GCE

Chemistry A

Advanced GCE **A2 H434**

Advanced Subsidiary GCE **AS H034**

OCR Report to Centres June 2015

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Advanced GCE Chemistry (H434)

Advanced Subsidiary GCE Chemistry (H034)

OCR REPORT TO CENTRES

F321 Atoms, Bonds and Groups

General Comments:

Over 39,000 candidates sat this year's F321 paper and the range of marks suggested the questions provided good challenges for all candidates within the cohort.

Centres need to be aware that the hand-writing was poor on some scripts. This meant it sometimes became impossible to award a QWC mark in **2(d)** and **6(b)**
In **6(b)**, for example, what was probably (or possibly) 'intermolecular' but reduced to little more than a squiggle could not be given credit.

Comments on Individual Questions:

Question 11(a) Virtually every candidate made a good start to the paper by securing at least one mark of the two available. Less able candidates gave the mass of the sub-atomic particles rather than their charge and a few gave 140 as the number of neutrons but such errors were a minority.

1(b)(i) This question was well answered although the erroneous appearance of water as a product of the reaction between an acid and a metal was seen relatively frequently.

1(b)(ii) This question was slightly more challenging and discriminated well. Some candidates missed the fact that the cerium was in the +3 oxidation state and, perhaps with the Ce^{2+} ion in their minds from part **(a)**, gave the formula as $CeSO_4$ along with an explanation that involved the loss of 2 electrons. However, a significant number of candidates did not focus upon the instruction in the question to explain 'in terms of the number of electrons transferred' and gave responses based solely upon changes in oxidation number.

1(b)(iii) A good number of candidates had no problem with this question but slightly weaker students talked vaguely about the reaction of metals with acids and clearly did not realise that the question was really examining how well they understood the definition of a salt.

1(c) This potentially difficult calculation was well addressed by candidates and many scored both marks available.

For future calculations such as this, centres need to be aware the common errors to be avoided in are the use of the atomic number in determining the number of moles of Eu and an incorrect application of a difficult 4:3 stoichiometric ratio.

1(d)(i) This was a definition that appears directly in the specification but has not featured recently in F321 and as such presented a significant number of candidates with a challenge. Where this mark was not secured the common errors were to either omit the 'whole number' part of the definition or to omit the idea that the empirical formula is actually a ratio of atoms.

1(d)(ii) This question perhaps demonstrated the extent to which candidates rely upon rote application of a 'mathematical' method without fully understanding what they are actually attempting to do.

Nearly all candidates were able to convert a ratio by mass to a ratio by moles of atoms, by dividing the mass ratios by the relevant relative atomic masses. These candidates were further able to obtain a unit value for one atom by the mathematical operation of dividing all values by the smallest number.

This gave a formula of $TmS_{1.5}O_6$ and many candidates were convinced that increasing the value of S atoms from 1.5 to 2 (the nearest whole number) would meet the requirements that an empirical formula has to have whole number values of atoms. Only the stronger candidates were able to realise that the initial ratio calculated needed to be doubled to obtain integer values which kept the same ratio of atoms.

1(e)(i) Although there is a clear statement in the specification that candidates should know the number of electrons in the first four shells many were uncertain about how many electrons would be found in a complete fourth shell.

1(e)(ii) This question proved to be slightly more demanding than **(i)**. There were a range of answers suggested where it was not possible to see how the student had come to that conclusion but 3 was not an uncommon response presumably arising from a confusion between the number of orbitals and the number of sub-shells or different types of orbital.

Question 2

2(a) Although the formula of AlF_3 was not given, this question was well answered. When the mark was not awarded it was rarely because of errors in the formula for AlF_3, but more in the ratio of the reactants or in fluorine not being given as diatomic. Occasionally, the symbol for fluorine was given as Fl.

2(b)(i) Most candidates were quick to describe ionic bonding by making reference to ions of opposite charge and so were awarded the first mark. Very few went on to describe the repeating or regular nature of the lattice.

2(b)(ii) This question was answered by the majority of candidates. It is noteworthy, however, that some candidates gave unacceptable versions of the diagram when attempting to show the presence of three fluoride ions e.g. $[F]_3^-$ suggests one anion. with a single negative charge, consisting of three F species.

2(c)(i) The quality of answers to this question were very high. Only the weakest of candidates failed to state that it is a pair (or two) of electrons which are shared.

2(c)(ii) As with the previous '*dot-and-cross*' diagram this was well answered. Only a very few attempted to show the molecule's bonding as ionic. Some candidates did lose the mark by adding a lone pair to the boron atom.

2(d) Of the marks available for this question, most candidates picked up the first two by correctly discussing the conductivity of aluminium and using the word delocalised spelt correctly in the correct context. When it came to aluminium fluoride most candidates knew that it conducts when molten but not when solid. Candidates were able to ascribe the conduction to the presence of mobile ions but they did not go quite far enough in explaining why it cannot conduct as a solid, as they omitted that the ions were fixed within the lattice structure or by the presence of ionic bonds. The final part of the question, describing the conductivity of BBr_3, was the most challenging part and a significant number of candidates omitted to comment on the lack of mobility of any charged particles that they had suggested.

2(e)(i) This was well answered. The most common error was to omit the state symbols. Only occasionally did candidates attempt to ionise Al directly to Al^{3+}.

2(e)(ii) Candidates made a good attempt at this question. For the first mark, successive ionisation energies had to increase. The most common error was to confuse the plot with that for the first ionisation energy against atomic number and so show step drops after the 3rd and 11th values.

For the second mark the candidates had to show major increases after the 3rd and 11th values. Here the most common error was to reverse the plot and so show these after the 2nd and 10th values as clearly the candidates were thinking about removing the electrons in the pattern of the configuration (2:8:3).

Question 3

3(a) Overall the answer to this question could be determined by most candidates. Some were confused by the fact that Cl appeared in two oxidation states in the products and suggested that this was a type of disproportionation reaction with the Cl in $MnCl_2$ having a -2 oxidation state.

3(b) Answers proved that candidates were familiar with electron configurations.

3(c) This equation was directly from the specification and candidates were familiar with it. Errors in balancing were rare.

3(d)(i) The lack of correct responses suggested that candidates may not have met this simple experiment. Centres are advised to use a practical approach in their teaching wherever possible. The most common error here was to suggest that the solution would turn purple.

3(d)(ii) The equation was correct in the majority of responses but the mark was lost by candidates due the state symbols not being included in their answer. Where state symbols were present it was very common to see I_2 given as a (g) rather than (aq). The reason for this is not clear but perhaps it stems from Cl_2 being (g) in the reactants.

3(e)(i) This definition enabled many candidates to pick up both marks. Where errors did arise they tended to be from not making clear that the attraction has to be for the electrons in the covalent bond or for there to be confusion between electronegativity and electron affinity.

3(e)(ii) It was surprising to see just how many different versions of 3-D shape were presented. The dipole mark was frequently lost usually due to omission of a partial charge on the central C atom.

3(e)(iii) Most candidates correctly focussed upon the fact that the molecule was not symmetrical.

3(f) Although some very good algebraic attempts were seen in this variant of an A_r calculation, it was clear from the working shown that even when the right answer was given, some candidates had not got to this answer in a systematic way but often in a very muddled and confused manner.

Question 4

4(a)(i) This opening part to the calculation was relatively straightforward and almost all candidates scored this mark. Even when the mark was not awarded it was often not because of a lack of knowledge of the formula but because the student used the incorrect volume of 29.50 cm^3.

4(a)(ii) Candidates who had answered correctly part **(i)** were able to give the right answer here but some muddled the stoichiometric ratio. Another source of error was to use the wrong volume of NaOH, with some opting to use 200 cm^3 as this was the total volume of solution X.

