

CCEA GCE - Chemistry
Summer Series 2016

Chief Examiner's Report

chemistry

Foreword

This booklet outlines the performance of candidates in all aspects of CCEA's General Certificate of Education (GCE) in Chemistry for this 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

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GCE CHEMISTRY

Chief Examiner's Report

Assessment Unit AS 1 Basic Concepts In Physical and Inorganic Chemistry

The mean for this paper decreased by slightly over two marks compared to 2015. This was due to a decrease in the mean for the multiple choice questions, the mean for Section B being broadly similar to 2016.

- Q11** This was well answered with most candidates obtaining full marks, a minority gave the structures of the atom and a small minority added electrons when they should have subtracted or vice versa.
- Q12 (a)** This question proved to be discriminating, the vast majority of candidates scored two marks with a minority achieving three or four. Very few candidates communicated the idea of each carbon delocalising one electron meaning only a minority scored four marks, and a number of candidates did not mention enough detail on the structure to achieve three marks. All answers were relevant and this meant almost all candidates achieved at least one mark for quality of written communication.
- (b)** The majority of candidates achieved two marks for this question.
- Q13 (a) (i)** The colour of iodine was known by almost all candidates.
- (ii)** This was not well answered, although most candidates knew bromine would form many did not use the colour from the acceptable colours document. Very few candidates gave a correct answer for hydrogen chloride.
- (iii)** This question was very poorly answered and many candidates did not seem to understand the question with most candidates providing a statement about the colours, and rewording their answer to Part (ii) without giving an explanation for the different behaviours.
- (b) (i)** This was well answered by almost all candidates.
- (ii)** This was well answered by almost all candidates, the most common errors were to give hydrogen chloride rather than hydrogen iodide or producing an incorrect formula for sodium carbonate.
- (c)** This question was well answered by almost all candidates.
- Q14 (a)** This question was well answered by the majority of candidates, although the mark scheme accepted a number of responses. Some candidates had problems due to making incorrect statements such as "Hydrogen can lose an electron to get a full outer shell" or answers which did not follow the direction of the question and omitted mention of electronic structure, such as, "Hydrogen can form diatomic molecules."
- (b)** The general trend of bond energy decreasing down the group was very well known, however many candidates did not state that fluorine is an exception to this trend.
- (ii)** This was not well answered with only a few candidates making any reference to bond length.
- (c) (i)** This was well answered by almost all candidates. A small minority of candidates inserted hydride ions in place of the chloride ions.

- (ii) This was reasonably well answered, however a significant number of candidates formed a covalent molecule of sodium hydride. The stem of Part (c) directed candidates to the fact that ions form and it is important that candidates utilise the guidance they are given in questions.
- (iii) This equation was well answered by the vast majority of candidates
- (iv) This calculation was well performed. However, weaker candidates often left the molarity part blank.
- Q15 (a)** The relative atomic mass was calculated correctly by almost all candidates, with only a small minority of candidates losing a mark by giving their answer to one decimal place.
- (b) (i) This definition was well known
- (ii) This question was poorly answered, the majority of candidates failed to give the correct equation or the conditions.
- (iii) Again, this question was poorly answered, many candidates talked about how sodium chlorate(I) had dipole-dipole forces, and a number of candidates who correctly identified sodium chlorate(I) as being ionic did not proceed to correctly mention what the forces would be in chlorine.
- (c) This was well answered with the vast majority of candidates scoring three marks.
- Q16 (a)** (i) This was well answered, candidates giving both the formula and the electronic structure correctly.
- (ii) Only a minority of candidates were able to give a correct meaning for isoelectronic, with a significant number of candidates writing about isotopes.
- (b) Parts (i) and (ii) calculations were well performed. However, a minority of candidates had problems with rounding errors.
- (iii) The majority of candidates scored two or three marks for this question. A significant number of candidates made reference to the $n = 2$ energy level. Candidates should note that information is specific to the hydrogen spectrum and may not be correct for other species, which having more than one electron, will produce much more complicated transitions.
- (c) This caused problems for a number of candidates, who often made errors in Parts (ii), (iv) or (v). The question posed problems to candidates who performed both strongly and weakly elsewhere in the paper.
- Q17 (a)** (i) The definition was well known and the majority of candidates applied the definition correctly to the fluorophosphate ion.
- (ii) Drawing the shape produced a number of challenges to many candidates. Dashes and wedges were not required to acquire the mark. However, if dashes and wedges were used they had to be used correctly. Many candidates who used dashes and wedges failed to use them correctly and did not get the drawing mark. They were however able to pick up the mark for naming.
- (iii) The explanation for the shape was well answered.
- (b) (i) This definition was well known.
- (ii) The oxidation state of cobalt was given correctly by almost all candidates.

