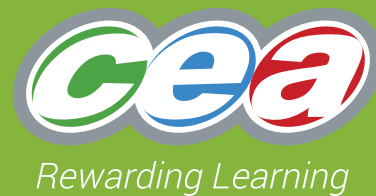


GCE



Chief Examiner's Report
Chemistry

Summer Series 2023



Foreword

This booklet outlines the performance of candidates in all aspects of this specification for the Summer 2023 series.

CCEA hopes that the Chief Examiner's and/or Principal Moderator's report(s) will be viewed as a helpful and constructive medium to further support teachers and the learning process.

This booklet forms part of the suite of support materials for the specification. Further materials are available from the specification's microsite on our website at www.ccea.org.uk.

Contents

Assessment Unit AS 1	Basic Concepts in Physical and Inorganic Chemistry	4
Assessment Unit AS 2	Further Physical and Inorganic Chemistry and Introduction to Organic Chemistry	7
Assessment Unit AS 3A	Basic Practical Chemistry Booklet A	10
Assessment Unit AS 3B	Basic Practical Chemistry Booklet B	12
Assessment Unit A2 1	Further Physical and Organic Chemistry	15
Assessment Unit A2 2	Analytical, Transition Metals, Electrochemistry and Organic Nitrogen Chemistry	18
Assessment Unit A2 3A	Further Practical Chemistry Booklet A	22
Assessment Unit A2 3B	Further Practical Chemistry Booklet B	23
Contact details		25

GCE CHEMISTRY

Chief Examiner's Report

Subject Overview

- As with all online marked units, candidates should be encouraged not to work in pencil as the erased indentations on the paper can be picked up in the scanning process and confuse the answer given by a candidate.
- With the multiple-choice questions, candidates should be encouraged to form proper letters as a poorly shaped B can be confused with a D resulting in a loss of a mark for the candidate.
- Definitions from the clarification of terms document are expected to contain all the key elements given. Colour changes and observations and descriptions of practical work should also follow the support documents.
- Practical chemistry will continue to be assessed in the theory papers as well as the practical papers and candidates are expected to be able to apply their knowledge to the context of the chemistry involved.
- As mentioned last year, it was expected that positive enthalpy changes, positive entropy changes, positive free energy changes, positive electrode potentials and positive emf values will have the positive sign.
- Curly arrows in mechanisms should **start touching** the bond or ring or close to the centre of a lone pair of electrons **and should go to** the atom to which the electrons are being transferred or back into the benzene 'hexagon'. This is best practice and avoids candidates losing marks.
- When carrying out a calculation, it would be beneficial if candidates labelled each numerical step in their answer, e.g. 'moles of $\text{H}_2\text{SO}_4 =$ ' and 'concentration of $\text{H}_2\text{SO}_4 =$ '. This would make any errors easier to spot so candidates gain all marks possible.
- Intermolecular forces continue to be examined in various places throughout the papers and candidates often lose marks for not stating 'between the molecules'.
- IUPAC nomenclature required the correct spelling of all parts with correct substituent alphabetical order and correct use of hyphens and commas.
- Only correct spellings of chemical names will be accepted in future.
- Candidates can often present an organic reaction more clearly as a structural/skeletal equation or condensed structural equation. Care should be taken to ensure all atoms are included in a structural equation. Also substituent groups of more than one atom in the middle of a condensed structural equation should be in brackets such as $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$.
- Connectivity of atoms and groups in structural formulae should be accurate. Candidates lose marks for covalent bonds going to the wrong atom of a group, particularly with an OH group on the left which should be presented as $\text{HO}-\text{C}-$.
- Ionic radius and atomic radius should not be confused, particularly when discussing successive ionisation energies.
- Quad is not an alternative to tetra in organic nomenclature.

Assessment Unit AS 1 Basic Concepts in Physical and Inorganic Chemistry

Summary points

- The standard of responses to questions assessing knowledge of definitions, as given in the clarification of terms document, was generally poor.
- The term 'atomic radius' should only be used when referring to atoms not ions.
- Care should be taken when giving charge and/or oxidation state that the sign and the number are in the right order.
- The concept of molecules in molecular covalent structures and intermolecular forces between these molecules is not well understood.

Q1 – 10 The multiple-choice questions were generally very well answered. Questions 3, 6 and 8 proved to be the most challenging. Questions 7, 9 and 10 proved to be the most accessible.

Q11 Question 11 focussed mostly on the atomic structure section of the specification with a couple of simple half-equations and ionic bonding also included. Overall, most candidates scored well. In Part (a)(ii), the number of electrons in each subshell should be written as a superscript and not a full-sized number or a subscript. The definition in Part (b)(i) was not well known with many candidates using the term 'average' or 'mean'. Part (b)(ii) was very well answered with both marks scored. In Part (c)(i), the definition of third ionisation energy was often not well known but most candidates were able to give a correct equation with state symbols in Part (c)(ii). A lot of candidates lost marks in Part (c)(iii) for not labelling the 3s subshell and/or having a fully occupied 3s subshell. The standard of answers in Part (c)(iv) was disappointing with a poor understanding often evident. Candidates should be advised to be very careful when using the term 'atomic radius'. The term should only be used when referring to an atom. When referring to an ion, the term 'ionic radius' should be used. Many candidates suggested that, ongoing from the second to the third ionisation, the nuclear charge increases. The simple half-equations given in Part (d)(i) were often of a very poor standard. Charges and electrons were often missing. The concept that oxidation involves electron loss (with electrons on the right) whereas reduction involves electron gain (with electrons on the left) was not understood by many. The answers for the dot and cross diagram in Part (d)(ii) were much better than in previous years. Electron sharing did not appear as frequently.