4(b)(i) This was probably the most challenging question on the paper and many candidates could not see the route to the answer. Encouragingly many did see the need to find the difference in the two titres and so their calculations did involve 11.50 cm^3. The second mark for scaling up the amount was not often awarded.

4(b)(ii) In essence this was a very easy question that simply required candidates to multiply their answer to (i) by 84.0 and give the answer to 3 significant figures.

Question 5

5(a)(i) This straightforward equation was well known.

5(a)(ii) Some candidates omitted 'thermal' and so did not secure the mark while others wrote out the equation rather than stating the type of reaction.

5(b) Of the two parts, the definition of base was more often given correctly. A few weaker candidates described a base in terms of the reaction with acids to give salts but most gave the correct answer. The description of an alkali was less well answered with some commenting on the presence of OH^- ions and others on the solubility but few doing both.

5(c) In the observation section most candidates noted effervescence but few then added the necessary observation of the calcium dissolving often despite $Ca(OH)_2(aq)$ appearing in the equation. The equation was well answered generally, although CaOH was not an uncommon species.

5(d) Most students identified the reagent as nitric acid but the equation proved more challenging. Most common errors were to give the formula as H_2NO_3 or calcium nitrate as $CaNO_3$.

Question 6

6(a) This question was well answered.

6(b) This was a challenging question. Most candidates knew that ammonia has hydrogen bonding and many also knew that the intermolecular forces in F_2 and Br_2 were van der Waals. Hereafter, the marks proved more difficult to award. The next most common mark was for linking the strength of van der Waals' forces between F_2 and Br_2 to the number of electrons. The mark for establishing that the forces acted between molecules was often missed as the candidates simply did not really address this part of the question despite being told to include the particles involved in their answers. The final mark for comparing the strength of intermolecular forces between all three molecules was very rarely awarded. Weaker candidates relied upon the false mantra of 'van der Waals' forces are weaker than hydrogen bonding' which the data clearly disproved. Other candidates attempted to explain the relative strength of the intermolecular forces solely in terms of the strength of van der Waals' forces between all three types of molecule. Only the most able students were able to secure full marks on this question.

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 very well e.g. 1(a)(i), 1(d)(i), 3(d), 5(d)(ii), 5(e)(ii) and 6(b)(ii). It was clear from responses to these questions that the majority of candidates had prepared well for the examination.

The questions that candidates found demanding were those that assessed their ability to provide accurately drawn diagrams, precisely worded explanations, and questions that required the application of knowledge and analysis of information in unfamiliar contexts.

These parts included:
- Use of diagrams: 5(a) and 6(d).
- Written explanations: 4(d)(i), 5f(iii), and 6(a)(ii).
- Application and analysis: 6(c), 7(b) and 7(c).

The examination contained all three mechanisms covered in the specification for this unit. On the whole these were attempted well, however it should be noted that some candidates appeared to be less comfortable with the nucleophilic substitution mechanism compared to the others. Many excellent examples of precisely drawn responses were seen, but the work of some candidates was untidy. Candidates should be made aware that scanned images of diagrams first drawn in pencil and overwritten in ink often caused problems for examiners.

Comments on Individual Questions:

Question 1
1(a)(i) Most candidates were able to define structural isomers. Some responses were imprecise with candidates stating that isomers had 'different arrangements of atoms' rather than referring to different structural formulae.

1(a)(ii) Many candidates found this question difficult and it was common to see incorrect names for compound **A**. These included incorrect use of locant numbers e.g. 2,3,3-trimethylbutane and inappropriate nomenclature e.g. 2,2-dimethyl-3-methylbutane. A small proportion of candidates named compound **A** as heptane.

1(b) The majority of candidates were able to provide the skeletal formula of pentane.

1(c) The majority of candidates were able to deduce the correct empirical formula of the alkane.

1(d)(i) Almost all candidates could provide a correctly balanced equation for the complete combustion of octane.

1(d)(ii) Candidates coped well with this unfamiliar question. Almost all candidates recognised the need to calculate the number of moles of octane combusted and received the first mark. The majority of candidates were able to process this to show that 2.56 moles of carbon dioxide should have been produced. It was encouraging to see a range of alternative approaches adopted by candidates. For example, some used the calculated moles of octane and the amount

of CO_2 given in the question to show that the reacting ratio was less than 8. The mark scheme allowed full marks for all valid responses.

1(e)(i) Most candidates identified the two processes required as fractional distillation and cracking. However, it was not uncommon to see responses that included reference to other processes such as reforming and isomerisation.

1(e)(ii) This question was answered very well and the majority of candidates were able to give an appropriate equation to show the formation of ethene from an alkane.

Question 2
2(a) The majority of candidates recognised that the preparation of butan-2-ol from but-2-ene was an addition reaction with an atom economy of 100%. Over half the candidates appreciated the preparation of butan-2-ol from 2-bromobutane resulted in the formation of a by-product and stated that the atom economy would be less than 100%, with the strongest candidates providing a correctly calculated value of 41.8%. Some candidates incorrectly identified the by-product as either Na or Br, so did not receive the second mark. A small proportion of candidates did not interpret the reaction scheme sufficiently and simply stated that both methods would have an atom economy of 100%.

2(b) This question was answered well and the majority of candidates identified a suitable catalyst for the hydration of an alkene. A common incorrect response was nickel.

2(c)(i) Candidates were required to recall the definition of bond enthalpy in this question and a range of responses were seen. Most candidates recognised that bond breaking was important, but weaker responses included contradictions by also referring to bond formation. The strongest candidates were able to state that bond enthalpy referred to one mole of bonds but it was not uncommon to see answers such as 'one mole of compound' and 'one mole of substance'.

2(c)(ii) Candidates approached this question well and the majority of responses were clearly and logically presented. The strongest candidates were able to identify all the bonds broken and formed and calculate the correct enthalpy change. Some candidates carried out the final step incorrectly, arriving at a value of $+42$ kJ mol^{-1}. A common mistake was to omit the bonds broken in water, giving an enthalpy change of -970 kJ mol^{-1}. Other mistakes were seen and error carried forward marks were awarded where appropriate. Candidates are advised to draw displayed formulae to help identify the number of each type of bond to be used in their calculation.

Answer: -42 kJ mol^{-1}

2(d) In general candidates coped well with this more demanding calculation based on percentage yield. Most were able to calculate the moles of butan-2-ol and the strongest scaled this correctly to give the moles of 2-bromobutane required. A common mistake was to scale by a factor of 0.8, rather than 1.25, however error carried forward marks were awarded and the majority of candidates scored two or three marks.

Answer: 8.21 g

Question 3
3(a) The effect of pressure on reaction rate is well known by candidates at this level and many candidates scored one or two marks in this part. The examiners were encouraged that a significant proportion of the cohort scored the first mark by relating the increased rate to the increased concentration of the molecules, rather than vaguer responses in terms of the relative proximity of the molecules. Weaker responses focused on the equilibrium rather than an

explanation of how the rate is affected. Candidates are advised to take note of key terms in questions, especially those in bold, as they often give guidance as to what is expected.

3(b) Most candidates were able to describe le Chatelier's principle.

3(c)(i) A good discrimination was achieved by this question. The most able candidates gave succinct responses which related the low temperature and high pressure to the change in equilibrium position. Candidates are encouraged to write as accurately as possible in this type of question. For example, the effect of pressure is best explained by reference the relative number of moles on each side of the equation. A statement about the nature of the forward reaction, in this case exothermic, is appropriate to explain the effect of temperature.

3(c)(ii) Most candidates identified high pressures as either dangerous or requiring expensive equipment. The strongest responses linked low temperature with a slow rate of reaction.

