

GCE



Chief Examiner's Report
Chemistry

Summer Series 2019



Foreword

This booklet outlines the performance of candidates in all aspects of this specification for the Summer 2019 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 section on our website at www.ccea.org.uk.

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GCE CHEMISTRY

Chief Examiner's Report

Subject Overview

There was a feeling amongst examiners that this AS level cohort was slightly weaker than last year. CCEA has provided a list of definitions (Clarification of Terms document) and examiners tend to insist on most of the definition being exactly reproduced in an answer. The result of CCEA providing this type of support is that more questions based on knowledge are better answered. The standards of previous years was maintained at A2 level.

There has always been a problem with the use of the word solution. When dealing with reagents, it is not sufficient to say add "sodium hydroxide" without the word solution. Sodium hydroxide is a corrosive solid and would never be used in a practical exam situation.

Examiners have had a sympathetic view with regard to the problems faced with the introduction of significant figures into this specification. The marks awarded for significant figures were phased into the examination process and due warning was given in previous Chief Examiner's reports and in examination papers which stated the number of significant figures to be used. Candidates continue to lose marks by not using significant figures correctly.

Candidates have for many years presented additional i.e. superfluous material in their answers to extended writing questions. When a detailed mark scheme is produced, there are often additional answers which are not relevant provided by candidates. Sometimes these are penalised and sometimes they are not, depending on the question asked.

Assessment Unit AS 1 Basic Concepts in Physical and Inorganic Chemistry

Overview

The paper allowed all candidates to access marks. The mean for the paper was down 2.8 marks out of the total of 90 marks when compared to the 2018 series. Candidates coped well with unstructured calculations which were introduced at AS in this new specification. Many candidates struggled with definitions and chemical observations which was surprising given that both are supplied in CCEA support material. Candidates understanding of the use of significant figures varied and many lost marks for not quoting final answers to the appropriate number of significant figures, which is usually the same as the number of significant numbers in the least accurate value quoted in the question.

- Q11 (a)** This part was answered well by candidates, the shape was well known and well explained.
- (b) (i)** This part was discriminating as a number of candidates failed to realise that one of the covalent bonds was a coordinate bond or failed to include the lone pair of electrons on oxygen.
- (ii)** Most candidates only scored one mark in this part, for stating that there is only one lone pair of electrons in the ion. Many simply made a statement that lone pair-lone pair repulsion is greater than lone pair-bond-pair repulsion which is greater than bond pair-bond pair repulsion; this was not credited for the second mark as it did not explain the change in bond angle with reference to the ion.
- (iii)** Only a small minority of candidates correctly answered this part, which was

one of the most poorly answered questions on the paper.

- Q12 (a) (i) to (iii)** Given that the three definitions are straightforward and first encountered at GCSE, they were marked with strict adherence to the CCEA support material (Clarification of Terms document). A number of mistakes/omissions were noted when marking these question parts, including: using the term “amount” instead of “number”, using the term “element” instead of “atom”, stating that isotopes (plural) are “an atom which.”
- (b)** Most candidates scored both marks in this part.
- (c)** Most candidates scored the mark in this part. Reference to the fact that the element ends in -ine was not credited.
- (d) (i)** This definition has not been previously asked although it is given in the CCEA support material. It proved to be discriminating as only the most able candidate scored in both parts.
- (ii)** Most candidates coped well with the calculation and scored full marks.
- Q13 (a)** The equation proved to be discriminating, as expected. Many candidates stated the correct formulae but did not balance the equation correctly. Some candidates stated the formula of nitrogen(II) oxide, despite the question stem which stated the oxide that was produced.
- (b) (i)** Well answered by almost all candidates.
- (ii)** Generally well answered by most candidates.
- (c) (i)** Many candidates had difficulty with this part. Many referenced the difference in electronegativity between gold(III) and chloride which was not credited whilst others attempted to answer the question with reference to data.
- (ii)** As with definitions, chemicals tests were marked with strict adherence to the CCEA support material (Acceptable Colours document). Many candidates failed to score both marks here as they omitted parts of the test, such as concentrated or solution.
- Q14 (a)** This part was well answered. A small minority of candidates stated that the sodium atom’s outer electrons (plural) reside in an s-orbital which is incorrect.
- (b) (i)** Another definition which has not been previously asked and which was answered very poorly by most candidates.
- (ii)** This part proved to be discriminating. Many candidates divided by the RAM of sodium rather than the RFM of sodium chloride. Many also did not quote their final answer to the correct number of significant figures.
- (c) (i)** Generally well answered by most candidates.
- (ii)** Generally well answered by most candidates.
- (iii)** The colour of the ion was well known by almost all candidates.
- (d)** A number of omissions from this standard chemical test resulted in a significant number of candidates losing marks in this part. Whilst reference to the use of ammonia was not required, many candidates gave additional information which often had mistakes.
- (e)** The test for the carbonate ion was generally well answered, although some candidates did not refer to the first scoring point.

- (f) (i) It was very surprising to see how many candidates thought that magnesium chloride is covalently bonded. Others lost marks for omitting charges or for not drawing two chloride ions.
- (ii) This equation was more discriminating than expected, with many confusing the valencies of sodium and magnesium.
- (iii) The calculation was generally well answered with any error in the previous part carried forward to this part.
- Q15 (a)** Generally well answered, although some candidates also referenced the exceptions to the general trend which was penalised. Candidates should be reminded to read and understand questions before answering.
- (b) (i) Well answered by most candidates.
- (ii) Well answered by most candidates.
- (c) This question was surprisingly one of the most poorly answered questions in this paper. Given that the content is not new to the specification and that the question assessed a fundamental aspect of chemistry, it was expected that candidates would score much better. Many different errors were noted when marking this question.
- Q16 (a)** Generally well answered by most candidates.
- (b) Candidates coped well with this unstructured calculation. The main error was that candidates did not multiply by two, despite correctly stating the formula of lead(II) iodide in the previous part.
- (c) (i) Generally well answered.
- (ii) Generally well answered.
- (d) (i) Whilst the observations were well known by most candidates, many gave additional answers which were incorrect and were penalised.
- (ii) This part, which assessed a new area of the specification, was not well known by candidates.