- Q12** Question 12 focussed on the redox and halogens sections of the specification. It was anticipated that Part (a) would be one of the easiest questions in the paper. This proved to be very far from the reality! The number of candidates scoring this mark was very low and the logic behind some of the suggested names was very difficult to understand. Part (b) was well answered but candidates need to include important details such as 'glass' when referring to the rod, 'concentrated' when referring to the ammonia and 'smoke' or the equivalent when referring to the positive result. Overall, candidates coped very well with writing the equation in Part (c). The definition in Part (d) required just two words: 'electron donor'. Many candidates did not score the mark. In Part (d)(ii), it was clear that, for many candidates, 'iodine' and 'iodide' mean the same thing and that there is no significant difference between 'atoms' and 'ions'. Most candidates missed the idea that the iodide ion loses an outer electron more readily than the bromide ion and that the explanation is very similar to that used when explaining ionisation energies. Again, candidates should be advised to be very careful when using the term 'atomic radius'. The term should only be used when referring to an atom. When referring to an ion, the term 'ionic radius' should be used. In Part (e)(i) the oxidation states were usually correct although the number often appeared before the sign. The observations in Part (e)(ii) and Part (iii) were well known although some candidates thought that sulfur, rather than hydrogen sulfide, had a rotten egg smell. Parts (e)(iv) – (e)(vi) proved to be too challenging for many.
- Q13** Question 13 focussed mostly on the bonding and structure sections of the specification with a little bit of qualitative tests, intermolecular forces and balancing equations. Many of the answers to Part (a) demonstrated confusion and a lack of understanding of the key ideas and terminology. The concept of a molecular covalent structure with covalent bonding within the molecules and intermolecular forces of attraction **between molecules** was not well understood. Most candidates were able to achieve the bottom band and score two marks. Those with a clear understanding and explanation worthy of the top band were much thinner on the ground. In both Part (b)(ii) and Part (c)(iii), although the candidates knew the tests and outcomes, important details were often missing, and this meant that 'easy' marks were lost. For example, 'Bunsen burner flame' should be 'blue Bunsen burner flame' and 'hydrochloric acid' should be 'concentrated hydrochloric acid'. A large number of candidates described holding the nichrome wire **above** the flame rather than in the flame. Candidates scored well on the balanced equations in Part (b)(i) and Part (c)(ii). However, the answers to Part (c)(i) were poor and often the better answers did not explain the different outcomes for electrical conductivity with solid and molten/ aqueous potassium carbonate. The explanations for the lack of polarity in carbon dioxide were often simple, accurate and in keeping with the answers in previous mark schemes.

- Q14** The theme in Question 14 was methylamine. Candidates had to apply their knowledge of covalent bonding, shapes, bond polarity and intermolecular forces. Overall, the question proved to be quite discriminating. In most cases, the dot and cross diagram scored the one mark. The bond angle was often incorrect with 180° proving a very popular incorrect response. The shape around the nitrogen atom was often incorrect and the explanations based on VSEPR were poor. In some of the better answers, candidates put too much emphasis of the lone pair-bonding pair repulsions and ignored the fact that the bonding pairs also repel each other. The definition of electronegativity was not well known by many although the polarity of the N-H bond caused very few problems. The answers to Part (b)(iii) were disappointing with the idea of intermolecular forces being 'between molecules' often missing. Part (c) proved to be very discriminating with some very impressive answers but many lacking in an ability to apply knowledge. The type of bond formed was usually a 'hydrogen bond' and for those who did get the correct type of bond, the explanation of how it forms was weak. There were some excellent answers in Part (b) (iii) where the candidates had read the question carefully and demonstrated a clear understanding of hydrogen bonding and applied their knowledge in an unfamiliar context.
- Q15** The theme in Question 15 was mole calculations including in the context of an acid-base titration. Overall, the question proved to be discriminating. The ionic equations in Part (a)(i) were poor. In Part (a)(ii) many candidates did not consider the idea that one of the reactants may have been present in excess. Giving the answer to 3 significant figures with an appropriate unit did not cause significant difficulty. Completing the titration table, particularly the middle column, proved to be very challenging. Many candidates did not use a 2:1 ratio in Part (b)(ii) and many missed the tricky idea that based on the concentration of the sodium hydroxide solution, the appropriate number of significant figures was 2. Most candidates chose an appropriate indicator and gave the correct colour change.

Assessment Unit AS 2

Further Physical and Inorganic Chemistry and Introduction to Organic Chemistry

Summary points

- The standard of responses to questions assessing knowledge of definitions, as given in the clarification of terms document, was generally poor.
 - Candidates are increasingly cognisant of giving answers to the appropriate number of significant figures or decimal points as indicated in the question. Calculations were generally answered well with most candidates accessing at least some marks.
 - As indicated in previous reports, when drawing mechanisms it is important that curly arrows originate on a bond or close to a pair of electrons. Candidates often lost marks due to poorly drawn curly arrows.
- Q1 – 10** The multiple-choice questions were generally very well answered. Questions 3 and 8 were the best answered. The most challenging questions were Questions 4, 6 and 10.
- Q11** Question 11 was generally well answered by most candidates. The equation in Part (a) was answered correctly by most candidates. In Part (b) both the percentage atom economy calculation and percentage yield calculation were answered well, with most candidates giving answers to one decimal place as indicated in each question part. A small number of candidates did not include the multiplication by two in Part (b)(i) and so lost one or both marks.
- Q12** This question assessed aspects of Energetics. The definition was well answered in Part (a)(i). In Part (a)(ii), candidates had to make reference to the temperature given in the question stem or the boiling point of water, which most did. The definition in Part (b)(i) proved challenging for a number of candidates which was surprising. Many candidates struggled with the calculation in Part (b)(ii); common errors included using 2.5 g or 27.5 g for the mass of the solution or using 99 as the RFM of potassium carbonate. Only the highest scoring candidates achieved three marks in this part. ECF was applied in Part (b)(iii) but many candidates did not know what to do despite the equation being repeated. Many candidates who did attempt the calculation often had values or signage the wrong way around. A positive sign was expected in the final answer and some candidates did not include this.