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

3(e) The strongest candidates identified that lower temperatures could be used with a catalyst and hence reduce the energy demand of a reaction.

Question 4
4(a) The majority of candidates were able to identify **B** as the monomer required to make PTFE.

4(b)(i) The monomer of polymer **H** was correctly identified by the majority of the cohort. However, a small proportion of candidates simply drew the repeat unit of **H**.

4(b)(ii) Most candidate were able to provide the formula of HC*l*. Common incorrect answers included C*l*O and C*l*$_2$.

4(c)(i) Stronger candidates were able to identify two suitable properties of **G**. Although the majority were able state a single property it was often accompanied by a repetitive or incorrect statement. Vague statements, which included 'it is a CFC' and 'it is easily compressed' were also frequently seen.

4(c)(ii) This question was answered very well. Almost all candidates were able to recall the benefit of the ozone layer. The equations showing the catalytic breakdown of ozone with C*l* radicals were reproduced accurately by the majority of the cohort. Although most candidates were able explain how the concentration of ozone was maintained in words, the statements were not always accompanied by the relevant equations. The majority of candidates did not provide an equation to show the formation of C*l* radicals from **G** and consequently only the strongest candidates received full marks.

4(c)(iii) The majority of candidates suggested a suitable compound from the selection provided.

4(d)(i) Most candidates identified that IR radiation would cause the bonds within the molecule to vibrate. However, there were many examples of vague responses such as 'they vibrate'. Candidates are advised identify the subject of their statement and avoid the use of words such as 'they' and 'it' in their responses.

4(d)(ii) The majorly of candidates identified the formulae of the two ions, although not all candidates specified the correct charge. Candidates should be aware that fragmentation in a mass spectrometer produces positive ions.

Question 5

5(a) Most candidates produced reasonable diagrams to illustrate the formation of a π-bond. A common mistake was showing a C=C group rather a C–C bond in the centre of each structure. Omission of the peripheral bonds was also frequently seen. Although over half of the cohort received some credit in this part it was clear that many candidates found this question difficult. Only the most able scored both marks.

5(b)(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 a CH_2 group.

5(b)(ii) The most able candidates were able to determine the general formula required. Many candidates came close and stated $C_nH_{2n-1}X$, but failed to specify that X was Br.

5(b)(iii) Candidates were asked to give the systematic name for ally bromide. Although a fair proportion stated 3-bromopropene, 1-bromoprop-2-ene was also a common response. Either of these was allowed by the mark scheme. A common incorrect response was 1-bromoprop-3-ene. Candidates should be aware that the lowest possible locant numbers should be used when naming compounds.

5(c)(i) Although the definition of a curly arrow was well known, many imprecise responses were seen. The most common was that a curly arrow represents the movement of electrons. Candidates should be aware that it is important to refer to an electron pair, when describing the meaning of a curly arrow.

5(c)(ii) Most candidates could state the correct definition. However, as with part (i) a significant number of candidates failed to specify 'electron pair' and stated that a nucleophile is an electron donor.

5(d)(i) This question discriminated well and most candidates were able to score at least one mark, often by showing the curly arrow and dipole on the C-Br bond. The best responses included neatly drawn structures and accurately placed curly arrows. The use of NaOH, rather than OH^-, by a lot of candidates led to difficulties for both the first and third marking points. The latter of which was missed as candidates stated the inorganic product as NaBr and neglected to show the Br^- ion formed from the heterolytic fission of the C–Br bond. Candidates are advised to only show the relevant ions when drawing mechanisms.

5(d)(ii) The majority of candidates could name this mechanism as nucleophilic substitution.

5(e)(i) There were many excellent attempts at this mechanism and it is clearly well understood by candidates at this level. Consequently the majority of candidates scored three or four marks. In some cases the placement of the curly arrow from the C=C group was the cause for a candidate to only score three marks. Curly arrows should be drawn accurately. Where an arrow is expected to come from a bond, candidates are encouraged to start the arrow touching the bond.

5(e)(i) The name of this mechanism was also well known by most candidates.

5(f)(i) To score the mark in this question candidates had to state that both hydrogen and nickel were required for step 1. It was often the case that only one of these was stated. Although hydrogen was often seen as a reagent it was common to see an incorrect catalyst, such as H_2SO_4.

5(f)(ii) This question required candidates to apply their knowledge of the radical substitution mechanism to form a bromochloroalkane. Examiners were encouraged by the number of excellent attempts and it is clear that candidates had prepared well for this type of question.

Consequently most candidates scored four or five marks. A common reason for a candidate only scoring four marks was the omission of UV radiation as an essential condition.

5(f)(iii) Candidates often found it difficult to provide clearly written explanations for this question. The majorly of responses focused on further substitution or the idea of different termination steps. Only the best candidates recognised that chlorination of 1-bromopropane would produce a mixture of structural isomers.

Question 6
6(a)(i) 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 alcohol **J** to obtain a value for ΔH_c. A significant proportion of responses across the whole ability range did not include a sign for the enthalpy change or did not round the final answer to three significant figures and so only scored three marks. Candidates should be aware that when a question includes a requirement to round the final answer to a stated number of significant figures, failure to do so will prevent full marks from being awarded.

Answer: -2260 kJ mol^{-1}

6(a)(ii) This question proved hard for candidates and although one of incomplete combustion or reference to non-standard conditions was frequently mentioned, such responses were often accompanied by vaguer statements. These statements included reference to data books containing average values, or mention of human or equipment error, e.g. the mass of alcohol was measured incorrectly. Consequently many candidates scored one, with only the best candidates securing both marks.

6(b)(i) Many candidates were able to provide a correctly balanced equation for the enthalpy of formation of alcohol **J**. However, it was often the case that no state symbol was provided for **J**. A significant proportion of candidates suggested an incorrect state symbol for **J**, *viz.* (aq). While others gave no state symbols at all. Candidates should be encouraged to check questions carefully when asked to give an equation to avoid omitting required information.

6(b)(iii) Candidates appeared well prepared for this type of calculation and the majority scored full marks. A significant proportion failed to give the correct sign, and received two marks.

Answer: -3320 kJ mol^{-1}

6(c) This question discriminated well and most candidates were able to score at least one mark, by identifying the C=O peak in the IR spectrum provided. The most able candidates gave succinct responses that included both the correct structures of **J** and **K** as well as a balanced equation. In addition, they included reference to the absence of a carboxylic acid O-H peak in the IR spectrum concluding that **K** must be a ketone. This marking point was missed by a large proportion of the cohort and often a branched primary alcohol for **J** and corresponding aldehyde for **K** were suggested. Some candidates incorrectly identified the C–H peak in the spectrum as an O–H and suggested that **K** was a carboxylic acid.

6(d) The majority of candidates were able to draw a diagram to show the hydrogen bond between an alcohol and water. However, a significant proportion lacked the accuracy required at this level and failed to show the role of the lone pair. It was also common to see responses that omitted the relevant dipoles. The question asked for the inclusion of relevant dipoles and lone pairs and candidates are advised to double check diagrams to ensure these key features are not neglected.

Question 7

7(a) Almost all candidates were able to correctly calculate the empirical formula of **L**. Although the majority also deduced the correct molecular formula, not all included their working. A small, but significant, proportion of candidates omitted this part of the question. Candidates are advised to show all working when required.

