for these processes. Providing balanced equations for each reaction proved to be the most challenging aspect of this question. A large proportion of candidates included hydrogen as the by-product rather than water, or specified no by-product at all. Another common error was the incorrect balancing of the complete oxidation equation. A significant proportion of responses did not use the correct amount of the oxidising agent when converting propan-1-ol to propanoic acid.

The examiners were encouraged by the candidates' ability to provide correct structural formulae, however some candidates showed the aldehyde group as -COH . Candidates should be reminded that an aldehyde group is expected to be represented as -CHO in this type of formula.

Question 8

8(a) Candidates were required to apply their knowledge of the reactions of alcohols to suggest the structures of the five compounds **B–F**. Generally this question was answered well and most candidates scored three or more marks. The majority of candidates chose to use displayed formula. Other candidates opted to use skeletal formula and only a small proportion showed structural formulae.

Almost all of the candidates were able to correctly calculate the molar mass of **B** as 74 g mol^{-1} which allowed most to suggest a structure for the compound. Many candidates used the information that **B** forms a ketone and provided the correct structure of butan-2-ol, although a significant proportion of candidates suggested **B** was butan-1-ol.

The more able candidates identified the structure of **C** as butanone, but a large proportion of the cohort did not suggest a structure. Some candidates who used displayed formula for **C** often included an extra hydrogen atom on the carbonyl group.

Most candidates were able to suggest a correct structure of carboxylic acid **D** and therefore deduced that the reaction between **B** and **D** was an esterification reaction. The most difficult part of this question was identifying **E** and **F**. The most able candidates provided a correct structure for the ester, however some candidates often missed one of the hydrogen atoms from their displayed formula. The most common incorrect response was to the structure of butyl propanoate. Some candidates identified the other compound formed in the reaction of **B** and **D** as water but a large proportion gave a second ester.

In general the structures given by candidates were accurately drawn but candidates should be reminded to check their work carefully to ensure the correct number of atoms and bonds are present if using displayed formula.

8(b) This question allowed the candidates to demonstrate their understanding of the more complex aspects of the course and use their problem-solving skills to tie together the all of the evidence.

The calculation of the empirical formula was completed well and most candidates were able to determine the molecular formula of **G**.

Many of the more able candidates were able to identify one, if not both, of the ions responsible for peaks **X** and **Y** in the mass spectrum. A number of candidates were able to show correct fragments but omitted the positive charge. Candidates should be reminded to include the correct charge when suggesting particles responsible for peaks in mass spectra.

The majority of candidates were able to recognise the characteristic absorptions in the IR spectrum. The strongest responses attributed these peaks to the appropriate bonds and deduced that **G** was a carboxylic acid.

Two marks were available for the structure of **G**. The most able candidates were able to interpret all the information and provide the correct branched carboxylic acid. Some candidates recognised that the number of hydrogen atoms present suggested the presence of a carbon-carbon double bond, but suggested a straight chain compound. Other candidates provided a cyclic carboxylic acid. These two approaches were awarded one mark. The most common incorrect structure seen for **G** was butanoic acid.

F323 Practical skills in Chemistry 1

General Comments:

This year the entry for F323 was nearly 36,000 candidates from about 1,100 centres, representing a small increase in candidature.

The scheme of assessment is relatively easy for centres to operate and administer. The range of available tasks allows centres to choose assessment material that integrates well within teaching schemes. The majority of centres prepare candidates well for the demands of the Tasks with many centres submitting marks covering the full range of grades.

Many centres displayed an excellent understanding of the assessment requirements and the vast majority of centres were able to submit marks that could be confirmed by the moderation process. 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 into ensuring that the sample submitted to their Moderator can be dealt with efficiently.

Unfortunately the work provided by some centres is not easy to deal with, often as a result of essential information being omitted from the work submitted. Centres are reminded that the sample provided should consist of the following.

- All the work requested by the Moderator. One Qualitative, one Quantitative and one Evaluative Task should be provided for each Candidate. Centres should not send more than one Task in each skill area for any one candidate. If two tasks of the type are submitted for moderation, and the tasks have the same mark, the centre will be contacted and asked which task is to form part of the sample.
- Centre 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.
- One CCS160, Centre Authentication Form, which confirms that the work has been assessed in such a way as to meet the scheme of assessment regulations.
- Any correspondence from OCR.

Moderation can be delayed where clerical or transcription errors are found in the submitted marks. Clerical errors are unfortunately only too common, often found within individual tasks where marks have not been added up correctly 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 are also found in the adding up of marks for the three tasks. OCR provides a spreadsheet on Interchange, which selects the best-scoring Task for each Task type and sums these to give the total mark for each candidate. This can serve as a suitable checking process especially for centres with large entries.

Finally centres sometimes transpose marks incorrectly during input on Interchange or when completing the MS1 form. It must be emphasised that it is the centre's responsibility to ensure that the marks submitted reflect accurately the work of their candidates.

Where clerical errors are found in the moderated sample, centres will be contacted to amend their marks. However not all work requested for moderation is sampled so centres should not rely on moderators to correct centre errors. If a clerical error is notified to a centre it is vital that this is dealt with in a timely fashion.

The most serious issue for moderators is when the marks awarded by the teachers in a centre cannot be supported.