- Q13** Question 13 assessed Alkane Chemistry. Most candidates gave correct skeletal formula in Part (a)(i) and the definition for structural isomers was well answered in Part (a)(ii). Many candidates correctly identified the correct branched structure in Part (a)(iii) although some candidates drew a skeletal structure. Some candidates struggled with the name of the isomer, often omitting hyphens or using the term 'quad' instead of the correct prefix 'tetra'. The equation for the combustion of isooctane was answered very well and most candidates correctly explained the sooty flame observation in Part (b)(ii). The calculation in Part (b)(iii) was well answered by most candidates, with credit being given if the mass of isooctane was correctly calculated despite an incorrect final answer. Most candidates correctly stated the percentage increase in atmospheric carbon dioxide and consequence in Parts (c)(i) and (ii). In Part (d), most candidates correctly explained the honeycomb structure of a catalytic converter in Part (d)(i) and the use of a thin layer of catalyst in Part (d)(ii). The equation was poorly answered in Part (d)(iii), as was the definition in Part (d)(iv). The name of the graphical distribution was generally well known and examiners applied professional judgement with spelling of the names. Only the highest scoring candidates scored full marks in Part (d)(iv), with many incorrectly making reference to the shape of the curve. Many candidates explained that a catalyst provides an alternative route of lower activation energy as part of their answer to the definition in Part (d)(iv) rather than in this question part.
- Q14** In Part (a), most candidates correctly stated the trend in atomic radius down Group II, however the explanations were often poor. Many candidates referenced shielding or outer shells rather than the increased distance between the nucleus and outer electrons. Almost all candidates gave the correct equation in Part (b)(i). Part (b)(ii) was the most challenging question part in the paper. Very few candidates gave the correct ionic equation however some candidates did correctly make reference to formation of alkali and scored one mark. Many candidates stated the colour change but did not explain why it occurred. Part (c) was generally well answered as expected, including the calculation in Part (c)(v). Most candidates gave the correct equation in Part (d).

Q15 This question assessed aspects of organic chemistry. The two mechanisms were very well known in Part (a). In Part (b), most candidates gave the correct equation in Part (i) and correctly identified 2-bromopropane and the major isomer in Part (ii). The mechanism was generally well known in Part (b)(iii), however candidates often lost marks as one of more curly arrows did not originate on a bond. In some responses, the negative charge and/or lone pair of electrons was missing from the bromide ion. Many candidates gave the formula of the correct reagent in Part (c)(i) although some candidates gave the name which was not credited. Others confused this question part with Part (d)(ii) and gave $K_2Cr_2O_7$, which was incorrect. Candidates struggled with the conditions in Part (c)(ii) with many making reference to the inclusion of ethanol. The elimination reaction was correctly identified by most candidates in Part (c)(iii). Propanone and propanal were correctly given by most candidates in Part (d)(i) although a significant number of candidates gave structures containing $C=C$ or $-OH$ groups. The radical substitution mechanism was answered very well by most candidates; it was clear that candidates had used the advance information in preparation for this paper. The final question part was the QWC question. Most candidates correctly identified butan-1-ol as having the highest boiling point and pentane as having the lowest boiling point. Candidates are expected to know the structure of aldehydes and ketones in terms of oxidation of primary and secondary alcohols. They would also be expected to elucidate the intermolecular forces present in any simple molecule the structure of which they are given or know (specification reference 1.4.2). In addition, candidates are also expected to understand that aldehydes have a lower boiling point than the primary alcohol from which they are formed and that this dictates how they are prepared in terms of distillation as opposed to heating under reflux which would obtain the carboxylic acid. The main error observed was that whilst candidates often correctly identified the main intermolecular forces acting, they did not state that the forces were acting between the molecules in each case and so scored four marks rather than six.

Assessment Unit AS 3 Basic Practical Chemistry Booklet A

Summary points

- Most candidates found that substance S did not disappear in the designated volume of hydrochloric acid and the observations for the reaction were therefore different than expected. A range of answers were allowed to accommodate for this.
 - The range of burette readings varied widely, and a lot of candidates ignored the instruction to give to one decimal place and to give the units.
 - Some candidates had liquid A showing deflection instead of no deflection.
- Q1** Question 1 was generally well answered by most candidates and there were few misinterpreted questions. In Part (a) many candidates correctly described the flame colour as yellow/orange. In Part (b) many candidates did not see the solid disappear completely in the hydrochloric acid and so a range of answers such as solid remains, some solid disappears, or white solid remains were given. Some candidates incorrectly described the white solid as a precipitate or emulsion, and this was not an acceptable observation. Very few were able to describe a colourless solution being formed and instead referred to milky or cloudy solution forming. Most candidates were able to describe fizzing or bubbling as an observation. In Part (c) (i) many candidates were able to state the colour observed in the conical flask as pink and some gave the colour change as colourless to pink. In Part (c)(ii) candidates gave a wide range of burette readings, a majority of candidates were able to give a value within the acceptable range, but some did not do this to the correct decimal places and forgot the units. In Part (c)(iii) and (iv) most candidates gave the correct answer as colourless and some gave the colour change pink to colourless. Part (c)(v) candidates gave a wide range of burette readings, with many candidates able to give a value within the acceptable range. Again, some candidates lost marks for not giving their reading to the correct decimal places and forgetting to state the units. Part (c) (vi) some candidates lost marks here when stating the colour change instead of the colour at the second end point which was pink or red. In Part (c)(vii) most candidates refilled their burette after each reading to have an initial burette reading of 0.0. Some lost marks here for not giving their answer to one decimal place. The titre value was sometimes incorrectly calculated, and candidates lost marks here again for an incorrect value or not having their titre to one decimal place.

Q2 In Part 2(a) test 1 most candidates gained this mark by stating that there was one layer or that A and B were miscible or mixed. Common mistakes here were commenting on reactivity, stating that there were two layers and stating that fizzing occurred. In test 2 most candidates were able to state that two layers were formed and that the mix of A and B were immiscible. In test 3 many candidates gained this mark by stating that there was one layer or that A and B were miscible or mixed. Common mistakes here were commenting on reactivity, stating that there were two layers and stating that fizzing occurred. In test 4 the majority of candidates were able to access both marks as there was a range of acceptable observations. The most common mistake was to give the incorrect colour of the universal indicator as orange. In test 5 most candidates successfully identified the final colour after heating as colourless. There were a range of answers given for the starting colours purple, red then also brown and orange as intermediate colours. Some common incorrect observations were to state fizzing occurred or to incorrectly state a brown precipitate was formed. In Part (b) a lot of candidates commented that liquid A deflected when it should not have. Possible explanation would be that the burette had been cleaned with propanone which would have caused deflection if any residue remained. The mark scheme was adapted to deal with this incongruity. In Part (c)(i) two layers were correctly identified by most candidates with the majority correctly giving the colour of the upper layer as purple and the lower layer as brown/orange/yellow. In Parts (ii) and (ii) the correct colours of both solutions were given by the vast majority of candidates, the most common mistake here was to state a red-brown colour.