7(b) This question allowed candidates to demonstrate their knowledge and problem solving skills to tie together all the evidence provided. It was common to see candidates identify the ranges of the characteristic peaks for a carboxylic acid in the IR spectrum but a significant proportion did not identify the relevant bond that each peak referred to. Many candidates interpreted the flowchart given at the start of the question to comment on the presence of an alcohol group in **L**, and using their molecular formula from part (a), deduced structures for both **L** and **M**. The strongest candidates were also able to provide a correctly balanced equation for the formation of **M**. The most common incorrect structure for **L** was 1,3-dihydroxypropanone, however, error carried forward marks were awarded to candidates who provided the corresponding dicarboxylic acid as the oxidation product **M**.

7(c) This was a very demanding question and the strongest candidates were able to identify both **N** and **P** in addition to calculating the number of repeat units the polymer. However, not all included the polymerisation equation. Some candidates who were unable to deduce a correct structure for **L** in part (b) approached this part as a 'fresh start'. Using both the molecular formula from (a) and the information in the flowchart worked out the molecular formula of **N** and built a response from there.

F323 Practical skills in Chemistry 1

General Comments:

In September 2015, centres will embark on a new specification in chemistry which does not have a coursework option. The entry for this unit in June 2016 will be limited to candidates resubmitting their practical work with the aim of improving their mark. Centres are reminded to keep the work of any resit candidates safe as this will be required for moderation next year.

Over the last seven years the number of candidates entered for this unit has increased, reflecting not only the increased uptake of the sciences at Advanced Level but also the popularity of OCR Chemistry Specification A within centres. This year approximately 35,000 candidates were entered for this unit from about 1,100 centres.

The vast majority of centres entering candidates for this unit have a clear understanding of the requirements of the scheme, provide work that is accurately assessed against the marking schemes and use suitable annotation to justify the marks awarded. This evidence allows Moderators to complete a simple moderation exercise leading to the confirmation of marks. 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 than goes in to ensuring that the sample submitted to their Moderator can be dealt with quickly and effectively.

However, even after several years, the sample for moderation provided by some centres still requires remedial action in order for moderation to take place. Centres are reminded that the sample provided for moderation should contain:
- Work which has been assessed strictly against the mark schemes provided by OCR.
- One qualitative, one quantitative and one evaluative task for each candidate.
- Centre or teaching set results obtained by the teacher or technician which are clearly labelled so that it is easy for a Moderator to see which candidates have been assessed against which set of results provided.
- The CCS 160, Centre Authentication Form.

Centres should also check that there are no errors when:
- Adding up the marks on the Tasks and transferring this number to the front of the Task sheet.
- Combining the marks of the three Tasks to give an overall mark out of 40.
- Completing either the electronic MS1 or paper based version.

Although these errors are picked up by Moderators for work in the sample provided for moderation, errors in work not requested can lead to candidates being awarded a grade which does not reflect their attainment. The responsibility for checking marks rests within the centre.

The most serious issue for moderators is when the marks awarded by the teachers in a centre cannot be justified. If the marking is found to be generous then the centre marks will be adjusted downwards and if found to be harsh an upwards adjustment will be applied. This year there are a number of centres whose marks have been adjusted. When this occurs all of the marks in the centre are adjusted not just the candidates sampled by the Moderator. 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 the centre. In order to produce a fair outcome the centre is required to remark the work.

Authenticating work

Centres are required to authenticate the work of all candidates that are presented for assessment, even if these candidates have completed their work at a different centre. When requested, the work of all candidates in the sample must be provided for moderation. It is essential that where centres accept candidates from other centres mid-year, any completed coursework that is to form part of the assessment must be obtained from the centre from where the candidate has transferred. Alternatively, the candidate should complete a task that they have not completed before at their new centre.

Centres should also be aware that when resubmitting the work of candidates from a previous session as part of a new entry, the mark provided to OCR should be a mark out of 40. This mark should be made up from any Tasks being carried over from the previous year and at least one new mark from the current year. For June 2016, centres should not enter candidates who do not complete a new task in 2016 for this unit.

Comments on Individual Questions:

Qualitative Tasks

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

Candidates still find these tasks quite difficult with many tending to write quite long descriptions rather than limiting their answers to cover the key observations in each test. Candidates should be aware of the requirement to give the colour and physical state in the recoding of the observations with answers such as 'it turned green and a solid was formed' not being acceptable for the observation 'green precipitate' .
Where a marking point requires multiple observations centres must ensure that all observations required are recorded before a mark is awarded.

Centres are reminded to try out all of the Tasks carefully and check that the centre results agree with the marking schemes **before** allowing candidates to attempt a Task. 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.

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

- 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.

Quantitative Tasks

The Quantitative marks were slightly higher on the whole than in previous years with many candidates presenting either Quantitative Task 1 or Quantitative Task 3 for assessment. It was clear that candidates are well practiced in titration skills and the subsequent calculations, which frequently resulted in marks between ten and fifteen being gained.

Quantitative Task 1 proved very reliable with the best candidates being able to obtain consistent results for the two exercises carried out. Qualitative Task 2 proved straightforward for the most able candidates who followed the instructions carefully and were able to make good progress with their calculations, however many of the weaker candidates found the steps in this calculation quite difficult resulting in lower marks.

Some centres still prefer not to use the look-up tables provided by OCR on interchange to check candidate accuracy and in some cases this results in work having to be returned to centres for remarking or scaling being applied to the centre marks. Clearly if a candidate uses a different mass to the teacher a different temperature change should be expected.

Calculations were 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. Candidates do not appear to find rounding answers easy and many candidates lose marks for over-rounding their answers too early in multi-stage calculations.

The same issues arise each year with this skill area:
- Centres should not credit answers which do not conform to the significant figures, decimal places or whole number requirement of a question.
- Titration, mass and temperature readings must be quoted to the degree of precision given in the question and should be consistent.
- 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.

Evaluative Tasks

The full range of Evaluative Task were presented for moderation. These Tasks continue to discriminate between candidates with the best candidates being able to score marks in the range thirteen to fifteen. There were a few areas in the marking of the Evaluative Tasks which were of concern to the Moderators. These included:

- 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.
- Where a question asks for a specified formula type, marks cannot be awarded if a candidate gives a structure in a different form. For example, a displayed formula requires candidates to show every atom and every bond.
- Where an answer requires a change and a reason for a mark, it is important that both are present and both are correct before a mark is awarded.
- Where explanations are required these should only be credited if given in full. Alternative words may not be appropriate, for instance energy change and enthalpy change are not interchangeable.

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

The unfamiliar GC-MS question at the beginning of the paper, the stretch and challenge in 2(d)(i) and 3(c)(ii), and the complexity of the analysis question gives the impression that this is a very challenging paper. Although there are fewer questions that require direct recall, the level of difficulty of many questions is in line with previous papers. The paper is not exclusively for the most able and there are plenty of accessible questions in which weaker candidates scored well. The quality of responses seen by the very best candidates was impressive. The candidates who obtained close to full marks showed exceptional knowledge and understanding at this level and demonstrated a real feel for the underlying principles of organic chemistry.

It was apparent that the majority of candidates had been well prepared for the examination. There were some blank spaces associated with the stretch and challenge questions mentioned above. Other questions that required candidates to apply their knowledge to unfamiliar situations, including Q1(d), Q2(b), Q2(c) and Q3(d)(ii), were well answered and enabled the most able candidates to earn high marks. Some candidates may have felt that they did not have sufficient time to complete a full analysis of the data in Q4d, but the vast majority were able to score marks on this question.

Questions that required the drawing of the structures of organic molecules, including Q1(c)(i) and Q3(a)(i), were usually well answered. Common errors included missing off OH groups in Q1(c)(i) and Q1(c)(ii), and missing off the NH_2 group in Q3(a)(i). Structures and formulae were usually clear but scanned images of diagrams first drawn in pencil and overwritten in ink again caused problems for Examiners. Candidates should cross out rough work and begin a new diagram of the structure they would like to be marked rather than overwriting a previous attempt.