Assessment Unit AS 2

Further Physical and Inorganic Chemistry and an Introduction to Organic Chemistry

Overview

Senior Examining teams are tasked with writing new questions if and where possible. Feedback highlighted that there were too many new questions with unfamiliar contexts in this AS 2 paper. Some assistant examiners felt that some candidates struggled for time in this exam but there was no evidence of candidates not being able to complete the paper in the allocated time. There were several new questions in the Multiple Choice section which cost candidates time to complete Section B. It may be a consideration to advise candidates to leave the Multiple Choice Section A to the end.

- Q11 (a)** The equations for the reactions of nitric acid with calcium, calcium oxide and calcium carbonate were not done as well as was expected. The reaction of Group II metals and their compounds with acids is in the AS 2 specification. However, candidates made many mistakes with the formulae of the compounds involved. Naturally there was the problem with using an incorrect monovalent ion for calcium.
- (b)** It was expected that this equation would be far more difficult than the equations in Part (a) and this proved to be the case. A very wide variety of equations were produced. There was only one mark for the equation and hence, if the equation was not balanced, the mark was lost.
- (c) (i)** Thermal stability is mentioned in the specification in Section 2.11.6: “state the trends in thermal stability of the carbonates and hydroxides”. Consequently it was disappointing to see that only a minority of candidates were able to either state the definition or to deduce it. There were two words so there needed to be an explanation of ‘thermal’ and an explanation of ‘stability’. Even if the explanation of these two words was correctly given, there was still a problem with applying it to the correct species. Some candidates restated carbonate from the specification but unfortunately this had to be penalised because a nitrate was being heated. Some candidates said that an atom was being decomposed by heat which is impossible, although all other species were accepted.
- (ii)** The question asking why thermal stability increases down a group has been asked many times. In this case, the mark was reduced to one but the performance on this familiar question was not as good this time.
- (d) (i)** Quite a few candidates thought that the metal nitrate heated was magnesium nitrate. It was accepted that all of the group II oxides produced alkaline solutions. A majority of candidates obtained the mark.
- (ii)** The calculation of the volume of gases produced by heating strontium nitrate was subject to the usual problems. It was not possible to obtain any marks if the formula used for strontium nitrate was SrNO_3 . Many candidates calculated the volume of gases separately and then added them together i.e. they calculated the volume of NO_2 and O_2 separately and then added them together. As with many calculations a major problem was the use of significant figures. The question said that 3.6 g were heated, i.e. the

number of significant figures was two. This meant that the answer should have been 1.0 dm^3 and not 1.02 dm^3 which meant that candidates lost a mark for this error. A common answer was obtained by multiplying $3.6/212$ by $24 = 0.4075 = 0.408 \text{ dm}^3$ and this should have been written as 0.41 dm^3 .

- (iii) This question was poorly answered. The equation for the decomposition of the nitrate produced the gases NO_2 and O_2 . Section 2.3.5 of the specification deals with oxides of nitrogen produced in car exhausts during the combustion of alkane fuels. There are only two gases produced but candidates could not deduce that the gas collected in the test tube was oxygen and that nitrogen dioxide, being an acidic gas, would have caused the Universal Indicator to give a red colour. Many gases/compounds were quoted which could not be formed e.g. chlorine.
- (e) The graph was accurately plotted by all candidates and the deduction of the temperature at which rubidium and strontium nitrate had the same solubility was correctly made.
- Q12 (a)**
- (i) C-H bond energy had not been provided in the question. It was not needed as the same number of C-H were both broken and formed so they cancelled out. This question was designed to stretch the top candidates. However, the majority of candidates managed to gain marks. The calculation was quite discriminating. Only better candidates managed to gain full marks.
- (ii) Naturally, candidates obtained both positive and negative values for the enthalpy change but seemed to have difficulty in knowing how to draw the diagram. The enthalpy value for the reaction was written in many different places apart from the correct one i.e. on the y-axis.
- (b) (i) The definition of a polar bond was reasonably known. It should have been an essential item of knowledge in a question that dealt with the addition of polar molecules to unsaturated bonds.
- (ii) The polarity of a hypochlorous acid molecule could have been deduced from the variation of electronegativity in the Periodic Table or it could have been deduced from the actual structure of the product $\text{CH}_2\text{ClCHOHCH}_3$ i.e. the Cl is delta positive because it adds first to produce the carbocation in the middle of the chain. Only a minority obtained the correct answer.
- (iii) The mechanism was well drawn on the whole. Even if the polarity of the hypochlorous acid molecule was incorrect, it was still possible to obtain maximum marks for the mechanism. A common error was to have an intermediate with two positive charges being attacked by two species which was obviously not viable.
- (iv) The naming of the organic compound was well done. Two names were in the mark scheme. The name 1-chloropropan-2-ol was far more popular than 1-chloro-2-hydroxypropane. Names such as 2-chloropropan-1-ol received no marks.
- (v) The structure of the minor product was well known and of course was very similar to the actual product. Some candidates actually repeated the major product the wrong way round. However, there were quite a few structures which had the chlorine and hydroxyl group on the same carbon atom. The reason for the formation of the minor product was well known. It was not possible to gain this mark if the Cl and OH groups were on the same carbon atom.