Assessment Unit AS 3

Basic Practical Chemistry Booklet B

Summary points

- The formula for calculating the heat produced was not well known and candidates made mistakes by using the incorrect volume of 2.5 or 27.5 and not dividing by 1000 to convert their answer to kilojoules.
- Assumptions for carrying out the heat energy calculation were not well known, and most candidates referred to the heat capacity instead of specific heat capacity and also gave incorrect units for the specific heat capacity and density.
- Candidates still have difficulty with giving their answers to the specified significant figures of decimal places.
- For the most part practical knowledge of addition of concentrated hydrochloric acid, how to remove a solid and what is needed to promote smooth boiling were well answered by candidates.
- Percentage yield was not well answered with candidates struggling to convert to a 40% yield.
- Balancing equations were answered well if the candidate had drawn out the full organic structure in the organic equations.
- The equation for the reaction of chlorine with water was well answered as was the equation for the reaction of chlorine with potassium iodide.

Q1 Part (a) was well answered by most candidates, the most common error being missing the units. Part (b)(i) was either answered well or candidates had error carry forward marks for using an incorrect volume or forgetting to change joules to kilojoules. Also, the lack of giving their answer to the correct decimal places meant candidates lost marks when they had correctly worked out the calculation and forgot to round to the correct decimal places. The assumptions in Part (ii) were only fully given by a few candidates. Most candidates got 1 mark here as they missed the word specific in specific heat capacity or did not give the correct units. Some candidates gave practical assumptions such as no heat lost to surroundings which was not an acceptable answer here. In Part (c)(i) candidates struggled to give the correct state symbols in the ionic equation and only some gained the mark here. The number of moles and mass in Parts (c)(ii) and (iii) were well answered for the most part and only some candidates had error carried forward marks to Part (iv). In Part (vi) candidates successful worked out the enthalpy change value but a lot of lost marks for not giving to the correct significant figures or not having the negative sign. In Part (v) the vast majority of candidates were able to state that the reagent used to test for sulfate ions was barium nitrate or chloride and then successfully gave white precipitate as the correct observation. Many candidates gave the flame test colour of copper(II) ions as blue-green.

- Q2** Part (a)(i) many candidates gave the correct answer here. In Part (ii) a lot of candidates were able to state the reason for using a measuring cylinder rather than a more accurate piece of apparatus was due to HCl being in excess. In Part (a)(iii) many candidates gave the idea that the concentrated Hydrochloric acid was added gradually due to the reaction being exothermic, some talked about it being a preventive measure against vigorous reaction, but a lot gave the idea that it was because the reaction was vigorous and not the idea that it was a preventative measure. In Part (a)(iv) many candidates stated that addition of water and the aqueous layer getting bigger was the reasoning, some did not read the question here and wrote about the aqueous layer being at the top or the bottom despite the reference in the stem of the question stating, 'without reference to density values'. In Part (a)(v) most candidates were able to give the purpose of adding the sodium hydrogencarbonate as being added to remove acidic impurities. Very few successfully gave the balanced equation. For Part (a)(vi) most candidates correctly stated that anhydrous sodium sulfate was a drying agent but then could not state that it was when the solution turned clear that enough had been added so most got 1 out of the 2 marks here. In Part (a)(vii) most candidates successfully stated that decanting or filtering was how the solid was removed. However, a handful of candidates described the process of using a filter funnel and filter paper but did not actually say what to do with these and therefore had incorrectly read the question. In Part (a)(viii) almost all candidates gave anti bumping granules as what is added to promote smooth boiling. Only some candidates were able to state that the pear-shaped flask was not heated directly due to the contents being flammable in Part (ix). Some commented on dissipating heat. In Part (a)(x) many candidates were able to comment that the change in boiling point would be that it increased or was over a broader range. The most common mistake here was to say that the boiling point was lowered. In Part (b) candidates lost marks here for using the incorrect relative formula mass of either the alcohol or the halogenoalkane and for not converting to 40% yield. In Part (c)(i) candidates who gave the full structural equation gained the most marks over those who used molecular or condensed formula. Common mistakes made here were not balancing correctly or incorrectly having water as a product rather than hydrogen. In Part (c)(ii) the correct test for hydrogen was well known.
- Q3** In Part (a) candidates were able to identify the colours of chlorine, bromine and iodine aqueous solutions but gave colours such as white or purple for potassium halide. Part (b)(i) was very well answered as was the balanced equation for the reaction of chlorine with potassium iodide in Part (ii). In Part (iii) most candidates identified two layers for one mark and less were able to say that the purple layer was on the top and colourless on the bottom. In Part (c) the equation for the reaction of chlorine and water was well answered and it was evident that candidates had learnt this off. In Part (ii) the conditions were often given as cold and dilute without the sodium hydroxide or alkaline solution being mentioned but this was not credited. Part (c)(iii) was well known with a wide variation of why ozone was preferred over chlorine in water treatment given.

Q4 In Part (a) most candidates were able to state that it was because iodine sublimed but then failed to say that it would not therefore react fully with copper. This was not well answered because of this. In Part (b) candidates answered this well by correctly stating that iodine was toxic, some only said it was toxic and did not refer specifically to iodine and therefore cost themselves marks here. Parts (c) and (d), the mass calculations, were well answered. Part (e) was, for the most part, well answered with a lot obtaining 3 marks here. Common errors were to get the iodine and copper masses round the wrong way, an incorrect mass calculated and used incorrectly in Part (e) and not giving the mass to nearest whole number by dividing by the smallest number of moles. In Part (f)(i) the correct statement of why the reaction was redox was obtained by most. A lot of candidates successfully identified the correct changes in oxidation states for both the iodine and sulfur, but a lot of candidates lost marks here for stating the change in oxidation number of the iodide ions and sulfate ions. Some referred to other elements which were not accepted. In Part (f) (ii) most candidates obtained 2 marks here but some lost marks for not stating that it is starch solution that is used and referred simply to starch. The observation was almost always correct. Some candidates gave a further test and observation for the identification of iodide ions and therefore lost both marks here.