If the marking is found to be generous then the centre marks will be adjusted downwards and if found to be harsh an upwards scaling will be applied. When this occurs all of the marks in the centre are adjusted, not just the candidates sampled by the moderator.

Moderators operate an acceptable tolerance which was reduced this year across Awarding Organisations. This will doubtless have resulted in more centres having mark adjustments than in previous years.

Applying a scaling factor however is much more difficult when the marking in the centre is deemed to be inconsistent as this may lead to an unfair outcome for some of the candidates. In order to produce a fair outcome the centre may then be required to remark the work.

Where a moderator finds that some work has been marked accurately and some has been marked harshly or leniently, the work is returned to the centre as an invalid order of merit. Specific advice is provided to the centre so that a reliable rank order can be established. This process could easily be avoided if centres carefully checked the mark schemes and additional guidance before awarding marks, and put in place a process of cross moderation to check that all teachers in the centre are applying the mark schemes in the same way.

During the year the senior moderation team review all practical Tasks in light of centre comments and feedback. As a result of this process, mark schemes are reviewed for the next academic year. Occasionally, during the year, a Task or mark scheme may be updated to reflect an identified issue or to provide clarity of marking. Although this occurs rarely, it is important that centres check Interchange prior to carrying out a Task to ensure the most up-to-date materials are being used.

Candidate Performance

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 many candidates fail to give their answers to the specified number of significant figures, decimal places or even to the nearest whole number when required. Many candidates show little appreciation of the accuracy of their quantitative results, losing marks for over-rounding their answers too early in multi-stage calculations.

It appears from the submissions moderated this year that each one of the Tasks is being used equally by centres, although the roll over Tasks from the previous two years always appear slightly more popular, possibly due to them being more familiar to teachers, or due to centres having sufficient supplies of the chemicals left over from previous sessions to operate the Task again.

2. Comments on Tasks:

Centres must carry out all Tasks **before** allowing candidates to attempt a Task. Centres should carefully check that the centre results agree with the mark scheme requirements. Tasks have been trialled extensively in centres 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 any of the marking points themselves having checked the solutions have been made up correctly, their observations should be submitted by e-mail to GCEScienceTasks@ocr.org.uk at OCR for a decision as to whether these alternative responses can be credited.

However when approval is granted by OCR these observations become the observations by which all candidates in the centre must be judged. These decisions must then be included with the work for Moderation when submitted. If a centre discovers a problem whilst carrying out or after carrying out a Task the only alternative (and the OCR advice) would be to carry out a different Task.

Each year, OCR receives queries from centres that a task had not performed as expected when being carried out by candidates. The cause is often with the provided solutions or use of old batches of chemicals. As a Task cannot be repeated, the only solution is then for candidates to carry out an alternative task.

Qualitative Tasks

This year, moderators saw approximately equal numbers of the three Qualitative Tasks. These provided adequate discrimination with the most able candidates being able to access full marks with the least able scoring typically three or four marks.

The Qualitative Task still proves to be demanding for candidates who frequently find it difficult to verbalise their observations. It is essential that candidates are aware of the difference between a precipitate and a solution and give both a colour and a physical state when recording their observations. Where a marking point requires multiple observations centres must ensure that all observations required are recorded before a mark is awarded.

Some examples of observations given by candidates in this year's sample are given below:

- “The solution went cloudy” does not communicate that a precipitate has formed and this does not gain credit.
- “The bottom layer changes colour and there is a purple ring in the test-tube” does not communicate that the upper layer turns purple or violet.
- “It turned yellow and a precipitate is formed” does not communicate a yellow precipitate as the colour yellow is not linked to precipitate and this should not gain credit.

There were a number of areas where the moderators could not support the centres' judgement and it is essential that the mark scheme is carefully followed and any observations that are not included in the mark scheme should not be credited.

- When the mark scheme requires multiple observations, no mark can be awarded if any of the required observations are missing
- Equations must be as given in the marking scheme and should be balanced with state symbols when specified to gain the marking point.
- Where a question asks for the identity of an ion, this can be identified by name or formula but, where a name is given, it must be the precise name of the species. For example chlorine cannot be credited if the required name of the ion is chloride. On occasion, the question may specifically ask for a formula or name and in such cases, only the formula or name can be credited.

Quantitative Tasks

The Quantitative tasks required a range of techniques based on rates investigation, enthalpy determination and an acid–base titration. The enthalpy task (Task 2) and the acid–base titration (Task 3) proved to be the most popular.

Qualitative Task 1 deals with two areas of the specification those of rates and enthalpy so may have appeared to be more demanding; however many candidates obtained high marks on this Task.

In Quantitative Task 2, candidates often made simple subtraction errors when calculating the masses of magnesium, magnesium oxide and solution. Unfortunately, this had not always identified during marking, sometimes contributing to a significant difference between the Centre mark and the Moderator mark. In the analysis of results, candidates often rounded values at an early stage in a staged calculation. The most accurate final result will always be obtained by rounding only at the end. It was disappointing to see candidates rounding titration results to two significant figures in their calculations, effectively reducing the accuracy of burettes and pipettes to that of measuring cylinders.

The same issues arise each year with this skill area.