- (iii) This question proved challenging and only a minority of candidates were able to balance the half-equations correctly. Surprisingly a number of candidates did not include electrons even though they were directed that the equations were half-equations.
- (iv) The combination of half-equations caused problems for the majority of candidates. Although errors in Part (ii) were carried through a number of candidates failed to cancel down the protons, producing answers that had protons on both sides of the equation.
- Q18 (a)** This question proved challenging. Only a minority of candidates mentioned getting the vapour into solution. The majority of candidates who used halide ions simply stated add chloride/bromide/iodide ions without mentioning what reagent would produce those ions, and a significant number of candidates used chlorine water or bromine water.
- (b) Parts (i) and (ii) these calculations were well performed by most candidates.
- (c) (i) The majority of candidates gave the correct formula for the silver ion.
- (ii) The vast majority of candidates got this equation correct, with only a small minority having problems due to balancing.

Assessment Unit AS 2 Further Physical and Inorganic Chemistry and Introduction to Organic Chemistry

The paper gave all candidates an opportunity to answer at least some of the questions. It also discriminated between the more able candidates and the less able candidates. The candidates appeared to have ample time to complete the paper.

- Q11** This should have been a straightforward question to start this section of the paper. Weaker candidates simply stated the effect of the change with no explanation. Some explanations were poor and failed to explain the change in terms of effective collisions. More able candidates answered the question well.
- (a) This was the best answered of the three parts to the question.
- (b) Some weaker candidates misunderstood the change in volume and answered the question in terms of an increase in pressure.
- (c) The explanation for the effect on the position of the equilibrium was poorly answered, even though this type of question has appeared on previous papers. The effect on the rate was well explained.
- Q12** This question included three definitions which were well answered by many of the candidates. Those who did not learn the terms from the support materials lost marks accordingly.
- (a) Most candidates gained at least one mark. The most common error was to omit the initial and final conditions remaining the same.
- (b) (i) Again most candidates gained at least one mark. The most common error was the use of the word substance instead of compound.
- (ii) Generally this was very well answered, although some candidates simply stated that hydrogen is a diatomic molecule.
- (iii) This calculation was well answered. The most common errors were not calculating the correct multiples or the omission of units.