- (vi) This question was expected to be difficult. The correct answer of the nitrite ion reacting with the carbocation was very rarely seen. The nitrite ion was often described as a nitro group which lost the mark.
- (c) (i) The term “bifunctional” has been examined before. This unit deals with functional groups. Despite this factor, the most common answer was that the molecule had two functions.
- (ii) The reaction scheme offered marks for all candidates and was very discriminating. The reaction with phosphorus pentachloride was the best answered followed by the reaction with hydrogen bromide. A common error was to react $\text{CH}_2\text{ClCHOHCH}_3$ with potassium cyanide and sodium hydroxide and not replace the chlorine atom.
- Q13 (a) (i)** This question was relatively simplistic, involving something that has been asked many times before in practical chemistry questions but in a different context. All the numbers were given to calculate the solubility of terpineol in water. Unfortunately for many candidates, the question was phrased to ask what would be observed on adding 1.1 g of terpineol to 200 cm^3 of water. The question content should have been familiar to candidates when they were preparing organic chemicals but many candidates failed to try to answer the question. For those who did answer, the necessity for significant figures was suspended as was the need to state the units g and cm^3 in their answers. Candidates could state how many grams dissolved or did not dissolve or state how many cm^3 dissolved or did not dissolve. Density calculations were also allowed. Marks were lost when some candidates said that some terpineol would exist as a solid.
- (ii) This question had been phrased to show the sequence that should be used to purify the terpineol. There was nothing surprising about this question, it was a standard procedure to purify a substance obtained by synthesis. However, there were many fundamental mistakes. Despite the emphasis on separation, many candidates thought the funnel was a normal filter funnel and attempted to separate the terpineol by paper filtration. Distillation was next. However, many candidates were not clear what they were distilling and did not name what was collected. It was acceptable to distil more than once but then few candidates were clear why they did so. A problem with quite a few candidates was that they wished to obtain all the terpineol, not realising that this was futile because of the loss of terpineol in the purification steps. Very few candidates could correctly follow this method of separation. The usual problem was found with drying the terpineol if it was carried out using the separating funnel. The question did provide help by saying that drying should follow distillation. Overall, the question was well done by capable candidates and was highly discriminating.
- (b) (i) There were two parts to this question which was not always recognised. The reasons why molecules absorb infrared radiation are stated in the specification and should have been better known. An explanation of why infrared spectra were produced simply involved the mention of absorption at a wavelength or frequency or wavenumber, but this was rarely given as an answer.
- (ii) This question was highly discriminating. First of all, candidates misinterpreted functional groups including the range of wavenumbers for a C-H “bond” and a C-C “bond”. Candidates’ understanding of infrared spectra could be improved. The absorption for C=C was very weak and

candidates were not attracted to it but it was there in the spectrum. Often the aromatic double bond was quoted. But the vibration for a bond with two carbon atoms combined with a double bond would be expected to be weak. The identification of the –OH group was far better but often lost marks by mention of the C-O bond for *other functional groups*.

- (iii) Despite this being a common past paper question, candidates still do not simply state that samples should be compared. A pure sample of terpineol will produce an infrared spectrum identical to a sample of terpineol “free from all impurities”. Although comparing the fingerprint section of terpineol with another spectrum is acceptable, there is little difference in comparing the two spectra with each other. It was common that candidates mentioned comparing the infrared spectrum with a database, but then there was no mention of what the result of the comparison was. It does seem that there is confusion between obtaining a melting point and comparing it with known data and obtaining an infrared spectrum and comparing it with “known data”.
- (c) (i) A vast majority of candidates were able to correctly deduce that the alcohol was tertiary giving a good explanation.
 - (ii) The question asked for what would be observed when terpineol was added to acidified potassium dichromate(VI). Although most candidates realised that no reactions took place, a small minority omitted to mention the lack of a colour change. Naturally, those that had stated that the alcohol was primary or secondary were rewarded with a colour change from orange to green.
- (d) This question proved to be very difficult for candidates. Many drew a non-skeletal structure but the structure was incorrect in many cases. However, a very small minority of candidates obtained the correct structure. Many candidates left a blank answer. Those that did answer usually gave a structure that had the double bond on the other side of the original double bond. This was the same as the original structure because of the rotation about the single bond.
- (e) (i) The term “unsaturated” is in the CCEA Clarification of Terms document and should have been better known. The problem with the definition is that it refers not only to the carbon-carbon double bond but also to the triple bond. Whilst the majority obtained the mark for the definition, many candidates lost the mark because they did not mention the triple bond.
 - (ii) The use of bromine water to test for unsaturation has been asked at both AS and A2 levels on a very regular basis. Most candidates obtained two marks. It was essential for candidates to shake the bromine water with the alkene. This will work with gaseous alkenes and liquid alkenes. It was not acceptable to pass the alkene through the bromine water.
 - (iii) Similarly, catalytic hydrogenation was not well answered despite it being very well known in the past. Hydrogenation refers to the addition of a hydrogen molecule across a carbon-carbon double bond but many candidates wished to use their own definition such as the reaction of an alkene with hydrogen to form an alkane or ventured into explaining what catalysis was. Compared to former years, the naming of the catalyst was extremely disappointing. In other years, the catalyst was named as nickel and almost without fail as finely divided nickel. This year, an enormous range of catalytic substances were named.

- (iv) This question fitted well with the concept of hydrogenation and molar volume. Similar questions have been asked before, yet only a minority of candidates made a reasonable attempt and only a few obtained the correct answer. In this question, there was no issue with significant figures.
- Q14 (a)** This question has been asked several times before. Although the majority of candidates drew the correct distribution curve, there were the usual problems of placing the curve to the left of the original curve and having a peak lower than the original. Occasionally, there were problems with drawing the new curve through the origin. Otherwise, the two marks were normally obtained.
- (b) Normally, the mention of the word 'kinetic' coupled with energy was sufficient to convince examiners to credit the mark. Too many answers simply stated that energy was similar to, or the same as, speed.
- (c) It was not possible to accurately distinguish between the mathematics and the chemistry of candidates' answers. Mathematically, at point 0,0 there are no molecules and no energy. However, in the mixture of gases the molecules could not disappear. A typically rewarded answer was, "no molecules have no energy".
- (d) Answers that were accepted included:
- "Particles can only have a maximum amount of energy"
 - "there are no particles with that energy (level)"
 - "the maximum energy a particle will have"
 - "there is an upper limit to the energy/speed"
 - "no particles have an energy greater than that point"
- "Particles can't have a maximum amount of energy" was an incorrect answer. The examiners were not in favour of accepting the mathematical aspects of the graph.
- (e) (i) The definition of 'activation energy' is in the CCEA Clarification of Terms document and it was well answered. The major error was to omit the word 'minimum'.
- (ii) Candidates will have, throughout their chemistry career, added silver nitrate solution to a solution of a chloride and seen that silver chloride is precipitated instantly, if not, very quickly. They should also know that the reaction is between ions. Yet, almost half of the candidates thought that the reaction was slow, whilst many thought that the reaction was "quite fast" or "quite slow". Many candidates referred to molecules.
- (iii) The effect of a catalyst on activation energy was well known. It was sufficient to say that it was lowered, or was less, or reduced. A small number referred to the fact that "it moved to the left" meaning that the symbol E_a on the Maxwell-Boltzmann distribution curve moved to the left on the x-axis.
- (f) (i) Although the Contact process was widely known, a significant number of candidates quoted the Haber process.
- (ii) Although questions have frequently been asked about the conditions for the Contact process, this question was somewhat unusual in asking about conditions having mentioned the Maxwell-Boltzmann distribution curve. Consequently, the mark scheme was different to the usual one:

Temperature

A temperature of 450 °C is the quoted temperature in books although a range of temperature(s) from 400-450 °C was accepted. Added to this was a “high” temperature. Most candidates obtained a correct temperature but the explanation for the condition was variably tackled. Answers varied from equilibrium arguments to activation energy arguments to those based on the Maxwell-Boltzmann distribution curve.

Pressure

Pressure answers were not as well known as temperature answers. If high pressure was quoted, which was incorrect, there was usually a “correct” reason e.g. fewer gas molecules on the RHS of the equilibrium equation. Answers such as ‘high pressures being dangerous’ were not accepted.

Catalyst

There were the usual variations of the catalyst, vanadium pentoxide i.e. vanadium(V) oxide and vanadium oxide, which were accepted. If the Haber process had been stated in Part (f)(i), then iron was accepted as the catalyst. In line with the Maxwell-Boltzmann distribution, it was often stated that the catalyst provided an alternative path of lower activation energy. Very general statements on catalysis were ignored by examiners.

Assessment Unit AS 3 Basic Practical Chemistry

Overview

Booklet A

The style of this paper was different than in previous examination series. It provided candidates with the opportunity to carry out a variety of practical tasks including practical tasks new to this specification. The mean mark for this paper was down 4.5 marks from last year. It was a discriminating paper and was more demanding for Grade E candidates than in previous series.

Booklet B

Candidates generally coped well with the practical theory paper and all candidates were able to access marks. The mean mark for this paper was the same as it was in 2018, indicating that this paper was of a similar standard.

Booklet A

- Q1**
- (a)**
- (i)** This question was well answered by the majority of candidates.
 - (ii)** Few candidates scored all three marking points. Only a minority of candidates recorded that there was more fizzing at the negative electrode.
 - (iii)** A significant number of candidates did not gain this mark. Despite the stem of the question indicating that candidates should provide an explanation based on the observations recorded in Parts (a)(i) and (a)(ii), many responses referenced only the observations made in Part (a)(ii).
- (b)**
- (i)** This question was well answered with the majority of candidates recording the presence of “droplets of a colourless liquid” or an acceptable alternative answer.
 - (ii)** This question has been asked in previous AS practical papers. The standard of responses provided was excellent.
- (c)**
- (i)** This question was a good discriminator. While the majority of candidates recorded “effervescence/bubbling”, few recorded the appearance of a “blue precipitate”.
 - (ii)** Overall the standard of responses was very good. A minority of candidates did not follow the instructions provided in the question and consequently they did not record the correct observation.
- (d)**
- (i)** This question was discriminating as many candidates only recorded one observation.
Many candidates correctly observed “effervescence” but few recorded the accompanying disappearance of the residue.
 - (ii)** This question was well answered.
 - (iii)** This question was well answered.
 - (iv)** The standard of candidates’ responses was excellent with only a very small number providing an incorrect flame colour.
- Q2**
- (a)** This question was a useful discriminator. Candidates were required to record two observations with liquid X to gain the first mark and many did not. Therefore a significant number of candidates gained one mark in this question.

- (b) (i) Overall the standard of responses was excellent. However, some candidates recorded more than the required two observations. If this included incorrect observations, candidates were penalised.
- (ii) In order to gain the mark, candidates had to provide a comparison in their answer. A significant minority of candidates lost the mark for not answering fully the question that was asked.
- (c) (i) Overall the standard of responses provided was good. The mark scheme did require two observations to gain one mark and in a minority of cases, only one observation was included negating the mark being awarded.
- (ii) The standard of responses was excellent.
- (iii) This question proved to be discriminating with only the most able candidates gaining both marks. Many candidates recognised that liquid Z was immiscible with water. Many did not recognise that liquid Z did not decolourise iodine and therefore did not react with it.

Booklet B

- Q1 (a) (i) This question was well answered.
- (ii) The majority of candidates only scored one mark for this question as their responses highlighted the reduction of carbon in carbon dioxide. The failure to read the question properly obviated gaining the second mark.
- (iii) This question was well answered by the majority of candidates. However, a minority of candidates failed to recognise that increasing the temperature would increase the number of particles with sufficient activation energy to react. As a consequence of this they did not gain the second mark.
- (iv) A discriminating question with only the most able candidates gaining this mark.
- (v) This question was very well answered.
- (vi) This is a familiar question in AS 3 papers and the standard of responses provided was excellent.
- (b) The calculation was extremely well answered with the vast majority of candidates scoring all three marks.
- (c) (i) This question was very well answered.
- (ii) This question was very well answered.
- (d) (i) The standard of responses provided was excellent with the majority of candidates gaining the mark.
- (ii) This question was poorly answered. Often the responses provided were vague and listing was an issue.
- (iii) This question was discriminating as only the most able candidates gave an answer to an appropriate number of significant figures.
- (iv) This is a familiar type of question both on AS 2 and AS 3 papers. However, a significant minority of candidates struggled with this calculation. Only the most able candidates provided an answer to an appropriate number of significant figures.
- (v) This question was a useful discriminator. Many candidates provided an incorrect response based on copper oxide being formed.