- Centres should use the look-up tables provided with each quantitative task within the zip files downloaded from Interchange to assess candidate's accuracy.
- Centres should not credit answers which do not conform to the significant figures, decimal places or whole number requirement of a question. The mark scheme is very specific about these requirements which are designed to be fair and reflective of the accuracy of the experiment. Some markers assumes that rounding and significant figure errors should be penalised only once. The mark schemes make it clear that such errors should be penalised on each occasion.
- Titration, mass and temperature readings must be quoted to the degree of precision appropriate for the apparatus being used. This is typically to the nearest 0.05 cm³ for burettes and to the nearest 0.5 °C for thermometers. It was common to see a final figure of zero being omitted.
- Calculations should be checked to ensure that the candidate has completed the Task correctly.
- Centres should check and obtain centre results before allowing candidates to complete the assessment.
- In all tasks, it is essential that candidates use the Periodic Table values for relative atomic mass in the Data Sheet to avoid the possibility of being penalised in mole calculations.

Evaluative Tasks

For the Evaluative Task many centres submitted Task 2 and Task 3. Task 1 was far less popular, possible because the content is frequently taught late in the year.

It is clear that candidates and centres are confident with the treatment of error calculations and many excellent examples of error calculations with excellent explanations were seen. There were a few areas in the marking of the Evaluative Tasks which were of concern to the Moderators. These are listed below:

- Where candidates are asked to produce an equation, this should be balanced and contain the correct state symbols when required, in order to gain a mark.

- When dealing with spectra, candidates can only be credited if the ranges and absorbances are related to the correct bonds.
- Where an answer requires an effect and a reason for a mark, it is important that both are present and both are correct before a mark is awarded.
- The only answer that should be credited is that presented on the answer line. If a candidate has a correct answer in the body of the script but then decides to give a different incorrect answer on the answer line, a mark should not be awarded.

Centres should remember the importance of providing a single and reliable set of marks for the candidates in a centre which reflect the abilities of the candidates entered. Awarding marks which cannot be justified for individual candidates puts all of the candidates' results in jeopardy and inevitably will lead to an adjustment being made.

F324 Rings, Polymers and Analysis

General Comments

This paper produced a good spread of marks 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, Q1(b)(i) and Q2(b), were particularly well answered and many candidates were able to construct an accurate and detailed response to the final spectroscopy question, Q4(b). Questions that required candidates to apply their knowledge to unfamiliar situations, Q2(d) and Q3(c)(iii), enabled the most able candidates to earn the highest marks.

Questions that required the drawing of the structures of organic molecules, Q1(d)(iii) and Q3(a), were often well answered. Common errors included missing off hydrogen atoms, adding extra oxygen atoms, connecting to the wrong position of an aromatic ring or including too many repeat units of a polymer.

Structures and formulae were usually clear but scanned images of diagrams first drawn in pencil and overwritten in ink 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)(i) The question asked for the product of the reaction with excess sodium hydroxide. Many answers included the product formed by the reaction of just one of the functional groups. Most commonly the phenol group was left unreacted. The mark scheme permitted the omission of the cation from the formula of the compound but this omission was rarely seen.

1(a)(ii) The observation for the reaction of a phenol with bromine was very well known and many candidates offered two correct observations when only one was required to score the mark.

1(a)(iii) A very well answered question. Most candidates copied the structural formulae given in the question. Some made errors when they unnecessarily converted the structures into molecular formulae. HBr was occasionally missing as a product.

1(a)(iv) Many candidates correctly gave the formula for propan-2-ol and included an acid catalyst. Common non-scoring answers omitted the acid or the alcohol or gave an incorrect name for the alcohol.

1(b)(i) Many fully correct and clearly structured mechanisms were seen. A proportion of candidates did not score full marks because they ignored the information in the question and based their mechanism on the Br^+ electrophile and did not finish with HBr as a product. Relatively few candidates lost marks for incorrectly positioned curly arrows.

1(b)(ii) This question was very well answered with the majority of candidates scoring at least two marks. The most common errors were the omitting the words *delocalised* or *lone pair* or failure to use the word *delocalised* in the correct context.

1(c)(i) This question discriminated well. Most candidates knew that nitric acid was involved in the first reaction but some also included sulfuric acid and tried to construct a mechanism involving the nitronium ion, rather than write the expected equation for the reaction. The omission of water as a product was an occasional error.

Many correct equations were seen for Step 2, but tin and *concentrated* hydrochloric acid was required to score the reagent mark.

1(c)(ii) Candidates needed to mention the electron pair on the nitrogen atom to score this mark.

1(c)(iii) The vast majority of candidates gave the correct structure for compound **B**, but common errors were the omission of the chloride ion in the formulae of the diazonium salt, or placing the positive charge on the wrong nitrogen atom.

1(d)(i) Most candidates knew this definition and the majority of those who failed to score this mark omitted to the word *monomer*.

1(d)(ii) Skeletal formulae were often very well drawn with incorrect connectivity being penalised very rarely. Some candidates knew the structure of the monomers but did not present them as skeletal formulae. If a structural formula is used for working it should be crossed out and not left as an alternative answer to the skeletal formula.

1(d)(iii) Many correct repeat units were seen. Common errors included missing off hydrogen atoms, adding extra oxygen atoms and connecting to the wrong position of the aromatic ring.

Question 2

2(a) This question discriminated well. Most candidates were able to score at least one mark for the correct use of Tollens' reagent. Answers needed to refer to test tube reactions and any reference to the use of Brady's reagent was ignored since it would give a similar observation with all three compounds. Many excellent answers described a logical sequence of tests involving the use of ammoniacal silver nitrate and acidified potassium dichromate. Some neglected to acidify the dichromate and equations were quite often missing from the answer. The best candidates included full balanced equations which clearly showed the structures of the reactants and products.