- (c) (i) Again this calculation was well answered with the same problems as Part (b) (iii).
- (ii) Most candidates gained at least one mark with this definition. The most common error was not referring to 'many compounds'.
- (iii) This proved a difficult question for weaker candidates. Only the most able candidates recognised that average values can only give an estimate of the value.
- Q13** (a) This was very well answered by most candidates.
- (b) Most candidates recognised that witherite was more stable and the majority of candidates gave a good explanation. Weaker candidates tried to explain the difference in terms of barium's greater number of electrons and van der Waals forces.
- (c) (i) Most candidates answered this correctly.
- (ii) Not as well answered as the previous equation, however most candidates still gained the mark.
- (d) (i) Reasonably well answered using the information in the question.
- (ii) Not as well done as the reaction at the cathode. The most common error was the formation of chlorine atoms instead of molecules.
- (iii) A disappointing number of candidates gave the test for chloride ions. The majority of those who gave the correct test gained both marks. The most common error with the correct test was the failure to use damp test paper.
- (e) This was a straightforward test using a slightly different context. Most candidates recognised the test. The most common error was the failure to dissolve the Epsom salts.
- (f) (i) This is a familiar question and was very well answered.
- (ii) This was reasonably well answered. Candidates lost marks for stating that the nuclear charge increased and there was an unpaired electron in the outer shell, or failing to state that the outer electron was being removed.
- (iii) This type of question is again familiar and so was well answered. The most common error was not referring to the outer electron.
- Q14** (a) (i) Most candidates gave the correct answer.
- (ii) Most candidates gave the correct answer.
- (iii) This was well answered by all but the weakest candidates with most gaining both marks.
- (iv) This proved to be one of the most difficult questions on the paper and was a good discriminator. Many candidates answered in terms of UV radiation and so gained no marks. The most common correct answer was in terms of the products formed.
- (b) (i) Very well answered with few errors.
- (ii) This proved to be the most difficult question on the paper. The concept is similar to that in the Haber process where the reaction mixture is cooled to condense the ammonia and the hydrogen and nitrogen are recycled. Only a few candidates recognised the gases and fewer the condensation process.
- (c) (i) This was very well answered by the more able candidates. Weaker candidates gave the incorrect inorganic products or included ethanol in the equation.

- (ii) Only the more able candidates were able to recognise the continued elimination.
- (iii) This definition was very well answered, with few errors. The most common error was to describe cracking large alkanes into smaller alkanes without including the alkenes.
- (d) (i) The two structures were well known and most candidates gained both marks. Weaker candidates used ethene as the basis of their diagrams.
- (ii) Those who drew the correct structures generally gave the correct names. The usual errors in numbering, commas and hyphens were seen.
- (iii) This was also well answered, particularly by the more able candidates. Some candidates lost a mark for only drawing one intermediate.
- (e) This was very well drawn by most candidates. The usual errors in omitting end bonds and chlorine atoms appeared.
- Q15** (a) Few candidates were able to provide a reasonable description of a biofuel, even though it was given in the context of fermentation. Too many suggested it was renewable or non-polluting.
- (b) Some very strange answers involving high temperatures and pressures. Good candidates were able relate this to ethanol and so gained both marks.
- (c) Some candidates appeared to misread the question and took the ‘without using equations’ to mean they should not describe the reactions taking place. There were many descriptions of the honeycomb structure of the catalyst. Good candidates were able to gain at least three marks.
- (d) (i) These isomers were generally very well drawn, although a few candidates failed to include the names despite having drawn the correct structures. The usual errors were seen in numbering, commas and hyphens.
- (ii) Some candidates omitted the ‘acidified’ in the potassium dichromate and so lost a mark. The products of mild oxidation were often given and listing was also a problem. This proved a good discriminator as many candidates gained 1/2 marks but only the most able gained 3/4 marks.
- (e) (i) Most candidates gave the correct equation. The most common error was the use of 6.5 oxygen molecules, even by very able candidates.
- (ii) Most candidates were able to gain at least two marks for the calculation and many gained full marks. The most common error was in the second step where the mass of the water was used. The other main error was in rounding of values.

Assessment Unit AS 3 Internal Assessment

Booklet A

- Q1** (a) As in previous examinations this question was extremely well answered with many candidates gaining full marks. Marks were lost as follows:
- failure to calculate the average titre;
 - failure to include units for the average titre;
 - failure to record all readings on the table to at least one decimal place;

- units missing from the table; and
 - rough reading not greater than the accurate readings.
- (b) This question was extremely well answered with many candidates gaining full marks.
- Q2** This question was also well answered with most candidates scoring highly. As in previous years the observations were often concise, clearly making use of previous mark schemes. When candidates recorded observations that indicated they were not following the practical procedure they were penalised.
- (a) Test 1: Well answered with most candidates achieving full marks or three marks. Candidates did lose a mark for stating ‘the white precipitate redissolves in dilute ammonia.’
- Test 2: Well answered. Candidates who recorded an observation on ‘boiling’ the solution were penalised.
- Test 3: Well answered with few errors.
- Test 4: Well answered with few errors.
- (b) Test 1: Well answered by most candidates. Those candidates who recorded an observation of ‘an acidic smell’ lost the mark.
- Test 2: Generally very well answered. Candidates who recorded the colour of the Universal Indicator paper as red lost the mark. In addition candidates who recorded the correct colour but provided an incorrect pH value were penalised.
- Test 3: Well answered with few errors.
- Test 4: Well answered with few errors.