- (vi) This question was poorly answered. While the majority of candidates recognised that ethanol had more bonds than methanol, they incorrectly related this to an increase in strength of Van der Waals' forces.
- Q2**
- (a)**
- (i)** This question was well answered by the majority of candidates. A minority of candidates provided an incorrect equation based on the formation of sodium sulfate.
- (ii)** The standard of responses provided was very good.
- (iii)** Although a diagram of the apparatus used was provided, few candidates answered this question correctly.
- (iv)** This question was well answered.
- (v)** This question was well answered.
- (b)**
- (i)** This question was discriminating. Only the most able candidates provided a correct response.
- (ii)** The test for chloride ions is well known and this question was answered very well.
- (c)**
- (i)** This question was well answered.
- (ii) & (iii)** Few candidates understood the concept of the reaction occurring and therefore few gained these marks.
- (iv)** This question was well answered.
- (d)**
- (i)** The calculation of empirical formula was well answered by the majority of candidates.
- (ii)** This question was discriminating. The more able candidates provided a correct response while less able candidates struggled with this question.
- (iii)** Candidates who provided a correct response to Part (d)(ii) gained this mark. Few candidates with an incorrect RMM were able to provide a molecular formula.
- (iv)** The standard of responses provided was disappointing.
- Q3**
- (a)** This definition was well known and the standard of responses provided was generally excellent.
- (b)** This question was surprisingly very poorly answered. Many candidates provided a suitable drying agent but did not outline the practical procedure in sufficient detail.
- (c)** Most candidates were able to carry out the calculation but few provided an answer to the correct number of significant figures.
- (d)** This question was well answered.

Assessment Unit A2 1 Further Physical and Organic Chemistry

Overview

This unit covers the areas of Further Physical and Organic Chemistry building upon many of the concepts introduced in AS 2. The examination contained a significant number of calculations which reflects the importance of mathematics within the area of Physical Chemistry. A result of these questions was that significant figures were an important consideration across this examination. Candidates are still adapting to the importance of significant figures in GCE Chemistry exams.

Compared to the Summer 2018 series, the mean for this paper was down 0.8% suggesting that the performance was very similar 'in both series'.

In the Multiple-Choice section, Question 1 caused some problems amongst candidates of lower ability. These candidates frequently incorrectly suggested there were 6 sigma bonds in benzene as opposed to 12.

- Q11 (a)** The definition of entropy was almost universally well known.
- (b)** The calculation was well performed and the units were given correctly. In this question, the vast majority of candidates gave the correct number of significant figures.
 - (c)** Candidates reasoned through the impact using a liquid would have on an entropy change and stated their answer clearly. Only a small minority lost a mark due to their explanations.
 - (d)** This definition was also known by almost the entire candidature. Very few candidates used the "less than" or "equals" symbol.
 - (e)** This calculation was well performed by almost all candidates, however significant figures proved to be a problem here. Candidates are reminded that they should check their numerical answers for the correct number of significant figures.
- Q12 (a)**
- (i)** The correct name for this aromatic compound was very well known by the candidature.
 - (ii)** This question, which assessed the quality of written communication, followed closely the general guide provided in the practical support document. Candidates adapted their answer well to the specific question context. In this part, very few candidates lost marks due to additional incorrect detail.
- (b)**
- (i)** Almost all candidates stated the order correctly.
 - (ii)** Although this question was a relatively straightforward calculation, many candidates lost at least one mark here. There were three areas where candidates frequently dropped this mark. Again, significant figures were a problem, but additionally candidates did not correctly transfer units or numbers from the table.
 - (iii)** The effect of temperature on the rate constant is in section 4.3.8 of the specification. The answers given by most candidates were simple short answers and the mark scheme was adjusted to accommodate this.
- Q13 (a)** The chiral centre was correctly labelled by virtually all candidates.

- (b) This definition was well known; however, a number of candidates provided an answer based upon the definition for 'optically active' rather than of optical isomers.
- (c) The stereospecific nature of receptor sites is in section 4.6.6 of the specification. However, this knowledge was not well known by the majority of candidates.
- (d) Both the definition of a racemic mixture and the explanation for the lack of optical activity were well understood and well communicated by the candidates.
- Q14** (a) Advantages and disadvantages of pH meters were well known and many valid examples of both were provided.
- (b) The selection of appropriate indicators was asked many times in previous past papers. This was reflected in the high standard of answers to this question.
- (c) The nature of the salt was well known, and the explanations frequently matched the answer sought in the mark scheme.
- Q15** (a) The equation for the formation of tripalmitin was correctly given by most candidates.
- (b) Most candidates were able to recognise that tripalmitin is saturated. However, very few candidates gave an explanation based upon the structure of tripalmitin specifically.
- (c) The definition of transesterification was very well known.
- (d) Although the definition of transesterification was usually correctly stated, many candidates had problems applying this to the writing of an equation and a wide array of incorrect answers were observed here.
- (e) The identification of the molecule that could be used as biodiesel was usually correctly given by candidates who got Part (d) correct. Error was carried forward for those who got Part (d) incorrect, however, many of these candidates had problems identifying which of their products would be suitable.
- Q16** (a) The standard of the answers for the mechanism for the electrophilic substitution of an aromatic molecule was high. The quality of curly arrows in mechanisms showed an improvement upon previous years, although leniency in the marking of the curly arrows was still applied. A tutorial on mechanisms is now available on the CCEA Chemistry microsite.
- (b) The structure of the intermediate was well answered by most candidates, but a significant minority of candidates gave an answer that had one less electron than necessary.
- (c) This part proved highly problematic for almost all candidates with few correct answers being seen. This was surprising as Part (a) had performed an acylation with an acyl chloride so it was believed candidates would benefit from that in the generation of their answers. However, the answers showed little evidence of this.
- (d) The concept of the aromatic compound losing stability was well understood and correct answers to this question were very common.
- Q17** (a) (i) The expression for K_w was produced correctly by almost all candidates.
- (ii) This question has not been asked in recent years but the mark scheme included a number of alternatives. Despite this, very few candidates were able to provide a suitably expressed explanation.
- (b) (i) This calculation was performed correctly by the vast majority of candidates.