Candidates occasionally made careless errors when completing reaction mechanisms using the 'curly arrow' model. The use of curly arrows has improved but there are still candidates who start or finish the arrows in the wrong place. Detailed guidance on this is provided for Examiners in the mark scheme for Q1(c)(ii) and Q2(b).

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

Comments on Individual Questions

Question 1
1(a) The analysis of mixtures using gas chromatography was not well understood. The specification states that a liquid stationary phase separates by relative solubility and many incorrect answers focussed on the adsorption of molecules onto the solid beads rather the relative solubility of molecules in the liquid polymer that coated the beads. No credit was given to answers that stated that the separation produced different retention times.

1(b)(i) This question was well answered. The majority of candidates focussed on the different molar masses of the compounds and many referred to the M^+ peak or molecular ion peak of compound **B**.

1(b)(ii) Relatively few creditworthy responses were seen here. The specification describes chromatography as an analytical technique that separates components in a mixture between a mobile phase and a stationary phase. Many candidates referred to differences in solubility or the strength of interactions without linking this to a particular phase in the column.

1(c)(i) A well answered question. Most knew the correct reagents for the oxidation of the aldehyde and the majority were able to show the structure produced when the aldehyde is reduced using $NaBH_4$. Some chose to esterify the phenol group rather than the alcohol group in compound **C** and this was given credit.

1(c)(ii) The full range of marks was seen. Common errors included missing charges, curly arrows beginning or ending in the wrong place and –OH groups missing or placed in the wrong position on the intermediate structure. Most candidates chose to show the reaction of the intermediate with water rather than with H^+ ions.

1(d) Generally well answered. Some candidates reacted compound B with only one mole of bromine or three moles of bromine and this underlines the importance of paying careful attention to information given in the stem of the question. Hydrogen, not HBr, was occasionally formed as the other product.

Question 2
2(a)(i) Many excellent answers with clear diagrams and explanations were seen. Delocalised electrons in structure **B** and p-orbital overlap were the most accessible marking points.

2(a)(ii) Many used the data given in the question to compare the enthalpy of hydrogenation of structure **A** and structure **B** but relatively few candidates scored the other mark for stating that structure **B** is better representation of benzene because it is more stable. Some candidates confused cyclohexene with structure **A** and incorrectly concluded that the hydrogenation of benzene is more exothermic than structure **A**. Some incorrectly referred to enthalpy of hydration or stated that energy is required for the reaction. Others referred to data they had memorised rather than using the information in the question as instructed.

2(b) A good test of candidates' understanding of the use of curly arrows and this question was generally well answered.

2(c) Well answered by those candidates who could apply their knowledge and understanding to new situations. It was a step too far for some who stuck to the more familiar equation for the generation of the Br^+ electrophile instead. Others made a good attempt but made errors with the charges.

2(d)(i) This question required candidates to recognise changes in chemical structure. The first reaction (the formation of a diazonium ion) and the third reaction (the formation of an amide linkage) should be familiar to candidates. The reagents for the first reaction were very well known and although the conditions for the reaction were often quoted they were not required for the mark. The correct structure of the second reactant was rarely seen with the most common incorrect responses being based on cyclic structures. Most candidates were able to deduce the structure of the third reactant.

2(d)(ii) Candidates had been well prepared for this type of percentage yield question and it was very well answered with almost all candidates scoring marks here and a high proportion gaining all three marks for the calculation.

2(d)(iii) Two chiral centres and four optical isomers was required in the mark scheme and less specific answers did not score the first two marks. Two pairs of enantiomers was an accurate description worthy of the mark and a reference to there being four enantiomers was also given

credit. The majority of candidates scored only the third mark with their suggestion of how to improve the synthesis. Some candidates missed the point here and instead described techniques required to separate the optical isomers.

Question 3

3(a)(i) The majority scored two marks here. The question had a three mark total for drawing two structures and this may have prompted some candidates to incorrectly form a salt with the alcohol group in **reaction 1**. Many were able to draw a correct structure for the ester formed in **reaction 2**, but very few protonated the amine group in acidic conditions. The protonation of hydrolysis products has been well represented in recent papers.

3(a)(ii) Well answered with most of the correct responses referring to perfumes and flavourings which are the uses listed in the specification. Common responses marked as incorrect were suggestions that this ester could be used for making dyes, polymers or textiles.

3(a)(iii) Most candidates were able to score at least one mark here, usually for correctly identifying **reaction 4** as an oxidation reaction. Although the use of excess reagent was not required for **reaction 3**, some missed ethanol as an essential solvent and **reaction 5** was occasionally described as a reduction.

3(b) This question discriminated well and many well organised and well-presented answers were seen. Candidates were usually able to identify the aldehyde structure in compound **E** and those who failed to include a chiral centre in compound **E** had possibly missed essential information in the stem of the question. However, they could still score marks for the polymer structures by the application of error carried forward. Some candidates correctly identified the four structures but then missed the last two marks for a description of how the polymers are formed. Although labels were not required to score marks for the four structures, the description of the formation of the polymers had to be linked to the correct structure or the correctly labelled compound and some candidates lost marks here because their description was linked to the wrong polymer.

3(c)(i) The majority scored this mark for the structure of glutamic acid.

3(c)(ii) Marks were awarded for a variety of structures and although few candidates scored both marks here, examiners were impressed by the excellent attempts to produce workable cyclic structures.

3(d)(i) Identification of functional groups in polymers seemed to be an area of weakness. Many candidates correctly named one of the functional groups but both were required for the mark. Examples of incorrect responses included amine, carboxylic acid, alcohol and ketone.

3(d)(ii) The question asked for the functional groups to be displayed in the structures of the monomers. Most candidates scored well here but this was only possible because the mark scheme did not require the functional groups to be fully displayed.

3(d)(iii) A well answered question with marks equally divided between answers that either suggested that the polymer can be hydrolysed or that the polymer can form hydrogen bonds with water. A statement that the polymer is soluble in water was not sufficient to score the mark.

Question 4

4(a) The use of MRI as described in the specification was well known but answers based on the analysis of drugs or the identification of functional groups were not given credit.

4(b)(i) The interaction of materials with the low-energy radio wave region of the electromagnetic spectrum is described in the specification but this question was surprisingly poorly answered. Infrared, ultraviolet, X-rays and gamma rays were all commonly seen answers in addition to ranges of chemical shift quoted from the data sheet.

4(b)(ii) The need for deuterated solvents was well known but some candidates confused the use of this solvent with the use of TMS as the standard for chemical shift measurements or the identification of O–H and N–H protons by proton exchange using D2O.

4(c) Almost all candidates scored this mark for counting the peaks in the ^{13}C NMR spectrum.

4(d) Although the use of 2,4-dinitrophenylhydrazine to detect the presence of a carbonyl group in an organic compound and to identify a carbonyl compound from the melting point of the derivative is required in the specification, the equation for this reaction and the structure of the derivative was not required in the question. The equation for the reaction and the structure of the derivative, with R^1 and R^2 groups from the original carbonyl compound, was given in the question. The structure of carbonyl **K** was similar in complexity to structures featured in previous papers. The mark scheme was constructed so that at least two of the first five marks awarded for the analysis were easily accessible by comparing the chemical shifts in the ^{1}H NMR spectrum with those displayed in the data sheet. These marks were often achieved by the construction of a clearly labelled and well organised table or by annotating the spectrum. Splitting patterns were well understood but one problem for candidates was the difficulty in associating the peak at $\delta =$ 2.3/2.4 ppm with a benzylic hydrogen; many candidates focused more on coupling than on chemical shifts and missed a chance to solve the structure. Of the two marks available for identifying R^1 and R^2, one could be derived quickly by linking information given in the question with one of the peaks in the ^{1}H NMR spectrum. The second identification mark required careful analysis of both the ^{1}H NMR and ^{13}C NMR data. Overall, most candidates were able to score marks on this question and completely correct answers were achieved by the most able candidates.