Booklet B

- Q1** (a) Parts (i) and (ii) more able candidates answered these questions well. However, the responses provided by a significant number of candidates clearly showed that there was confusion in relation to these terms with many providing ways to improve accuracy which involved reliability and vice versa. This was disappointing as this type of question has been asked in previous AS/A2 practical papers.
- (iii) This equation was very well known and almost all candidates were awarded this mark.
- (b) Parts (i)-(vii) these questions were very well answered with a significant number of candidates scoring full marks. Since ‘carry error forward’ was applied in the calculation this ensured that most candidates scored at least four of the six available marks.
- (c) This calculation was also very well answered by the majority of candidates. The most common error involved incorrect units with cm^3 used rather than dm^3 .
- Q2** (a) (i) Test 1: The standard of the answers provided for this question varied. While some candidates provided excellent answers others lost marks for the inclusion of terms such as ammonium gas and ammonia ions, NH_3^+ . Candidates also lost a mark for failing to include a deduction for the Universal Indicator turning blue.
- Test 2: Generally well answered. However, it was disappointing to see the number of candidates who recorded an incorrect charge for the carbonate/hydrogencarbonate ions.

Test 3: Well answered by the majority of candidates with a small number recording the deduction for Fe^{2+} .

(ii) Well answered. Any errors provided in the deductions were carried through.

(b) (i) Test 1: This question was answered very well with only a small number losing this mark. The most common incorrect response was 'alkene present'.

Test 2: Generally well answered. However a significant minority of candidates just recorded a deduction of 'polar'. Those candidates were not awarded the mark.

Test 3: A number of responses were accepted including 'oxidation occurs' and 'not a tertiary alcohol'. An alternative acceptable answer was 'a primary/secondary alcohol or aldehyde'. Many candidates provided the last statement as the deduction but omitted the term 'aldehyde'.

Test 4: This was not well answered by candidates. Many seemed unfamiliar with this test. A common error in the deduction recorded was 'the presence of iodine'.

(ii) While the majority of candidates scored one mark for this question many failed to draw the bond between the oxygen and hydrogen atom in the hydroxyl group. Any errors in the deduction were carried through. Therefore candidates who had incorrectly deduced a carboxylic acid in the deductions were awarded two marks for the structure of ethanoic acid.

(iii) This question was well answered.

Q3 (a) (i) This question was very well answered.

(ii) This question proved to be a very useful discriminator. While the more able candidates correctly recognised the need to 'dissipate heat' many candidates simply stated the reaction was exothermic and were not awarded the mark.

(iii) This question was well answered.

(iv) Most candidates gained this mark. However it was disappointing that a significant minority of candidates did not know this definition.

(v) This question was well answered. The omission of the term 'anhydrous' prevented some candidates from attaining this mark.

(b) (i) This question was a useful discriminator with the more able candidates scoring highly. However a significant number of candidates lost marks by use of incorrect RMM values. Rounding errors also resulted in candidates being penalised.

(ii) The reasons for the reduction in the yield were well known by the majority of candidates.

(iii) This question was very well answered.