- (ii) The response to this question was poor overall. Most candidates looked at the pH and seeing a value below 7, stated that water was acidic. This was despite the fact that almost all candidates had previously set the concentration of H^+ and OH^- as being equal in the calculation. Candidates who did correctly identify water as being neutral were almost always able to provide a suitable explanation.
- (iii) This calculation caused a number of problems and the response here was the weakest of all the calculations in the examination. Candidates who lost marks typically made one or more of the following errors: not doubling the moles of OH^- due to the dibasic nature of barium hydroxide, not dividing by the volume to find concentration, not using the value of K_w provided in the question.
- (c) (i) This part was correctly calculated on the whole. The most common mistake was candidates calculating the moles of OH^- but then not subtracting this from the original moles of acid, inserting the initial moles into the K_a expression.
- (ii) Suitable equations and explanations were frequently given for the effect of adding acid.
- Q18** (a) This question was synoptic with the AS 2 unit. The answers were varied, although many candidates obtained at least one mark.
- (b) This question was well attempted with most candidates able to give suitable detail in their explanations. However, a significant minority felt the compromise was between rate and cost and failed to correctly consider the exothermic nature of the reaction.
- (c) The expression for K_c caused very few problems to the candidates.
- (d) The calculation of the moles of oxygen was very well attempted. The most common errors were in either significant figures, or in not realising that the amounts given were equilibrium amounts which led to candidates introducing errors into the calculation.
- Q19** (a) (i) The equation for the lattice enthalpy of calcium chloride was well known with few errors.
- (ii) Most candidates were able to answer this question succinctly and correctly, however, language caused a problem for some candidates who did not make it explicit that they were talking about ions.
- (b) (i) This simple energy level diagram posed very few problems for candidates.
- (ii) Similarly, the calculation of the enthalpy of hydration was performed correctly by the vast majority of candidates.
- Q20** (a) (i) Candidates almost always correctly stated that the isomer was the E isomer. However, very few followed this up with a correct explanation. Many candidates gave a definition of geometric isomerism rather than an explanation.
- (ii) This preparation was well known with candidates reproducing relevant details from the CCEA practical support document. Some candidates did lose marks by introducing incorrect steps such as refluxing or distillation.
- (b) The equation for reduction of the aldehyde group was well known with very few candidates also reducing the carbon-carbon double bond.

- (c) The explanations for the difference in melting points were frequently of a very high standard. The majority of candidates was able to express which intermolecular forces were present and make a suitable comparison.
- Q21** (a) The equation for the hydrolysis was given correctly by almost all candidates.
- (b) The chemical test for hydrogen chloride caused problems and this question produced some of the weakest responses on the paper. Candidates frequently omitted that the ammonia needed to be in solution and concentrated. Additionally, candidates often included the terms 'misty' or 'steamy' in their description of the observation.
- (c) (i) The equation for the reaction of ethanoyl chloride and ethane-1,2-diol was produced correctly by the majority of candidates. Examples where candidates reacted in a 1:1 ratio were awarded one mark.
- (ii) The calculation of percentage yield caused few problems apart from the use of significant figures, which as mentioned previously, caused problems in this examination.
- (d) This question was mostly well answered, however, some candidates provided a second or third advantage which was a variation of the previous explanation. Furthermore, some candidates offered incorrect answers which resulted in the deduction of marks.
- (e) The formula of phosphorus(V) chloride was well known, but a number of variations of the name were observed and the mark scheme was adjusted to take account of this.

Assessment Unit A2 2

Analytical, Transition Metals, Electrochemistry and Organic Nitrogen Chemistry

Overview

The paper was successful in allowing candidates of all abilities to complete the paper. All questions were answered correctly by some of the candidates and no candidate answered all the questions correctly. There was a wide range of marks with the more able candidates being stretched and rewarded for their knowledge and understanding and weaker candidates were able to answer more straightforward questions.

There is a problem with the use of significant figures, with most candidates failing to use them correctly. The candidates had sufficient time to complete the paper and the language used in the questions was appropriate to the candidature.

- Q11 (a) (i) & (ii)** Most candidates gained both of these marks. Errors tended to be when candidates failed to circle the full group. A few candidates circled the carboxylic acid group instead of the ester.
- (b)** Candidates were expected to refer to the structures at the start of the question and apply the term to the structures. Many were able to do this successfully. A number of candidates incorrectly referred to the alpha-helix in enzymes.
 - (c)** The concept of optical activity was well understood and well answered. Some candidates described them as having asymmetric centres, implying that both amino acids had more than one asymmetric centre and this was marked as a CON (contradiction).
 - (d)** More able candidates recognised the question related to the ratio of $-\text{COOH}$ and $-\text{NH}_2$ groups and answered accordingly. Some candidates only referred to the aspartic acid or the phenylalanine and were penalised accordingly.
 - (e)** This was generally well answered with most candidates gaining both marks. A few candidates only drew one structure.
 - (f)** The mark scheme required a named strong acid or base and this was generally what was given. Examiners did not accept HCl as a strong acid unless it was clearly shown to be aqueous. Weaker candidates gave water as the agent.
 - (g)** Whilst most candidates gained some marks, overall, this question was poorly answered. Frequent errors included; no named solvent, use of paper instead of a TLC plate, no lid, no explanation regarding methanol and no comparison. The lack of comparison when identifying substances is very common and this type of question is generally poorly answered.
 - (h)** Few candidates gained both marks. Most referred to either the temperature or the pH but seldom both and so most candidates only gained one mark.
 - (i)** This was poorly answered. Most candidates recognised the stereospecificity of the binding site but then went on to describe the mechanism of an enzyme. This was seen as a CON and penalised accordingly.
- Q12 (a) (i)** This was generally well known, although some strange substances such as sodium did appear.
- (ii)** This was generally well answered. Some candidates lost the mark for failing to use the word 'solution'.