2(b) Good candidates had no problem with this reaction mechanism. Some did not read the question carefully and reduced the wrong carbonyl group. Other errors included an incorrect starting position for the first curly arrow, the omission of a CH₂ unit from the carbon chain or changing the aldehyde functional group to a carboxyl group.

2(c) The interpretation of carbon-13 NMR spectra seems to be very well understood and the vast majority of candidates were able to correctly predict the number of peaks for all three compounds.

2(d)(i) Many candidates responded well when asked to apply information in a unfamiliar situation. The question discriminated well but a high proportion scored all three marks. Some candidates lost marks in the second part by providing a list of three or more different structures, some of them being incorrect.

2(d)(ii) This was a challenging question. Only more able candidates predicted the correct cyclic structure.

Question 3

3(a)(i) Many correct dipeptide structures were seen. Common errors included peptide chains and including extra oxygen atoms in the amide link.

3(a)(ii) Most candidates gave the correct structure for the alanine zwitterion. Common errors include the protonation of the amine group and the ionisation of the alcohol group in serine.

3(a)(iii) This question proved to be a difficult challenge for many. Extra oxygen atoms or two repeat units were occasionally seen.

3(b) Many candidates did not have the skills required to score marks on this question. Errors were made in all three columns and most often in assigning appropriate shift values from the data sheet.

3(c)(i) This part was answered well by many candidates. Some missed the chiral centre on the proline moiety or added an asterisk to a carbonyl carbon.

3(c)(ii) Most candidates gained this mark by stating that the use of a single stereoisomer results in fewer side effects and increased pharmacological activity. Vague answers and comments about a reduced dose did not score marks.

3(c)(iii) This question discriminated well. Most candidates were able to score one mark for the formula of ethanol. Only a small number of able candidates scored full marks for including the correct formulae for the protonated amine groups formed during acid hydrolysis.

3(c)(iv) To get the mark for this question candidates had to include points about the separation of the mixture and identification of the compounds. Answers based on identification using retention times or measurement of molar mass did not score the mark.

Question 4

4(a) This was well answered by the majority of candidates.

4(b) Good discrimination was achieved in this question. Nearly all could score at least one mark from the first two marking points by identifying the peak associated with the proton in the aldehyde group, or the peak given by benzene ring protons. Many gave a good explanation of a splitting pattern to score the fifth marking point. These marks were often achieved by the construction of a clearly labelled and well organised table.

Many were able to suggest a structure for compound **H**. The best candidates included a 1,4 substituted benzene ring after correctly interpreting the information from the carbon-13 NMR spectrum. Candidates should avoid drawing several different structures and not indicating which one they wish to have marked.

F325 Equilibria, Energy and Elements

General Comments:

It was evident that most candidates had made some attempt to prepare for the exam by revising the subject material, 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 over 80%. The paper allowed for more very high marks to be secured in the high 80s or low 90s than last year's paper. There were some stretch and challenge questions for the most able, but a sufficient number of straightforward questions for the weaker candidates to access.

Answered well

- 1(a), 2(c), 3(a), (b)(i)(ii), 4(b), 6(b)(ii), (c)(iii) and 7(a), (b)(i) were answered well. This showed that candidates were able to perform standard calculations relating to lattice enthalpy, equilibrium, straightforward pH concepts, entropy and free energy, and electrode potentials.
- Basic explanations and definitions, e.g. 1(a)(ii), 5(b)(i), (c), 6(c)(iii) and 7(a) were also answered well.

Common Errors

- Poor setting out of unstructured calculations, e.g. 3(b)(ii), 4(c)(iii), 6(d), 8(d)).
- Poor preparation. For example, in Question 5(a), it was clear that many candidates had not learnt this learning outcome.
- Imprecise language when referring to particles, e.g. 1(c), 4(a)(ii).
- Lack of precision in balancing equations, particularly charges on either side of the equation, e.g. 7(d)(ii) and Q8(a), (b) and (e).

Some candidates answered stock recall questions extremely well but then struggled badly in parts that required them to apply their knowledge and understanding, e.g. Question 8.

There was no evidence that any time constraints had led to a candidate underperforming and scripts where there was no response to the final question also had large sections of the paper which had not been tackled.

Comments on Individual Questions:

Question No. 1

1(a)(i) Many candidates successfully completed the Born-Haber cycle to obtain all three marks. The species including any ionic charges and state symbols were almost always correct but sometimes one or more state symbols had been omitted. The commonest error was in the number of electrons in the middle stage; some showed two electrons and the electron was more often omitted entirely. Candidates are advised to check carefully between stages in the cycle to ensure that all species charges and state symbols are accounted for and included.

1(a)(ii) The majority of candidates had learnt the definition for lattice enthalpy and scored two marks. When fewer marks were awarded, the more common reasons were for responses in terms of a mole of gaseous ions, or omission of the mole altogether. Occasionally some weaker candidates confused the definition with that for the enthalpy change of formation and so referred

to forming a mole of the ionic compound from its constituent elements. Such responses gained no credit.