Assessment Unit A2 1 Further Physical and Organic Chemistry

Summary points

- The quality of responses to calculation-based questions were of a higher quality than in previous series. However, it is apparent that candidates lack an understanding of how to present numerical answers to an appropriate number of significant figures.
- The standard of recall-based content such as definitions was less than satisfactory.
- An improvement is required when showing organic mechanisms. More precision is needed when showing the movement of electrons with curly arrows. In addition more accuracy is needed to ensure that a curly arrow touches a bond or comes from a lone pair.
- Order 2 rate concentration graphs sometimes had a vertical section which was penalised.

Q1 – 10 The multiple-choice questions were generally very well answered. Questions 7 and 8 and 9 were the best answered. The most challenging questions were Questions 2 and 10.

Q11 The standard of responses to Parts (a)(i) to (a)(iv) was very good. If candidates provided an incorrect order of reaction in (a)(i) and/or (a)(ii), ECF was applied in Parts (a)(iii) and (a)(iv). A vertical section of an order 2 rate concentration graph sometimes had a vertical region in Part (a)(iv) which was penalised. A significant percentage of candidates were unable to provide an acceptable definition for the term rate constant in Part (a)(v). Most candidates attained at least 2 marks in Part (a)(vi). A mark was deducted if the final answer was not given to two significant figures as requested in the stem of the question. Again, ECF was applied from rate equation in Part (a)(iv). Part 11(b)(i) and Part (b)(ii) were very well answered. A significant number of candidates lost a mark in Part (c)(i) for omission of the + sign before the numerical answer. Question 11 Part (c)(ii) was very well answered and ECF was applied from Part (c)(i). Question 11 Part (c)(iii) was very well answered. Question 11 Part (d)(i) was well answered. In Part 11(d)(ii) many candidates scored both marks.

Q12 In Part 12(a) many candidates scored 4 out of a possible 6 marks. The observations of a silver mirror for the oxidation of benzaldehyde with Tollens' reagent was well known as was the colour change of orange to green for the oxidation of benzaldehyde using acidified dichromate(VI). However, many candidates did not provide all the practical detail that is required to carry out the tests such as use of a test tube/boiling tube and the need to heat in a water bath for the reaction of benzaldehyde and Tollens' reagent. While most candidates provided the equation for the oxidation of benzaldehyde and the half equation for the reduction of Ag^+ , many could not provide the half equation for the reduction of dichromate(VI) ions to Cr^{3+} ions.

Part 12(b) required candidates to provide an equation to produce cyanide ions from hydrogen cyanide and to subsequently outline the mechanism for the nucleophilic addition reaction of cyanide ions with benzaldehyde. A significant minority of candidates did not provide an equation and were penalised. Overall, the standard of the mechanisms provided was poor. Curly arrows need to start from the middle of the lone pair on the cyanide ion and the head of the arrow must be directed at the carbon atom of the carbonyl group. The curly arrow which depicts the breaking of the pi-bond must start on the bond and finish on the oxygen atom. The intermediate structure must show a lone pair on the oxygen and a negative charge. Again, the curly arrow must start from the lone pair on the oxygen and finish at the H^+ ion. Part 12(b)(ii) was well answered overall. However, candidates who merely stated that low pH would shift the equilibrium to the left were not awarded the mark. In Question 12 Part (b)(iii) the first mark was awarded for the formation of a racemic mixture. The second mark was awarded if candidates described why the racemic mixture was formed or why the racemic mixture was optically inactive. Questions 12 Part (c)(i) and Question 12 Part(c)(ii) were well answered. The calculation for the pH of the buffer in Part 12(c)(iii) was answered well. Candidates who calculated the pH of a weak acid rather than a buffer could still access 2 marks. Candidates could improve the presentation of their calculations as it was at times not obvious for examiners to ascertain where an error had been made from the quality of the working out provided on scripts.

Q13 In Part (a)(i) candidates were required to outline a mechanism for the acylation of benzene (3 marks) and two equations to show the formation of the acylium ion and the regeneration of the catalyst (2 marks). Most candidates attained the 2 marks for the equations. However, as before, the standard of the mechanism provided by many candidates was poor. More attention must be given to the drawing of curly arrows and to the drawing of the intermediate structure showing the incomplete ring with positive charge. Question 13 Part (a)(ii) was not well answered even though it was a basic definition from the AS specification which candidates should be very familiar with. Omission of either ion or molecule from the definition lost the mark. Question 13 Part (b)(i) was well answered. In Question 13 Part (b)(ii) either an equation of the nitration of phenylethanone using nitric acid or the nitryl cation was accepted. However, many candidates lost the mark for omission of the additional product of either H_2O or the H^+ ion. The quality of responses provided for Part 13 Part (b)(iii) varied. Basic errors in responses included use of a sealed capillary tube. In addition, many candidates included recording the time when melting starts and finishes rather than the temperature. Few candidates included the fourth indicative point in their responses. Question 13 Part (c)(ii) was well answered with many candidates awarded both marks. The calculation of the volume of phenylethanone needed in Part (c)(ii) was well answered. Common mistakes were the incorrect RFMs of either 2,4-dinitrophenylhydrazine and/or phenylethanone used. In both cases ECF was applied. In addition, a significant minority of candidates multiplied by 0.9 rather than divide. Again, ECF was applied. Part 13(d) was a stretch and challenge question with only the most able candidates achieving the 2 marks.