- (iii) Most candidates got one mark for the completion of the circuit. Explanations involving electrons flowing in the solution were marked as a CON.
- (b) (i) Most candidates gained both marks. The unit on its own gained no marks.
- (ii) This was a new question with many possible errors. Each error was penalised once e.g. missing (aq) was carried forward. The most able candidates gained both marks but the least able candidates gained no marks.
- (iii) This was very well answered with state symbols often included when missing in the previous part.
- (iv) The direction of the electron flow was often correct but only the more able candidates were able to give a correct explanation.
- (c) (i) to (iv) Despite many years of practical exams and Chief Examiner reports, many candidates still do not use solutions when describing precipitation tests. This error was carried forward through each part. A surprising number of candidates described the use of thiocyanate ions as a test for iron(III) ions, this was accepted by the examiners. Starch solution was often incorrectly used to identify iodide ions. The colour change for starch with iodine sometimes implied the starch changed colour from yellow/brown to blue-black, this was marked as a CON.
- Q13** (a) (i) This was well understood. The most common errors were the omission of the same molecular formulae or stating that they have the same molecular and structural formulae but the functional group is in a different position (not realising the contradiction).
- (ii) The candidates who read the question and applied the information to oleic acid gave the correct answers. Some candidates simply drew the structures of auric acid and adipic acid. A good discriminator.
- (b) (i) Candidates still fail to identify this type of question as referring to intermolecular forces and that the forces need to be applied to both structures. Weaker candidates performed poorly on this question. Incorrect answers included reference to branching and no explanation being applied to the ester.
- (ii) Few candidates recognised this as a question on volatility, only the more able candidates gained the mark.
- (iii) Many candidates correctly identified the area under the peaks but failed to describe how to turn this into a percentage and so lost a mark. Weaker candidates referred, incorrectly, to retention times.
- (c) (i) The repeating structure was generally well known. Some candidates lost a mark for indicating more than one unit. Others lost a mark for having NH- and -COO on the same end rather than one correctly at each end.
- (ii) This is a definition directly from the Clarification of Terms document and so this was required by the examiners in its exact form. Well answered by the more able candidates.
- (iii) This was application of knowledge and reasonably well answered, more able candidates referring to amino acids and peptides.

- (iv) This was application of knowledge and was well answered by most candidates. Incorrect diols were penalised once and errors carried through. Most candidates gained at least one mark.
- (v) Questions similar to this have been asked in the past and this was well answered. A few candidates mentioned ester groups as well as amide groups and were penalised accordingly.
- (d) This was very well known from the support materials and many candidates gained full marks.
- Q14 (a)**
- (i) This type of question has been asked before, but it continues to be very poorly answered by all candidates. There were few examples of two marks and most candidates got no marks.
- (ii) Again, this was poorly answered with many candidates getting no marks and only a few gaining both marks.
- (b) This was only well answered by the more able candidates. Examiners required the use of both the relevant wave numbers and the corresponding bonds.
- (c)
- (i) Few candidates recognised this as two reactions, the addition reaction and the substitution reaction as stated in the question. The substitution reaction requires light and so to slow it down requires the light to be removed e.g. by covering the container with paper. A small number of candidates gained the mark.
- (ii) Many candidates recognised that a colour change was taking place but gave the wrong colour change. The end-point is reached when the bromine is in excess and so the colour change is from brown to colourless. This was only answered correctly by the most able candidates.
- (d)
- (i) Those candidates who referred to the structures at the start or in the next part of the question recognised the answer to be two.
- (ii) Some excellent structures, but equally some very poor structures were produced. Candidates were required to use dotted lines and wedges, the correct structure also includes straight lines. This caused some confusion, especially for the weaker candidates.
- (iii) This type of question has appeared in previous examination papers and was accordingly well answered.
- (e) This question required an explanation of identification. The melting point is stated in the question and candidates were expected to refer to this in their answers. Few candidates did so, but those who did tended to be the weaker candidates.
- Q15 (a)** These reagents are well known and this question was generally well answered. The usual problems with nitrate and HCl arose.
- (b)
- (i) This explanation is in the CCEA support materials and this question was generally well answered, especially by the more able candidates. Some weaker candidates gave answers with electrons emitting energy as they returned to lower levels, as in the flame test, and were penalised accordingly.
- (ii) Candidates who answered the previous part correctly generally answered this part correctly. Both parts require knowledge to be applied and this favours the better candidates.

- (c) This was poorly answered with candidates incorrectly describing ionic bonding between the sodium salt and water and giving no explanation for the methyl red.
- (d) (i) The reagents are generally well known and many candidates gained both marks.
- (ii) Many candidates related this to the manganate(VII) titration and gave the wrong colour change. Here the manganate(VII) is in excess at the end-point and so the colour change is from colourless to purple.
- (e) (i) This reaction requires the formation of the tin(II) ion and so the formation of tin(II) chloride was required. Few correct answers were seen. It was disappointing to see some strange symbols for tin e.g. Ti.
- (ii) This question was generally poorly answered. The structure often incorrectly contained $\text{-NH}_4\text{Cl}$. The most common mark gained was for the formation of the sodium salt of the acid.

Assessment Unit A2 3 Further Practical Chemistry

Booklet A

There were three questions in Booklet A. The first involved carrying out an iodine-thiosulfate titration, recording the results, giving observations and calculating percentage error. The second involved the thermal decomposition of copper(II) carbonate, recording masses, calculating the loss of mass, giving observations and carrying out reactions involving copper(II) carbonate and copper(II) oxide. The third question involved observations using an organic solid. The mean mark for Booklet A was down 1.7 marks on the Summer 2018 mean.