1(a)(iii) Most candidates correctly calculated the lattice enthalpy using a correct sequence of enthalpy values. The commonest mistakes were omission of '2' for either the atomisation or ionisation of potassium or use of incorrect signs. Candidates are advised to check carefully that any balancing numbers are linked to the correct enthalpy changes in the cycle.

Answer = $-2116 \text{ kJ mol}^{-1}$

1(b) This descriptive part caused more problems. Candidates were expected to apply their knowledge and understanding of lattice enthalpies to supplied data. The predicted order of melting points based on the sum of the ionic radii gave the easiest mark, although some showed the order the opposite way round. The explanation proved to be much harder. Candidates were expected to relate ionic size with attraction and then to the energy required to overcome the attractive force. Precision in language is always essential here and many candidate spoilt their response by use of incorrect particles. It was very common to see terms such as 'atomic radius, molecules, van der Waals' forces and ionic radius of NaBr. Some candidates simply compared the radii, the skill required for the first marking point.

Question No. 2

2a This part covered several aspects of entropy, increasing in difficulty across (i), (ii) and (iii).

2ai This part was usually answered, the best responses linking the state change from liquid to solid with increased order and a decrease in entropy.

2(a)(ii) Candidates were expected to predict an increase in entropy from formation of a gas (CO_2). This was communicated either in text or as an equation with state symbols and both approaches were credited.

2(a)(iii) This part caused more problems as candidates were expected to recognise the different gaseous moles on formation of ozone. Candidates were expected to state the 3:2 ratio from $3\text{O}_2(\text{g}) \rightarrow 2\text{O}_3(\text{g})$ or 2:1 ratio from $\text{O}_2 + \text{O} \rightarrow \text{O}_3(\text{g})$; the best responses did this, either by quoting the molar ratio or from use of the equation. Vaguer responses such as 'fewer moles' were not credited. Strangely, some candidates gave a 'correct' response for the reverse reaction.

2(b) Comparison of negative numbers is a difficult skill, shown by the many contradictions seen in the candidate responses. The key to success here was to compare the two key terms, ΔH and $T\Delta S$ and to relate these to feasibility from the sign of ΔG . Problems arose in responses that ignored the negative signs leading to ambiguous statements. The required ' $T\Delta S$ becomes more negative' was often communicated as ' $T\Delta S$ increases'. The latter term is ambiguous, its meaning depending on whether the sign is included or omitted. The comparison of $T\Delta S$ with ΔH caused more problems with many responses seen of $T\Delta S > \Delta H$. Mathematically, the opposite is true as both values are negative. The better approach was to communicate this relationship in text as ' $T\Delta S$ is more negative than ΔH .' The responses from the best candidates used this precise language but many candidates did not score marks here because of the ambiguity.

2(c) In contrast with 2(b), both parts to the question were completed with ease by most candidates.

2(c)(i) Almost all candidates successfully showed that the entropy change was $131 \text{ J K}^{-1} \text{ mol}^{-1}$. The majority then went on to use the Gibbs equation to obtain the correct value of ΔG . It was only the weaker candidates who succumbed to use of 131, rather than 0.131 in the expression, resulting in a negative absolute temperature. Some candidates used $25 \text{ }^\circ\text{C}$ instead of 298 K .

Candidates are advised to check that correct provided values had been used: a common transcription error was use of -155 instead of -115 for the ΔH value.

Answer: $76.0 \text{ kJ K}^{-1} \text{ mol}^{-1}$

2(c)(ii) This part was answered correctly by almost all candidates, using the provided ΔH value and the candidate's calculated ΔS value from (c)(i). Some candidates unexpectedly converted their correct K value into $^{\circ}\text{C}$. The only significant error seen here was with incorrect rounding.

Answer: 878 K

Question No. 3

3(a) The K_c expression was shown correctly by almost all candidates, the only mistakes being the very occasional inverted expression or use of '+' within the denominator.

3(b)(i) The correct answer of 0.504 mol was seen in the majority of scripts but examiners were also presented with many other responses. The key was use of the 1:3 molar ratio of C_2H_2 and H_2 formed in the equilibrium mixture, with simple multiplication of 0.168 by 3 giving the correct answer. The commonest incorrect answer was 0.1404 from $3/2 \times 9.36 \times 10^{-2}$: from use the molar ratio of moles CH_4 formed and H_2 formed.

Answer: 0.504 mol

3(a) Many candidates are well-rehearsed for this type of question. Candidates were expected to use the equilibrium amounts, convert to concentrations by dividing by 4 and to use these values to obtain the K_c value. A common mistake was omission of the concentration stage, leading to a value of 2.45 . More calculator errors were seen than in the past, perhaps caused by the cubed power within the numerator. Candidates without a cubed function key on the calculator can simply multiply a value with itself three times. Few candidates failed to express their numerical value for K_c to three significant figures. The units caused few problems although some inverted units were seen.

Answer: $0.153 \text{ mol}^2 \text{ dm}^{-6}$

3(b)(iii) Although this part was more challenging than the initial molar ratio in (b)(i), many candidates were able to work out the amount of CH_4 that had reacted as $2 \times 9.36 \times 10^{-2}$ and to then add this to the remaining amount of CH_4 : 9.36×10^{-2} . This part did cause a lot of difficulty for weaker candidates with a range of incorrect numerical answers being seen.