- Q14** Question 14 Part (a)(i) was a basic definition that too many candidates did not know. Most candidates scored 1 mark for question Question 14 Part (a)(ii). As in previous series candidates lose a mark for not clearly depicting van der Waals' forces as intermolecular. Question 14 Part (b)(i) was well answered. Candidates did need to show a reversible arrow to attain the mark. Most candidates attained both marks in Question 14 Part (b)(ii) and Question 14 Part (c)(i). Question 14 Part (c)(ii) was very well answered. The majority of candidates achieved 1 mark in Question 14 Part (c)(iii) for giving the correct formula on the LHS and RHS. Many candidates lost the second mark for incorrect balancing. Questions 14 Part (d)(i) and Question 14 Part (d)(ii) were very well answered.
- Q15** Many candidates provided the correct formulae for the reactants and products in the combustion of the fat in Question 15 Part (a)(i). The minority of candidates achieved the mark for the correct balancing of the equation. Question 15 Part (a)(ii) to Question 15 Part (b)(iii) were well answered. In Question 15 Part (b)(iii) margarine was an acceptable alternative answer to biodiesel and was awarded the mark. A significant number of candidates could not provide the IUPAC name for product B in Question 15 Part (b)(iv) even though a prompt had been provided in the stem of the question. The calculation in Question 15 Part (b)(v) was well attempted by candidates. The most common error was the incorrect calculation of the RFM of the fat and/or ethyl hexadecanoate, and again ECF was applied in order that candidates could access some of the available marks. Questions 15 Part (c)(i) and Question 15 Part (c)(ii) were well answered.
- Q16** Question 16 Part (a) was well answered. In Question 16 Part (b)(i) each level of the Born Haber cycle was marked independently. While many candidates achieved 5 marks, the most common error was the omission of $\frac{1}{2}$ before H_2 . In Question 16 Part (b)(ii) many candidates provided 218/109 as the value of the bond enthalpy. These candidates were awarded 2 of the available 3 marks. Question 16 Part (c)(i) was very poorly answered. Many candidates incorrectly included Li in the ionic equation and were penalised. Another common error included the formula of the hydride ion being shown as H^+ . Most candidates achieved the first scoring mark in Question 16 Part (c)(ii) for correctly identifying water as an acid. Many either did not explain why water was acting as an acid or gave an incorrect explanation and therefore could not attain the second mark.

Assessment Unit A2 2

Analytical, Transition Metals, Electrochemistry and Organic Nitrogen Chemistry

Summary points

- Organic chemistry skeletal and condensed structural structures contained errors in the number of carbon atoms for skeletal formulae or the substituent groups in the middle of the chain not being in brackets.
- Question 12 addressed some inorganic chemistry and was poorly answered by many candidates, many of whom could not identify even the gas causing effervescence in Question 12 Part (b)(i).
- Organic nomenclature must have the correct spellings. There were many examples of missing letters in names which were penalised.
- When the formula of a salt formed from an amine is given with charges, both charges should be given.

Q1 – 10 The multiple-choice questions were generally well answered. Candidates appeared to be most challenged by Questions 6 and 8.

Q11 Question 11 addressed polymerisation and many candidates scored well. The organic names for the monomers for nylon-6,6 which were expected were hexanedioic acid and either hexane,1-6-diamine or 1,6-diaminohexane. Many knew the correct terms to apply to this polymer and some correctly realised that the two monomers had 6 carbon atoms to explain the nylon-6,6 name. The definition of biodegradable was relatively well answered but 'hydrolysed by micro-organisms' is expected, not 'broken down'. As with all intermolecular forces questions, Question 11 Part (a)(vi) proved more challenging with 'between molecules' often missing from the answer. The structure of the molecule formed from 3 molecules of hydroxyethanoic acid was often given as a repeating unit which was not credited. Most gained the mark for ester in Question 11 Part (b)(ii). As per last year in Question 11 Part (a)(v) and Question 11 Part (b)(ii) amide bond and ester bond were not accepted as part of the answer.

Q12 This question was related to some inorganic chemistry and an explanation of observations. Many candidates were not able to write the correct equation for the reaction of barium with water in Question 12 Part (a)(i), the oxide being a common incorrect product. The identification of the precipitates in Question 12 Part (a)(ii) was again not well answered with some gaining marks for barium sulfate but the ionic equation for its formation often left out the charge on the barium ion. The copper(II) hydroxide blue precipitate was not often seen. Credit was given for the neutral complex in place of $\text{Cu}(\text{OH})_2$. In Question 12 Part (b) several observations were given in a table and candidates were asked to identify several features. These were not well answered but some candidates did manage to identify the compounds in the solutions in Question 12 Part (b)(ii). Very few were able to suggest the identity of C or suggest an additional test.

Q13 Many candidates were able to write the ionic equation for the reaction between VO_2^+ and iodide ions in Question 13 Part (a)(i) and calculate the emf in Question 13 Part (a)(ii). Common errors were not correctly balancing the equation in Question 13 Part (a)(i) or no + sign or missing units in Question 13 Part (a)(ii). Colours of vanadium compounds were well answered in Question 13 Part (b)(i) and many correctly calculated the mass of $\text{V}_2(\text{SO}_4)_3$ in Question 13 Part (b)(ii). Common errors including not converting mg to g for calculating moles, incorrect ratio used or subtracted values being used to follow through to moles of $\text{V}_2(\text{SO}_4)_3$. Most were able to identify an oxidising agent in Question 13 Part (b)(iii) but equations were sometimes given which were not accepted. Most candidates scored well the first QWC question in the paper, describing how to measure the standard electrode potential of the Cu^{2+}/Cu half-cell. Common errors were in the set up of the copper half-cell or missing the required concentrations in both cells. In Question 13 Part (d) candidates were given electrode potentials for the alkaline hydrogen-oxygen fuel cell and many candidates responded well. The negative electrode is the electrode where oxidation occurs and this was the expected answer in Question 13 Part (d)(i). Most were able to calculate the emf and many could write the overall equation for the reaction occurring in the cell in Part (d)(ii) and Part (iii). The cell representation in Part (d)(iv) required the correct position of the salt bridge and then the other phase boundaries being correct and this was seen from many candidates. Any suitable environmental advantage was accepted in Question 13 Part (d)(v).