4(e) It was not possible to score a mark for this question unless a structure had been drawn for compound **L**. However, many candidates were able to score this mark as error carried forward from structures that had failed to gain any credit in the previous question were allowable.

F325 Equilibria, Energy and Elements

General Comments:

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

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

Many candidates answered stock recall questions extremely well and it was evident that revision had included much practising of past exam questions. This did mean that questions presenting new and different information, or questions that presented a new slant on the assessment of learning outcomes, proved to be more difficult. Sometimes candidates answered using rehearsed answers for different questions.

Answered well

- Calculations: Q2(a) reaction rates, 3(a)(ii)–(iv) entropy and free energy, 3(b)(i) Equilibrium 4(b),(c),(e)(i) Straightforward pH concepts, 5(a)(iii) Lattice enthalpy
- Basic explanations and definitions: 1(c) Ligands, Q2(c) Rates and graphs, 4(a)(e)(i) Acids and the action of buffers 5(a)(i)(ii) Born–Haber cycles and lattice enthalpy.

Good discrimination
- Learning of specification content: 1(d) Transition metal reactions
- Application using unfamiliar contexts, 2(d)(ii) Mechanisms and rate-determining step, 3(b)(iv) Equilibrium shifts in terms of Kc, 4(e)(iii) Buffer calculation, 6(b)(ii) pH linked to electrode potentials and equilibrium
- Construction of equations, particularly balancing of charge and oxidation number: 1(d) ligand substitution 5(c) unfamiliar redox and ligand substitution, 6(b)(ii),(d)(iv) cell reaction, 7(a)(c) unfamiliar equations and half equations.

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

Comments on Individual Questions:

Question 1
This question assessed chemistry of transition elements. It proved to be a relatively gentle introduction to the paper, assessing a broad range of properties and reactions.

1(a) This part was a gentle opener to the paper with almost all candidates obtaining the correct oxidation number of +5.

1(b) This part allowed candidates to select any transition element to illustrate catalysis. The commonest seen were iron, in the Haber process, nickel, in the hydrogenation of alkenes, and $FeBr_3$, in the bromination of benzene. Equations were usually correct. The examiners did allow any reaction that was catalysed by a transition element. It was disappointing to see some equations that showed ammonia as NH_2 or NH_4^+.

1(c)(i) Most candidates obtained this mark in terms of donation by two electron pairs to form two coordinate or dative covalent bonds. Some candidates omitted donation or formed one coordinate bond only.

1c(ii) Most candidates were able to identify the three bidentate ligands in $C_9H_{30}N_6Ni^{3+}$ and the correct response of $C_3H_{10}N_2$ was commonly seen. The question asked for a molecular formula and structural or other formulae were not credited. Weaker candidates often responded with $C_9H_{30}N_6$.

1c(iii) Most candidates were able to produce a diamine of $C_3H_{10}N_2$. A displayed or semi-displayed formula was the commonest response seen with propane-1,3-diamine being the commonest isomer seen (any possible diamine of $C_3H_{10}N_2$ was credited).
The role of the two nitrogen atoms in providing the electron pairs was usually described, although examiners also credited this feature if seen in the structure.

1(c)(iv) Most candidates responded correctly with a coordination number of 6 although there was the usual incorrect response seen of '3' from counting each bidentate ligand instead of the number of the coordinate bonds.

1(c)(v) In past sessions, candidates have been required to draw out stereoisomers and this question proved to be much more straightforward. Only the very weakest candidates were unable to complete the diagrams to provide two mirror image forms.

1(d) This question assessed knowledge and understanding of precipitation and ligand substitution reactions of transition metal ions. The question discriminated extremely well between well-prepared and poorly-prepared candidates. The well-prepared often collected the full six marks with comparative ease. However, marks were sometimes squandered by incorrect balancing of equations (e.g. formation of $2H_2O$ rather than $4H_2O$ with NH_3), careless positioning of numbers (such as $Cu(OH_2)$ and $[Cu(H_2O_6)]^{2+}$) or omission of charges (such as $[Cu(NH_3)_4(H_2O)_2]$). The observations were very well known with yellow, rather than green, usually seen for $CuCl_4^{2-}$. It was sad to see the responses of poorly-prepared candidates that had clearly been invented in the exam. Often these scored no marks or perhaps one for remembering that copper(II) hydroxide is a blue precipitate. Cobalt tended to be the choice of weaker candidates.
Some candidates mixed and matched between copper and cobalt and this approach was fully credited.

For precipitation, the specification allows a simple equation in terms of Cu^{2+}(aq) rather than complex ions. It was relatively common to see an equation for the precipitation reaction of $[Cu(H_2O)_6]^{2+}$ with hydroxide ions forming $[Cu(OH)_2(H_2O)_4]$ and this approach gained full credit if the equations were correctly balanced. The two equations for ligand substitution required complex ions throughout. It should be noted that the specification requires the complex ion $[Cu(NH_3)_4(H_2O)_2]^{2+}$ and the simpler representation of $[Cu(NH_3)_4]^{2+}$ was not credited. $[Cu(NH_3)_6]^{2+}$ was a common incorrect complex ion seen.

Question 2
This question assessed different aspects of reaction rates, based around the reaction of hydrogen with nitrogen monoxide.

2(a) This part required candidates to calculate a rate constant from a rate–concentration graph and a rate equation. Most candidates were able to obtain correct values from the rate–concentration graph, with a tolerance of ±0.1 allowed, and to calculate a value for the rate constant; three or four marks were common.

In the calculation, almost all candidates were able to rearrange the rate equation and to calculate a value for the rate constant, although this was not always expressed to two significant figures and to standard form. A significant number of candidates omitted one or both the powers of 10 for rate and concentration in their calculation.

Answers: The value of *k* allowed depended on the values of rate and concentration that had been used from the supplied graph and the required value of *k* was usually either 8.3×10^4 or 8.3×10^4 dm^6 mol^{-2} s^{-1}.

2(a)(i) This part was almost universally correct. The commonest error was two upwardly sloping curves, starting from the origin, and this response was awarded one mark.

2(b) Almost all candidates were aware that a rate constant increases in value with increasing temperature.

2(c) As with part (b), this part was answered extremely well, with the expected downward slope and a comment about a constant half-life. Comparatively few incorrectly shaped lines were seen.

2(d)(i) Most candidates were aware that the equations for the three steps must add to give the overall equation and the majority of candidates obtained the correct equation.

2(d)(ii) Candidates found this part far more difficult. Most were clearly expecting to answer in terms of the species in the slow step being present in the rate equation and many responded in this way. This strategy will only work if the slow step is also the first step. Only the best candidates were able to interpret the data, explaining that N_2O_2 in the slow step had been formed from 2NO in the preceding fast step.

Question 3
This question assessed aspects of feasibility and equilibrium, set in the context of two different reactions.

3(a)(i) This part was usually answered correctly in terms of fewer moles or molecules of gaseous products, with most candidates linking also to decreasing disorder. A significant number just mentioned decreasing disorder without including the reason for the decrease.

3(a)(ii) Although this part required candidates to calculate a standard entropy, rather than the more common entropy change assessed in previous exam papers, most candidates dealt with the problem with ease. Examiners rewarded partial success, usually where there was one incorrect sign or omitting to divide by 4.