Answer: 0.4296 mol

3(c) This part tested candidates understanding of how three quantities would change from changes to experimental conditions. This was marked by column. Of the three quantities, K_c and rate were correct more often than the equilibrium amount of C_2H_2 . This question discriminated extremely well. Strangely, some candidates chose to use their own words instead of those provided and examiners often saw words such as 'increases' and 'decreases'. As the meaning was clear, such responses were still credited.

3(d) The vast majority of candidates were able to provide two large-scale uses of hydrogen with the production of ammonia, manufacture of margarine and fuel cells being the most common seen. The examiners did allow 'Haber process' in isolation, including phonetic spelling. Only the weakest failed to score here, often using guesses such as Contact process, catalytic converters and even fire extinguishers.

Question No. 4

4(a)(i) This part was almost universally correct.

4(a)(ii) Able candidates were often able to suggest one of the two acceptable reasons in the mark scheme: different coefficients in the rate and overall equation or the unlikelihood of more than 2 species colliding. Although the reacting species were all ions, the examiners did allow various terms provided that they were indicative of particles. Reactants was not allowed as the reactants in the two equations were the same and collisions are specific to particles.

4(b) It was common to see correct lines for both graphs. Incorrect sketches often showed curves reminiscent of a half life relationship of an inverse 2nd order curve.

4(c)(i) Able candidate usually obtained both marks but average and weaker candidates often experienced problems, particularly with the rate for Experiment 3. The commonest mistakes stemmed from not using the squared terms in the rate equation, resulting in rates of 1.80 for Experiment 2 and 9.60 for Experiment 3. Other incorrect answers for Experiment 3, such as 21.6 were the result of multiplying the rate in Experiment 1 by various multiples of 4.

Answers: Experiment 2, $5.40 \text{ mol dm}^{-3} \text{ s}^{-1}$; Experiment 3, $614.40 \text{ mol dm}^{-3} \text{ s}^{-1}$

4(c)(ii) Almost all candidates used the information from Experiment 1 to calculate a value for the rate constant. Most were able to obtain 6.6 recurring with most middle and able candidates correctly rounding their answer to the required two significant figures. Weaker responses showed incorrect powers of 10, rounding to two decimal places (in this case three significant figures) and incorrect rounding to 6.6. Rounding and significant figures are a basic GCSE mathematical skill. Candidates are well advised to check any significant figure or decimal place requirements in calculations before moving on the next question. Candidates coped well with the unfamiliar units for the rate constant of a fifth order reaction. The examiners accepted units in any order but the more correct positive before negative order of indices was usually seen.

Answer: $6.7 \times 10^8 \text{ dm}^{12} \text{ mol}^{-4} \text{ s}^{-1}$

4(c)(iii) This question linked two areas of the specification, pH calculations of weak acids with reaction rates. Overall candidates coped admirably with the challenge and most calculated the $[\text{H}^+]$ successfully. Weaker candidates often made no further progress but many candidates then moved forwards to correctly calculate the initial rate. The examiners used the candidate answer from 4(c)(ii) for ECF purposes. Because of the range of possible intermediate roundings in this calculation, a generous range of values was allowed for the initial rate.

Answer: 5.33×10^{-3} to $5.38 \times 10^{-3} \text{ dm}^{12} \text{ mol}^{-4} \text{ s}^{-1}$

Question No. 5

5(a) The position of scandium as zinc and d-block elements that are not transition elements has been rarely assessed and some candidates had clearly not learnt this part of the specification. The examiners required a standard definition of a transition elements and an explanation of why scandium and zinc do not comply with this definition in terms of the electron configurations of the Sc^{3+} and Zn^{2+} ions and the empty and full d sub-shell of these two ions respectively. The well-prepared easily collected all 6 marks but it was sad to see marks wasted by responses that were clearly being made up during the examination (often in terms of any of the d-block elements in Period 4). Reasons for not obtaining marks included a definition in terms of elements rather than

ions, shortened electron configurations using [Ar] (despite 'full' being asked for) and explanations that simply repeated the definition.

Candidates are advised to prepare for the exam by learning all of the specification.

5(b)(i) Most candidates obtained at least one of the available two marks, usually for identifying the role of nitrogen, with its lone pair, as an electron pair donor. The commonest omission was the required coordinate bond formation to the transition metal ion.

5(b)(ii) Success depended on a systematic approach with both the number of ligands and the overall charge. The examiners did not allow formulae containing charges within the required square brackets as collectively the overall charge displayed would then be wrong. The commonest error seen was an incorrect overall charge, either as – or as 3+.

5(b)(iii) Most candidates responded correctly with a coordination number of 6 although there was the usual incorrect response seen of '4' from counting each ethanediamine ligand just once.

5(b)(iv) This type of question has been encountered on previous papers and candidates were generally comfortable with drawing stereoisomers. The examiners did require the connecting amine groups to be shown including bonding from the N atoms to the metal ion to full credit. Intermediate marks were available if H atoms or NH₂ groups had been omitted. In general, candidates displayed 3D diagrams very competently using 'in' and 'out' wedges. Some candidates did manage to repeat the *trans* isomer once or even twice. Most candidates displayed the *cis* optical isomers as clear mirror images and this strategy is recommended. A few candidates instead chose to rotate the whole structure and whether the second diagram was a different optical isomer or the same structure rotated was then largely down to luck.

5(c) This part assessed the role of ligand substitution within haemoglobin, a part of the specification that has not been assessed for many sessions.