- Q1**
- (a)**
 - (i)** This proved to be straightforward for most candidates. The most common error was to record all three initial burette readings as "0".
 - (ii)** Most candidates scored the two available marks. A small number of candidates did not include units.
 - (b)**
 - (i)** Most candidates scored the one available mark. A small number of candidates suggested that a brown precipitate had formed.
 - (ii)** Many candidates did not score full marks in this question due to the incorrect sequencing of the colour changes and/or the inclusion of additional incorrect information such as the addition of starch after the solution had turned colourless. Some candidates suggested that a precipitate formed during the titration.
 - (iii)** The uncertainty in the burette was quoted to two significant figures. Many candidates did not quote the percentage error to two significant figures.
- Q2**
- (a)** This proved to be straightforward for most candidates. A very small number of candidates described the solid as "crystals".
 - (b)** A surprisingly large number of candidates did not quote one or both of the masses to one decimal place. Some candidates did not include units with the masses.
 - (c)**
 - (i)** Most candidates got the mark for the formation of a black solid. The second mark proved to be more difficult to obtain with only a small number of candidates giving a good description of the movement of the solid. A significant number of candidates described "effervescence".
 - (ii)** Many candidates obtained a very small mass decrease. A decrease in mass of at least 1.0 g was expected. For many candidates it was difficult to believe that the solid had been heated "until there is no further change in its appearance".
 - (d)**
 - (i)** In most cases, some of the carbonate will have remained after heating so there will have been effervescence. However, the main observations were the "disappearance" of the black solid and the formation of a blue solution. Many candidates referred to the formation of a "black solution". Additional incorrect information such as a "pungent smell" was penalised.
 - (ii)** Most candidates scored both marks. Incorrect observations such as the formation of a "white precipitate" were penalised.
 - (e)**
 - (i)** Most candidates observed a "blue precipitate" and scored the mark. Some candidates suggested that two layers had formed.

- (ii) Most candidates gave the formation of a “green solution” but many did not include the “disappearance” of the precipitate. The formation of “two layers” was a common answer which would suggest that some candidates did not “stopper and shake the test tube”.
- Q3 (a)**
- (i) Most candidates gave a response within the expected range.
- (ii) Many candidates commented on the formation of a white solid but did not mention the fact that the bromine water lost its colour.
- (iii) Most candidates obtained the effervescence mark but some did not comment on the “disappearance” of the white solid.
- (b) Most candidates gave the correct colour for the flame but many did not state that a black solid/soot formed on the test tube.

Booklet B

There were six questions in Booklet B. The first question focused on chromatography. The second on electrode potentials. The third question focused on organic chemistry from Unit A2 1 and analytical techniques from Unit A2 2. The fourth question was on the preparation and purification of aspirin. The fifth question was on experimental methods for the study of the rate of reaction. The final question was on volumetric analysis. The mean mark for Booklet B was up 0.4 marks on the Summer 2018 mean. The overall mean mark for the A2 3 unit was down slightly on the Summer 2018 mean.

- Q1 (a)** Overall this was well known. Some candidates sprayed with ninhydrin after the first run. It is worth bearing in mind that the chromatography paper does not become a “chromatogram” until it has been developed.
- (b) The vast majority of candidates scored the mark for correct calculation of the two R_f values.
- (c) There were some excellent answers to this question with candidates appreciating that two-way chromatography would need to be performed on separate pure samples of leucine and serine using the same solvents and conditions with a clear understanding of the significance of the results. However, overall the responses were disappointing. A significant number of candidates suggested that a single pure substance would produce more than one spot on the chromatogram.
- (d) There were excellent answers to this question with candidates appreciating that some amino acids may have similar R_f values with the first solvent. The essential point was that two-way chromatography gives better separation.
- (e) (i) Overall the answers to this question were disappointing. Pure substances will give one peak in GLC.
- (ii) The best answers made it clear that the retention time will match that of the pure drug and the mass spectrum will also match that of the pure drug. Weaker answers simply suggested “compare to database” without giving any further detail. In this context, the term database is much more appropriate than data book/tables.
- Q2 (a)** It was surprising the number of candidates who did not know this definition which is available in the CCEA Clarification of Terms document.
- (b) (i) Most candidates did very well in this question. The temperature was sometimes missing and some candidates had a salt bridge which did not make contact with the solutions.

- (ii) Most candidates scored the one mark in this question.
- (c) This calculation proved to be much more discriminating than the calculation in Part (b)(ii).
- Q3** (a) (i) & (ii) Most candidates had very good knowledge of this area of organic chemistry. The most common error in Part (ii) was to leave out the charge on the molecular ion.
- (b) (i) to (iii) Most candidates had very good knowledge of this area of organic chemistry although some did not give a full explanation of the significance of the observation with phosphorus pentachloride. In general, the explanations of the splitting pattern were of a very high standard.
- Q4** (a) Many candidates scored full marks in this question. When marks were lost, it was often as a result of an incorrect relative molecular mass.
- (b) Many candidates gave details of the preparation of aspirin before focusing on the purification. Although there were some excellent answers, there were also many answers which included details on how to purify an organic liquid.
- (c) Candidates scored well in this question and it was clear that the method was well known. When marks were lost it was normally due to a missing detail such as "heat slowly". The purity of the product was based on the sharpness of the melting point. Many candidates just said "compare to database" without any additional detail.
- (d) In general, the answers to this question were poor. Many candidates gave an equation for the formation of the sodium salt without hydrolysis of the ester group.
- Q5** (a) In general, the answers to this question were of a very high standard. It was clear that the relevant section of the CCEA Practical Support Document had been learned. However, candidates should be encouraged to apply knowledge rather than simply quoting the support document word-for-word. The phrase "required solutions" was often used rather than identifying that, in this case, the "required solutions" were solutions of iodine of varying concentration.
- (b) (i) The nature of this graph was well understood.
- (ii) Despite most sketches in Part (b)(i) being straight lines, many candidates suggested that tangents to the curve needed to be taken. It was also clear that some candidates believe tangents and gradients are the same thing.
- (c) The idea that the concentrations of propanone and hydrochloric acid will remain approximately constant was not well understood.
- Q6** (a) (i) & (ii) The self-indicating nature of this titration and the associated colour change was well known. Some of the explanations of the colour change in Part (i) revealed a lack of understanding of why there is a colour change at the end-point.
- (b) Many candidates scored both marks in this question.
- (c) (i) Although the purpose of the zinc was often understood, the equations were often incorrect.
- (ii) Many candidates scored both marks. The most common incorrect answer was 60%, i.e. the percentage of iron(II) ions which had not been oxidised.

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