Answer: $S = +131$ J K^{-1} mol^{-1}

3(a)(iii) The majority of candidates used the Gibbs equation to obtain the correct value of ΔG. Many weak candidates used –164, rather than –0.164, in the expression, resulting in a positive value for ΔG. Others used their answer to 2(a)(ii) rather than the value supplied with the equation. A few also used 25 ºC instead of 298 K. Candidates are far more adept with this calculation that used to be the case.

The comment on feasibility was marked dependent on the sign obtained for ΔG.

Answer: $\Delta G = -185$ kJ mol^{-1}

2(a)(iv) Although answered well, this part discriminated well. Two strategies were see. The first and more common repeated the ΔG calculation from 2(a)(iii) to show that ΔG was just positive (0.028 kJ mol^{-1}) and hence that the reaction was now not feasible. The second strategy showed that 1427K and therefore 1154ºC is the temperature at which ΔG has a value of 0 kJ mol^{-1}. Although most candidates were successful here, many weaker candidates seemed unaware of what to do. It was then common to see random numbers being used and ºC, instead of K, in the ΔG expression (much more common than in 2(a)(iii). The best candidates also identified that the reaction becomes unfeasible above 1147ºC. The explanation was marked consequentially of the sign obtained in 2(a)(iii).

3(b) Many candidates are now well-rehearsed for this type of question. Candidates were expected to determine the equilibrium amounts, convert to concentrations by multiplying by 4 or dividing by 0.250, and to use the concentration values to obtain the K_c value.
Three easy marks were available for the K_c expression, a correct calculation using calculated concentrations, and the units. As expected the equilibrium amounts caused the biggest problems for candidates. Most correctly obtained 0.180 mol for SO_2 and 0.820 mol for SO_3 (although some had these reversed or even the same). The amount of O_2 was often incorrect with 0.410 mol (0.500 – 0.090), rather than 0.090 mol, being commonly seen. The majority used 1000/250 or ÷ 0.250 to calculate concentrations from their equilibrium amounts. Some omitted this stage whilst other just divided by 250 or multiplied instead of dividing. Throughout, the examiners marked consequentially so that an individual error was not repeatedly penalised. Consequently the majority of candidates scored 4–6 marks for this part.

Answer: $K_c = 57.6$ dm^3 mol^{-1}

3(b)(ii) Surprisingly this part presented problems to many candidates. The examiners were expecting to see a response in terms of a decreased pressure from the presence of fewer gas molecules. However, many candidates responded with an increase or even the same pressure. This question discriminated extremely well.

3(b)(iii) Candidates had far more success with this part, with the vast majority responding with a negative ΔH value and decreased yield of SO_3. Weaker candidates often used exothermic (or even endothermic) instead and obtained the incorrect effect.

3(b)(iv) Explaining shifts in equilibrium in terms of K_c is far more difficult that the simpler le Chatelier approach. The examiners were impressed by the responses from able candidates with some excellent explanations comparing the values of the denominator and numerator between the two experiments and the consequential effect on the concentration of SO_3. Many responses did state that K_c is unaffected by changes in concentration or pressure but the explanation then used le Chatelier's principle.

This part discriminated extremely well and unfortunately weaker candidates often failed to score.

Question 4

4(a) For most candidates, this was an easy mark, although some only responded for a weak acid (partial dissociation) or for a Brønsted–Lowry acid (proton donor).

4(b) The majority of candidates correctly calculated the pH via K_w. Another less popular but successful approach was via pOH. Either approach could result in both marks. Weaker candidates sometimes calculated the pH as 0.30 (from –log 0.500). This gained no credit.

Answer: pH = 13.70

4(c)(i) Almost all candidates successfully wrote the expression for K_a. Responses using $[H^+(aq)]^2$ were not credited. Rarely, the expression was shown inverted or square brackets were omitted from one or more of the terms. Candidates are recommended to carefully check the formulae as this easy mark was sometimes not awarded for a missing C atom within a formula (even in the scripts of able candidates).

4(c)(ii) This part discriminated extremely well. The added stage of an initial dilution to a stock weak acid pH calculation created problems for many candidates. Although most were able to use the correct square root expression to obtain a value for $[H^+(aq)]$, the concentration used was often incorrect. Although just a four times dilution from 0.480 mol dm^{-3} to 0.120 mol dm^{-3}, many candidates obtained 0.120 using learnt equations rather than the simple ratio. Others used the original concentration of 0.480 mol dm^{-3} or incorrectly calculated concentrations, commonly seen as 0.0480, 0.0120 or even 0.192 (from $\times$ 4). Some candidates calculated $[H^+(aq)]$ using 0.480 mol dm^{-3} but then divided by 4 before calculating the pH. Able candidates invariably obtained the correct pH but many obtained pH values from the values above such as a pH of 2.59 (from 0.480 mol dm^{-3}), for which partial credit could be awarded.

Answer: pH = 2.90

4(d)(i) Equations for reactions of weak acids continue to improve. Ionic signs within the formula of sodium propanoate were allowed but both were then needed. Common errors included an incorrect formula of sodium propanoate, usually $(CH_3CH_2COO)_2Na$, sodium carbonate as $NaCO_3$ or an equation with correct species but unbalanced. As with 4c(i), candidates are recommended to carefully check the formulae for missing atoms.

4(d)(ii) The required equation using $H^+(aq)$ and $OH^-(aq)$ was commonly seen but a significant number of candidates wrote an equation using $H^+(aq)$ and $CO_3^{2-}(aq)$, perhaps writing an ionic equation for the reaction in (d)(i) rather than a different reaction.

4(e)(i) Some candidates correctly calculated the pH here as $-\log K_a$ but most used the standard buffer pH method, using a 1:1 acid–base ratio. Weak candidates often first took the square root of the K_a value, obtaining a pH of 2.43. Unfortunately, some candidates rounded a correct pH to 4.9, despite a two decimal place requirement being emphasised in the question.

Answer: pH = 4.87

4(e)(ii) The role of buffers in controlling pH is a common recall question and most candidates had prepared their rehearsed answers. Although this question asked for the addition of ammonia as a specific base, all but the weakest candidates identified that this was a question about addition of a base. The commonest and best answers stated that NH_3 accepts a proton to form NH_4^+ (with many ionic equations seen). The correct equilibrium shift was usually included.

4(e)(iii) This buffer calculation was aimed as stretch and challenge and the majority of candidates struggled to derive the concentrations of CH_3CH_2COOH and $CH_3CH_2COO^-$.
An easy mark for the amount of magnesium added was available for almost all candidates. The problem was then to derive the amount and concentration of CH_3CH_2COOH that would be obtained 0.500 mol^{-3}. Many did not identify that Mg and CH_3CH_2COOH react in a 1:2 molar ratio, subtracting 0.25, instead of 0.50, from the original concentration. Rarely did candidates realise that the $CH_3CH_2COO^-$ concentration would increase from the initial concentration of 1 mol dm^{-3}. Others assumed that no $CH_3CH_2COO^-$ was present at the start. Consequently, candidates often used a variety of acid–base ratios in their buffer calculation. Instead of the correct ratio of 0.5/1.5, it was very common to see 0.75/1.25, 0.75/0.25, and especially 0.5/1, 0.75/1 and 0.25/1.0.

The very best candidates tackled the problem with apparent ease but this was seen comparatively rarely in scripts of other candidates.

Answer: pH = 5.35

Question 5
5(a)(i) Many candidates completed the Born-Haber cycle to obtain three out of the four available marks. Strangely, very few candidates showed the correct species in the bottom box for the elements under standard conditions. Almost invariable, iodine was shown incorrectly, usually as $I_2(g)$ or $2I(g)$. The other three boxes were usually correct although sometimes state symbols had been omitted or electrons had been included together with the gaseous ions in the top right box. Candidates are advised to check carefully between stages in the cycle to ensure that all species charges and state symbols are included and accounted for.