(c) This type of question was asked in the June 2015 A2 practical paper. Since it had been poorly answered in this paper, it was expected that candidates would be better prepared for this type of question in the June 2016 series. However the standard of the diagrams provided was extremely poor with many candidates not achieving marks in this question. The following errors were penalised:

- closed system;
- no heat source;
- gaps in the apparatus;

- thermometer too high/low;
 - incorrect flask;
 - flask more than $\frac{3}{4}$ full;
 - double jacket missing on the condenser;
 - water in/out incorrect;
 - rubber bung missing;
 - thermometer through bung;
 - receiving flask closed; and
 - reflux apparatus.
- (d) This question was very poorly answered with the vast majority of candidates providing an explanation for the difference in boiling point between ethanol/ethanal based on Van der Waals forces.
- Q4** (a) This question was answered well. Candidates lost a mark for the incorrect ester. Omission of water as a product prevented both marks being scored.
- (b) (i) This question asked for an explanation. However the vast majority of candidates simply stated that the equilibrium would move to the right-hand side. This was not sufficient to attain the mark.
- (ii) While many candidates scored this mark there was also a significant number of candidates who incorrectly stated that it acted as a catalyst and/or a dehydrating agent.
- (c) Parts (i)-(iii) the standard of the answers provided was high and most candidates achieved all available marks. Error carried forward was applied from Question 4(a).
- Q5** (a) This question was well answered by the more able candidates. Some candidates lost a mark for simply stating 'heat to constant mass'. Candidates who provided answers based on the use of a drying agent or anhydrous copper sulfate lost both marks.
- (b) Most candidates achieved 2/3 of the four available marks. Many candidates did not include 'stir' on addition of the sulfate salt to water and lost a mark. Candidates who outlined a procedure to calculate the standard enthalpy of reaction were also deducted a mark as they were not answering the question as asked on the examination paper.
- (c) There are two alternative tests that could have been provided. However, many candidates used both aqueous ammonia and sodium hydroxide solution. It was not often apparent that these were used on separate samples of the aluminium sulfate solution and in such cases the candidates were penalised. A common error which resulted in the deduction of a mark was the use of the term 'redissolve' when referring to the addition of excess sodium hydroxide solution to the white precipitate. In addition many candidates lost a mark by not clearly indicating that 'a few drops' of sodium hydroxide/ammonia solution were initially added to form the white precipitate.

Assessment Unit A2 1 Periodic Trends and Further Organic, Physical and Inorganic Chemistry

In Section A there were two particular questions that caused problems for candidates. Question 3 asked for the number of isomers with the molecular formula C_4H_9Br . The answer was D because the number of optical isomers had to be included. As a consequence very few candidates obtained the correct answer and the question was completely non-discriminatory. The statistics for the candidates suggested that there were more capable candidates than in former years. Although this proved to be true the general impression given by the answers on the paper was that the average ability was down compared to previous years and despite the improved upper ability the consequence was that the average mark was five marks lower than last year.

- Q11** Although this question should have been relatively easy it proved to be an excellent discriminator. This was strange because it would have been expected that this was simply a question of knowledge and not application. But this was not to be the case. The questions seemed to get more difficult as the question progressed. The easiest was the reaction of sodium oxide with water and the last three questions were the most difficult. This was a worrying start to the paper and an unexpected start which tended to support the view that candidates were not, on average, that well prepared. Yet there was a minority that sailed through this question with hundred percent success.
- Q12** (a) (i) The question asked for two hydrocarbon fuels. The most common answers given by greater than 95% of the candidates were coal and oil. Of course these answers are wrong but they were accepted on this occasion! They will not be accepted in the future. Alkenes were not accepted, they are used for other purposes.
- (ii) All that was expected for the answer was “combustion” or an equivalent word which was given by the vast majority.
- (b) (i) The problem with this question and the following question was that the explanation did not follow the usually correct answer. Although it might be said that carbon dioxide is absorbed from the atmosphere and the amount of carbon dioxide is reduced the conversion to sugars was mentioned by about half the candidates.
- (ii) Respiration followed a similar pattern. It was said that respiration produced carbon dioxide and increased the carbon dioxide concentration but the “combustion” of foodstuffs was similarly omitted by about half the candidates.
- (iii) A principle was made that the word dissolved should be used. It was not accepted that water absorbed carbon dioxide. If the carbon dioxide reacted with calcium compounds that was fine but if they were precipitated that was not acceptable. If the carbon dioxide formed carbonic acid that was also acceptable.
- (c) The “greenhouse effect” is a complicated effect but the mark scheme accepted that three words were sufficient despite some long and falsely construed answers. Naturally, such extensive answers caused difficulty in marking what seemed plausible answers. Success was pretty low at all levels of ability with this question. It was not sufficient to simply state that carbon dioxide was involved. Its exact role was needed.
- Q13** (a) (i) Candidates needed to read this question carefully. A slight majority of candidates decided that the value of the lattice enthalpy was positive as they