Q14 This question covered many of the aspects of the production of aspirin. Candidates were able to give the correct IUPAC name for salicylic acid in Question 14 Part (a). Benzoic and benzoic answers were penalised as was a missing hyphen between 2 and hydroxy. In Question 14 Part (b) many candidates were able to state the IUPAC name and give the structure of another compound which could be used in place of ethanoic anhydride in the synthesis of aspirin and most were able to explain why ethanoic anhydride is used. The ion causing the peak at $m/z=32$ in the mass spectrum of ethanoic anhydride was well answered in Question 14 Part (c). Sometimes the charge was missing or incorrect and this was penalised. The most common mistakes in Question 14 Part (d) were incorrect chemical shift ranges which was most often the alcohol peak range. Integration ratio was the most correct part of this question and a significant number thought incorrectly that there was a doublet and a quartet in the nmr spectrum as opposed to two singlets. In Question 14 Part (e), very few were able to give a correct equation for the ionisation of both the COOH and OH groups in salicylic acid. The most common errors were including OH⁻ on the left of the equation or H₂ in place of H⁺ on the right. The ligand replacement reaction was also not well answered in Question 14 Part (e)(ii) with many candidates forgetting about 2H₂O on the right or starting from Fe³⁺(aq) rather than the hexaaqua cation. Almost all candidates obtained both marks for the co-ordination number and the shape of the complex in Question 14 Part (e)(iii). Very few candidates obtained marks for the half equation for the reduction of manganate(VII) to manganate(VI) in Question 14 Part (f)(i) and oxidation was not often seen in Question 14 Part (f)(ii). The second QWC was the use of TLC to check if the reaction was complete. R_f values were given for the reactants and products and many were able to describe the process of thin layer chromatography but a significant number confused it with paper and a few with two-way paper chromatography. Very few candidates were able to explain that it was the salicylic acid spot at an R_f of 0.315 that would be missing if the reaction was complete as the question did state that the ethanoic anhydride was in excess. Procedural errors included not using the term spot, putting the TLC plate in a container filled with solvent, running until the solvent reached the top and the wrong locating/developing agent used as this was given in the question. Question 14 Part (g) dealt with a back titration involving aspirin with excess alkali. Colour changes the wrong way round were common in Question 14 Part (g)(i) and very few could explain the types of reaction occurring in Question 14 Part (g)(ii). The calculation in Question 14 Part (g)(iii) proved successful for many candidates with error carried forward to the percentage in Part (g)(iv). Many different answers were allowed for the difference in the values in Part (g)(iv). In Question 14 Part (h) most candidates were able to give the IUPAC name for gentisic acid and a few were able to successfully explain why it was more soluble in water than aspirin. A comparison was required.

Q15 The flow chart for the synthesis of dopamine from phenylalanine was given and candidates were asked to suggest the IUPAC name for phenylalanine in Question 15 Part (a). Locant numbers and the phenyl group proved challenging and the alphabetical order of substituent groups was often incorrect. The dipeptide structure in Question 15 Part (b) yielded some inconsistencies in structural formulae as the skeletal formulae were given in the flow chart in the stem. Candidates often left off hydrogen atoms if drawing as a full structural formula. Often the peptide group was correct but not circled. In Question 15 Part (c)(i) the reagents for the preparation of nitrous acid were often incorrect with the two concentrated acids required for nitration given or sodium nitrate as opposed to sodium nitrite. The equation for the reaction of phenylalanine with nitrous acid caused a few issues with many candidates using HNO_3 and nitrating the benzene ring. Observations were generally well answered in Question 15 Part (c)(iii). The decarboxylation explanation was well answered in Question 15 Part (d)(i) but almost all candidates failed to recognise carbon dioxide as the inorganic product. This seemed to be an issue with understanding the term inorganic in Question 15 Part (d)(ii). Question 15 Part (e)(i) proved straight forward with many explaining correctly why dopamine is not optically active. In Question 15 Part (e)(ii) the salt formation from dopamine and sulfuric acid proved challenging for many with incorrect skeletal and structural formulae given for dopamine (one CH_2 missing often) and the structure of the salt. It should be noted that both charges are required if given in any ionic compound including these salts. In Question 15 Part (f) many knew the reduction of nitriles with lithium but fewer were able to correctly identify the dehydration of the amide using phosphorus(V) oxide.

Assessment Unit A2 3A

Further Practical Chemistry Booklet A

Summary points

- A surprising number of candidates scored poorly in Question 1 due to poor completion of the table.
 - The mark scheme was widened in Question 2 and Question 3, with a number of alternatives being accepted, which took account of the variety of responses by candidates/centres.
- Q1** Most candidates drew an appropriate table to record results, although a significant number of candidates did not label headings/side headings appropriately using the words **rough** and **concordant/accurate**. A few candidates did not include a column to record their titre value and as a result were unable to access marks for titre calculations, or for rough and accurate calculations. A small number of candidates stated initial titre values of 50.0 cm³ which also negated titre calculation marks. The majority of candidates correctly stated values to 1 decimal place. In Question 1 Part (b) most candidates correctly used first and second accurate titre values to calculate average titre, although a common error was to not include units. The majority of candidates correctly identified the colour change in Question 1 Part (c). Since the question required a colour change, no credit was given for blue-black alone, or for colourless on its own.
- Q2** In Question 2 Part (a) most candidates were awarded 1 mark for identifying the colour change from blue to white. The mark scheme was adjusted to accept a loss of blue colour or for a colour change from blue to grey solid. Some candidates referenced the appearance of a colourless liquid or condensation, though very few referenced crackle. In Question 2 Part (b)(i) a lot of candidates did not observe a blue precipitate being formed and in Question 2 Part (b)(ii) a large number of candidates did not refer to the disappearance of the precipitate but focussed on a deep blue solution forming, despite this being worth 2 marks. Generally, the colours produced in each of the tests in Question 2 were well interpreted, with the largest issue being in identification of precipitates being formed. In Question 2 Part (b)(iv) most referred to white/cloudy solution – though quite a few did not identify this as a white precipitate. For Question 2 Part (b)(iii) the mark scheme was widened to accept purple/violet solution in response to comments from centres. Question 2 Part (b)(vi) was well attempted with most candidates accessing at least 3 of 4 marks available. Most candidates clearly stated initial and final temperatures with correct units.
- Q3** Question 3 Part (a) was very well answered. The mark scheme for Question 3 Part (b) was widened as quite a large number of candidates observed that solid X did not dissolve fully. In Test 1, the accepted answer was **colourless solution** as it was stated in the question stem, to ‘make a solution by dissolving X’ so a restatement of this did not gain credit. In Test 2, candidates were expected to state their observation using universal indicator paper and were not expected to deduce pH from their observation. In Test 4, quite a few candidates did not achieve the expected results and the mark scheme was adjusted to account for this.