5(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.

5(a)(iii) Most candidates correctly calculated the lattice enthalpy using a correct sequence of enthalpy values. The commonest mistake was the omission of '2' for either the atomisation or ionisation of iodine, leading to answers of –2366 or –2661 kJ mol^{-1}, or use of incorrect signs. There were more transcription errors seen than in previous session, most notably, –113 shown as –133. Candidates are advised to check carefully that any balancing numbers are linked to the correct enthalpy changes in the cycle and to double check values for possible transcription errors.

Answer = –2473 kJ mol^{-1}

5(b)(i) Few candidates produced two incorrect electron configurations but there were many mistakes seen for either species. For Fe^{2+}, the commonest error was for loss of electrons from the 3d rather than 4s sub-shell of an Fe atom. For a Br^- ion, it was common to see the electron configuration of a Br atom. Surprisingly a common error was to see $4p^4$ rather than $4p^6$ from loss rather than gain of an electron. Only just over half the candidates showed two correct configurations so clearly more care is needed when answering.

5(b)(ii) The majority of candidates predicted that Fe would react with all three halogens to form Fe^{2+} ions, supported by equations and electrode potential data. Many simply stated that Fe has the more negative *E* value (or the halogens the more positive value). It was also common to see cell voltages used, such as +0.98 V for a reaction between iron and iodine. Both approaches were credited.

The most able candidates correctly predicted that Fe^{2+} ions, initially formed from the reaction of iron with bromine and chlorine, would then be oxidised to Fe^{3+}. The best answers showed exceptional understanding. Candidates are advised to consider all the information supplied in a question as the majority had ignored completely the Fe^{3+}/Fe^{2+} data.

5(c) This part required candidates to interpret unfamiliar information to construct reactions for redox and ligand substitution reactions. As with question 1(d), marks were sometimes wasted by incorrect balancing of equations or careless positioning of numbers. This part discriminated extremely well. For the redox equation, common mistakes were omission of species (such as H^+) failure to balance the redox reaction by charge (with the '3' balancing numbers for Fe^{2+} and Fe^{3+} being omitted) or inclusion of e^- on one side of the equation.

For the ligand substitution equation, H_2O was sometimes omitted on the right-hand side and careless positioning of numbers, such as (H_2O_5) was sometimes seen. Candidates are recommended to check all species very carefully for any such slips.

Question 6
6(a) This part required candidates to apply their knowledge and understanding to three cells. Just over half the candidates were able to list the redox systems by *E* value. There was no clear pattern with incorrect responses.

6(b)(i) Surprisingly, this part caused many candidates a problem with less than half the candidates obtaining the correct answer of 0 V. The commonest incorrect responses seen were pH values of 1 or even 7.

Answer: pH = 0 V

6(b)(ii) This part discriminated well with many candidates unable to interpret the information. Although the question asked for an explanation in terms of electrode potentials and equilibrium, these were often absent in the responses. Surprisingly, many identified the incorrect polarity for the hydrogen half-cell and then concluded that a decrease in pH is a result of a decrease, rather than an increase in $[H^+(aq)]$. To score well required a very good understanding of equilibrium in the context of electrode potentials.

6(b)(iii) Perhaps influenced by incorrect polarity in 6(a)(ii), many equations were shown the wrong way round. As with 5(c), many equations were not balanced by charge with Ag^+ and Ag often having no balancing number.

6(c)(i) The majority of candidates were able to complete the equation for acid–base equilibrium and to identify the acid–base pairs. Candidates are advised to use numbers to label the acid–base pairs, such as 'acid 1' and 'base 1'. Attempts at using 'acid' and 'conjugate base' are ambiguous when more than one acid–base pair is involved. Although credited, it was strange to see hydrogen cyanide often written as CNH.

6(c)(ii) The majority of candidates recognised that acid conditions would lead to protonation of CN^- forming toxic HCN.

6(d)(i) Many responses seen here were far too vague. It was common to see answers about a fuel reacting but with no reference to oxygen. Responses in terms of less pollution or greenhouse gases gained no credit.

6(d)(ii) Most candidates were credited here, recognising that ethanol is a liquid and can therefore be more easily stored or transported.

6(d)(iii) Almost all candidates wrote correct species but the equation was not always balanced correctly with $3\frac{1}{2}O_2$ or $2O_2$ being the commonest errors. Candidates need to take great care when balancing an equation containing an alcohol to account for the O atom with the alcohol formula.

6(d)(iv) The equations seen were impressive with nearly half the candidates providing an equation that could be credited. The examiners credited many different balancing numbers of $O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$. The commonest seen were multiples using $\frac{1}{2}O_2$ and especially $3O_2$. As correct answers often showed no working, perhaps the oxygen half equation had been memorised by many candidates.

6(d)(v) This part required identification of oxidation and reduction in an unfamiliar context. The reduction of O was far easier than the oxidation of C and this was reflected in 1/2 being the commonest mark awarded. Discrimination was very good with able candidates collecting both marks.

Question 7
F325 papers have traditionally finished with an application question such as Question 7 in which candidates are required to apply their knowledge and understanding in an unfamiliar context. As with all of these questions, candidates are advised to read each question carefully and to select the appropriate information from that provided. The information often contains carefully planted clues.

7(a) The information needed to write the equation was within the information provided for step 1 and the stem for (a). Candidates were much more successful with the first than the second equation. The clue that an alkaline solution had been formed should have helped with the identification of NaOH as a product of both reactions. The brown precipitate provided a clue that $Fe(OH)_3$ had been formed although the examiners also credited an equation producing Fe_2O_3.

7(b) Many candidates were on firm territory with a redox titration problem. The majority went through a well-rehearsed sequence of steps to obtain four marks for reaching the amount of CrO_4^{2-} ions in the original solution. Sometimes, candidates used the 1:1.5 molar ratio for CrO_4^{2-} : I_2 the wrong way around to obtain 1.9125×10^{-3} rather than 8.50×10^{-4} mol CrO_4^{-4}. More candidates had problems in scaling up by 40 to obtain the original amount of CrO_4^{2-} as 3.40×10^{-2} mol. Strangely many used a factor of 4 instead.

The last two marks proved to be more elusive, with many candidates calculating the percentage of $Fe(CrO_2)_2$ rather than Cr in the sample of chromite.

The responses seen show just how far candidates have travelled since early structured titration calculations for AS to complex unstructured calculations at the end of the A-level course.

Answer: 33.7%

7(c) This part required candidates to construct three equations for an unfamiliar reaction. The examiners allowed equations using H^+ rather than OH^-. It was then possible to credit many candidates with the full three marks with many excellent responses seen. Predictably the equations involving CrO_4^{2-} were more difficult but even some weaker candidates were able to construct an equation for the oxidation of iodide ions. The very best candidates did manage to construct the equations in alkaline conditions.

F326 Practical Skills in Chemistry 2

General Comments:

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

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

It was 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 though 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. A number of Centres corrected the paper version of the MS1 but had not passed those corrections on to OCR.

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

Comments on Individual Tasks:

Qualitative Tasks

The quality of the work received was generally good with Task 2 being seen by the Moderators slightly more often than the other two. However, error carried forward was again 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.

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

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

Quantitative Tasks

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

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

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

Graphs were often drawn well but occasionally points were not always plotted correctly. More frequently, points were not then taken from the line of best fit or used to calculate the gradient correctly.

Evaluative Tasks

The generous use of 'benefit of the doubt' continues to be a slight issue where alternative wording is credited for explanations. The response must closely match 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.

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