5(c)(i) The majority of candidates secured one of the available two marks for describing ligand substitution between O₂ and either H₂O or CO₂. The second mark required a specific reference to the role of Fe²⁺; this was often omitted with responses instead predominately discussing the role of haem or iron.

5(c)(ii) As with 3(a) the K_{stab} expression was shown correctly by almost all candidates, the only mistakes being the very occasional inverted expression or use of "+" within the denominator.

5(c)(iii) The majority of candidates obtained both marks by following the cues in the question for an explanation in terms of CO having a greater bond strength and higher stability constant than O₂ with haemoglobin.

Question No. 6

6(a) Most candidates showed an acid-base equilibrium involving proton transfer and then identified the acid-base pairs. The acid-base pairs were usually correctly identified but the proton transfer was sometimes shown the wrong way round. Common errors included omission of a positive charge on H₃O⁺ and an equilibrium involving OH⁻ ions rather than water. Neither approach could be credited.

6(b)(i) The key required feature was the dissociation of water but many instead discussed dissociation of the acid.

6(b)(ii) The majority of candidates correctly calculated the hydroxide ion concentration via K_w . Another less popular but successful approach was via pOH. Either approach could result in both marks. Weaker candidates were successful in calculating the hydrogen ion concentration but this was then often shown also as the hydroxide ion concentration in the final answer.

Answer: $1.15 \times 10^{-11} \text{ mol dm}^{-3}$

6(c)(i) The equations seen were certainly better than in previous sessions, perhaps as candidates will have practised similar questions from past papers. Ionic signs within the formula of calcium ethanoate were allowed but both were then needed. Common errors included an incorrect formula of calcium ethanoate with one ethanoate group only and an unbalanced ethanoic acid on the left-hand side of the equation.

6(c)(ii) The mark scheme was specific in wanting the names or formulae of the components of the buffer solution and also the idea that some ethanoic acid remains. More general responses in terms of an acid and its conjugate base were not credited.

4(d)(i) The role of buffers in controlling pH is a common recall question and most candidates had prepared their rehearsed answers. Well-prepared candidates were thus able to collect full or nearly full marks for this part. There was a significant minority of candidates who had obviously not learnt this part of the specification and, despite their best efforts to invent answers, there was rarely anything that the examiners could credit. This was a great pity because marks were effectively being thrown away.

Candidates are recommended to construct their responses using the weak acid equilibrium equation only. Some candidates shown both the correct relevant equilibrium but also others, including for calcium ethanoate. Subsequent explanations in terms of equilibrium were then ambiguous as the examiner could not tell which equilibrium was being discussed. Some candidates thankfully did label and reference multiple equilibria so that some credit could be awarded.

6(d) Able candidates answered this question with comparative ease, collecting all five marks for a carefully constructed answer. This was in contrast to weaker candidate who struggled, often resorting to the 'square root' method for calculating the pH of a weak acid.

The calculation started off with an easy mark for calculating the hydrogen ion concentration from the pH. Unfortunately, this 'square root' method then resulted in another hydrogen ion concentration which contradicted the original. Other weak candidates resorted to use of K_w . The result was that weaker candidates would often score no marks at all for this part.

Many candidates were aware of the importance of the acid/base ratio in buffer calculations and were able to gain at least some marks for this part. The commonest error in partially successful responses was with the scaling factor of 400/1000, being either omitted to give an answer of 28.7 g, or used twice to give an answer of 4.952 g

Answer: 11.48 g

Question No. 7

7(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 dm^3 for concentration. A less common error was comparison with a hydrogen fuel cell.

7(b)(i) This proved to be a relatively easy mark although some showed the equation the wrong way round or did not balance the silver species on one side of the equation.

7(b)(ii) This part was designed to be very demanding and this proved to be the case with weaker candidates made little if any headway. The key requirements were a decreased concentration of copper ions resulting in an equilibrium shift to the left, increasing the electron flow from the copper electrode and decreasing the electrode potential of the copper half cell. This results in a larger difference in electrode potential between the two half cells and an increase in the cell potential. Even able candidates often responded in terms of the standard electrode potential changing which can never be the case. Many candidates suggested that the added water would react with copper ions forming a copper hydroxide precipitate with an equilibrium shift to the right. To score well required a very good understanding of equilibrium in the context of electrode potentials.

7(c)(i) This part was answered well by most, the commonest acceptable responses being in terms of no CO_2 , only H_2 produced or greater efficiency. Vague response in terms of less pollution or fewer greenhouse gasses gained no credit.

7(c)(ii) Most candidates were aware that hydrogen can be stored as a liquid under pressure. Some candidates responded with adsorption or absorption, perhaps not realising the significance of 'storage on the surface of within a solid' provided in the question.

7(d)(i) In past exams, candidates have found it easy to calculate a standard cell potential. This slightly different slant on the question produced far more incorrect responses with +2.31 V (wrong sign) and 3.11 V (wrong subtraction) being common.

Answer: -2.31 V

7(d) The attempts at this equation were impressive with many securing both marks for the correct balanced equation. One mark was available and awarded often for the following: a correctly balanced equation but with hydroxide ions not cancelled; the correct equation but reversed; an otherwise correct equation but with the charge missing from the $\text{Al}(\text{OH})_4^-$ ion.