Assessment Unit A2 3A

Further Practical Chemistry Booklet B

Summary points

- Calculations were well attempted with signs and units included, with significant figures being applied correctly by most candidates.
- Recall of definitions and questions that required methods for standard practical procedures were poorly answered, with many candidates failing to identify the correct equipment required for specific practical techniques.
- Candidates must take greater care with connectivity when drawing organic structures and with correct charges and notation for electronic charge when writing ionic equations.

- Q1** This question addressed the determination of the concentration of hydrogen peroxide solution by titration with sodium thiosulfate solution. Question 1 Part (a) was quite well attempted by most candidates, although quite a few were unfamiliar with the use of starch solution as an indicator in this titration, with alternative indicators, used in acid-base titrations being stated. Many candidates described the process of the titration correctly but did not gain credit as they failed to make reference to the colour changes observed, or did not mention the equipment used, in each step. Quite a few candidates confused this method with the estimation of a solution of iodate(V) ions. The ionic equation for the reaction between thiosulfate ions and iodine was well attempted with most candidates correctly stating the ratio of reactants in Part (b) (ii). The calculation was very well attempted with most candidates outlining steps in a logical sequence which allowed at least partial credit to be awarded.
- Q2** This question examined candidates' knowledge and understanding of electrochemical cells. In Question 2 Part (a) diagrams were well presented. The majority of candidates achieved at least 3 marks in this question. Most common errors were the omission of the platinum electrode in the $\text{Fe}^{2+}/\text{Fe}^{3+}$ half-cell, or the drawing of this half cell as the reduction half-cell. The calculation of emf was the least well attempted calculation on this paper. Few candidates correctly calculated the emf and included both + sign and correct unit in their response.
- Q3** This question examined the nitration of methyl benzoate. The method for the nitration of methyl benzoate was outlined and the structure of methyl 3-nitrobenzoate was provided. The equation for the production of the nitronium ion was quite well attempted. However, some candidates did lose equation marks for incorrect sign on nitronium ion and/or hydrogensulfate ion. Question 3 Part (a)(ii) was well attempted with most candidates achieving both marks. Credit was not given to responses discussing explosive products. Question 3 Part (b)(ii) was surprisingly poorly attempted despite this method being published in A2 Practical Support Document. In Part (b)(iii) candidates were expected to discuss the identification of the **pure** product. The question in Part (b)(iii) does not refer to identification of impurities and responses based on impurities were not awarded credit. Candidates did not gain credit for comparison with tabulated values. For credit, it had to be clear that the melting point of the pure sample **matched** that of tabulated values. In Question 3 Part (c) a structural equation was required as the correct structure of methyl 3-nitrobenzoate was asked for. Most candidates achieved 2/2 in this, with the most common error being the inclusion of an extra oxygen in the 3-nitrobenzoyl chloride structure (drawn as COOCl). The calculation in Part (c)(ii) was very well attempted, with the most common errors being use of an incorrect RFM or a failure to give the final answer to 2 significant figures as requested.

Q4 This question was based on the chemistry of esters and the use of spectroscopic techniques in their identification. Question 4 Part (a) asked for the identification of an acid and its conjugate base. Many candidates did identify an acid correctly for M1 but did not follow up by identifying the conjugate base of that acid for M2. For Question 4 Part (b)(i) two acids were named in the stem of the question – since candidates were asked to identify an impurity in the crude ester – a general statement of ‘acidic impurities’, was not accepted. Question 4 Part (b)(ii) was poorly attempted by a significant number of candidates. The method for the preparation of a liquid ester from a carboxylic acid and an alcohol is published in the A2 Practical Support Document. Candidates were asked to give practical details for this method and were expected to state the apparatus and techniques used to do so. To gain credit for identification of the layers obtained, candidates needed to make it clear that water was added to the solution in the separating funnel, and not after the layers had been separated. Question 4 Part (b)(iii) was well attempted. Reference for suction filtration was not accepted as an alternative to filtering/decanting. Suction filtration would not be necessary as the filtrate is the desired product, not the calcium chloride. For Question 4 Part (c)(i) the term base peak is defined on the Clarification of Terms Document and only this wording was accepted for its explanation. Most of the candidates correctly identified the base peak. In Question 4 Part (c)(ii) candidates were expected to correctly identify the fragment ions as being positively charged. In Question 4 Part (d)(i) candidates were asked to **name** the standard and so the term TMS was not accepted. Question 4 Part (d)(ii) was fairly well attempted. There are two methyl groups in methyl butanoate, therefore, candidates had to clearly state or identify on a diagram which of the two they were discussing. The question asked them to explain with reference to chemical shift which hydrogens produced the signal at A, so answers referring to spin-spin splitting did not gain credit. For Question 4 Part (d)(iii) and (iv) candidates were asked to circle the hydrogen atoms responsible; responses that circled groups, including the carbon atom attached to the correct H atoms did not received credit. Question 4 Part (d)(v) was poorly attempted. The question asked for the structure of an ester; responses that identified 2 singlet peaks – but in a carboxylic acid did not gain credit.

Contact details

The following information provides contact details for key staff members:

- **Specification Support Officer: Louise Millar**
(telephone: (028) 9026 1200, extension: 2610, email: lmillar@ccea.org.uk)
- **Officer with Subject Responsibility: Elaine Lennox**
(telephone: (028) 9026 1200, extension: 2320, email: elennox@ccea.org.uk)