Question No. 8

F325 papers have traditionally finished with an application question such as Q8 in which candidates are required to apply their knowledge and understanding in an unfamiliar context. Candidates are recommended to read each question carefully and to select the appropriate information from that provided. The information often includes important clues.

8(a) The information needed to write the equation was largely within the information provided for step 1. In step 1, candidates were provided with three reactants and two of the products. They were also told that the reaction was carried out using an excess of hydroxide ions, so any potential H^+ ions produced would be neutralised to water. Only the very best candidates were able to interpret this information to score both marks for the correct equation. Many attempts seen did not start with iron(III) oxide. When arriving at a complete equation, candidates are recommended to check the overall charge on either side. This must balance, a feature not seen in the majority of responses. One mark was available for an equation with all species correct, including water as the third product, or a 'correct' equation but with H^+ produced.

8(b) As with 8(a), the relevant information was mostly included within the referenced part: step 2. The responses were very disappointing as the required equation is very similar to a simple precipitation reaction between silver and halide ions. The requirement for state symbols was clearly stated but often omitted from otherwise correct equations.

8(c) The majority of candidates identified iodide ions or potassium iodide as the oxidising agent. Iodine was often recognised as the product but the explanation was usually in terms of oxidation number despite the question asking for electrons – very much a case of reading the question.

Precise language was also required as iodine and iodide are rather different, especially as iodine is the product. The best responses discussed the species being reduced, BaFeO_4 or Fe(VI) .

8(d) After the information-finding demands of parts (a)–(c), candidates were on much firmer territory here with a stock redox titration problem. Many candidates secured all 4 marks and most were able to obtain some marks along the way. The hardest mark was the step from the initial amount of $\text{Na}_2\text{S}_2\text{O}_3$ to the amount of BaFeO_4 .

Answer: 51.8%

8(e) This part required candidates to construct an equation for an unfamiliar reaction. Candidates were reasonably competent in identifying the gas as O_2 and precipitate as Fe(OH)_3 . Unfortunately, some responded with 'oxygen' despite the formulae being asked for in the question.

The correct equation proved to be the hardest mark on the paper, being seen extremely rarely. As with the equation in 8(a), often the overall charge didn't balance on either side of the equation, a consideration that would have led to many more correct responses.

F326 Practical Skills in Chemistry 2

General Comments:

This year over 20,000 candidates were entered for this unit from over 1,000 Centres, continuing the upward trend in Centres adopting this scheme of assessment.

This scheme of assessment is 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. This is even more evident this year as the removal of the January sitting of modules has led to more flexibility with schemes of work. It is clear that Centres prepare 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 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. Centres are also reminded that it is their responsibility to decide the best Task for each category. The main confusion seemed to be with cases where a candidate had achieved the same mark for two Tasks in the same category and the teacher did not want to make the decision as to which would be the best to include in the moderation sample. It must be emphasised that the Moderator will not look through the work and decide which to moderate. The work will be returned to the centre for the decision to be made by the teacher.

Moderation can be delayed by some weeks 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.

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. Candidates do not appear to find rounding answers easy and candidates lose marks for over-rounding their answers too early in multi-stage calculations. Encouragingly, the number of candidates affected by these issues appears to have decreased this year.

Comments on Individual Tasks:

Qualitative Tasks

The quality of the work received was generally good with Task 2 being seen by the Moderators slightly more often than the other two. However, error carried forward was frequently given for incorrect structures of the amino acid in the final question for this Task

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. This was most often seen in the marking of the tables on the last page of Task 1 and Task 3

The difference between ion charges and oxidation numbers also needs to be clear and this caused some difficulties in Task 3 when both were required and resulted in this Task scoring fewer marks.

Equations must be written as shown in the Mark Scheme and should be balanced with state symbols when specified to gain a marking point.

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 with Quantitative Tasks 1 and 2 proving more popular than Task 3. 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.

There were some rounding and sig. fig. issues apparent in Task 1 and in Task 2; 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 in

Task 2. Although less popular, Task 3 was usually marked well, but marks could be lower if the accuracy marks for the titration were not able to be awarded. The final mark was often awarded generously.

Evaluative Tasks

The generous use of 'benefit of the doubt' was not as widespread this year but Centres must be still remain cautious that, where alternative wording is credited for explanations, the response closely matches the Mark Scheme requirement.

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. When observations are linked to a process, for example, heating to constant mass, the process must be mentioned, i.e. heating.

Task 1 was the least popular and 'heating' to constant mass and Part d(i) were still very generously marked but marks were picked up more easily in the later questions indicating that Centres were preparing their candidates more thoroughly in this topic. In the final question, the mention of 'ions' was frequently omitted, thus preventing the awarding of the mark.

Tasks 2 and 3 were the most popular. Task 2 marked well but marks were sometimes given too generously in the latter half of the paper when the correct functional groups had not been identified or errors had been made in the nmr table. Care also needs to be taken in how the marks for the table are counted.

In Task 3, a number of Centres made errors in marking the titration table and average titre but instances of this were far fewer this year and missing out 'moles' and 'heating' to constant mass were also an issue in Parts (f) and (h) of this Task.

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

OCR Customer Contact Centre

Education and Learning

Telephone: 01223 553998

Facsimile: 01223 552627

Email: general.qualifications@ocr.org.uk

www.ocr.org.uk

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Facsimile: 01223 552553

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