had learnt. In this case, in this question, they were wrong. What was more surprising were the wrong answers given for the other enthalpy values by a sizeable minority.

- (ii) Candidates resorted to their previous knowledge. Even if they had written a value of -915 in the diagram which was the correct value, they changed this to +915 when performing the calculation. No matter which way they proceeded the correct calculation received full marks. Any error correctly carried through despite tortuous calculations also received full credit.
 - (iii) The question stated exactly what was wanted i.e. suggest why the values of the lattice enthalpies decreased in terms of the Born-Haber cycle. From the answers seen it was difficult to discern what question had been asked. It was certainly not in terms of the lattices of the hydrides. Yet even when a candidate stated, quite correctly, that the value was because of the ionisation enthalpy of the metal and the answer explained why this was so it then degenerated into an explanation of the lattice energy/enthalpy which then negated the previously accepted answer. The second answer regarding the enthalpy of vaporisation was very rarely spotted. The question set out all the enthalpy values and they could have been compared. The question proved to be far more difficult than expected despite questions being asked about the Born-Haber cycle year by year.
- (b) The examiners had a detailed mark scheme prepared for this question and had explored many varieties of answer but despite this attention to extreme detail all was abandoned because candidates did not clearly explain their answers. Perhaps it was because they needed a diagram to show the relationship between the enthalpy values? Seeing as no diagram whatsoever was seen this cannot be the answer. Eventually only the correct answer was credited or a simple multiple.
- (c) Candidates, almost without exception, stated that the value for ΔH was negative but then went on to say that the value for ΔS was negative and contrived to manipulate this as a consequently negative value for $-T\Delta S$ despite the fact that a negative value of a negative term is positive. Only a handful of candidates argued that ΔH outweighed $T\Delta S$.
- (d) (i) The definition of a nucleophile was well known.
- (ii) The mechanism was well known for the attack of negative ions. Many candidates used water to form the organic product as they were instructed to in the question. A few omitted the consequent formation of hydroxide ions. There were also several answers which gave a dihydroxy compound as a consequence of the reaction with water.
- (iii) The organic product from the reduction of propanone was well known as propan-2-ol.
- (iv) The reduction of a carboxylic acid with lithium gives an alcohol but many candidates gave the aldehyde as the reduction product.
- Q14 (a)** Although the question stated exactly what was taking place candidates had difficulty in writing the atoms/symbols in the correct place. Potassium salts should have the K next to the appropriate atom. In the case of potassium chloroethanoate it is oxygen but many gave it next to CH_2 and ended up writing COOCl .
e.g. KCH_2COOCl
The question should not have been as difficult as it turned out.
- (b) (i) Some candidates were misled by the information supplied at the start of the question and wished to carry out the crystallisation below 160°C because the

cynoethanoic acid decomposed above this temperature. Aspects of toxicity and flammability, despite being in the mark scheme, were very rarely referred to. The idea that the solute should be soluble at high temperatures and less soluble at low temperatures was frequently mentioned but a mark was often lost because it was stated that the solute was insoluble at low temperatures. Impurities were mentioned but often incorrectly e.g. stating that they would be insoluble in the hot solvent. Sometimes it was said that the solvent should be non-volatile but all solvents are volatile. Candidates were frequently mixed up between choosing a solvent and how to recrystallise a solute. For example, the solute was dissolved in a minimum volume of hot solvent and filtered. Most candidates gained a mark but very few gained four marks.

- (ii) The term decarboxylation has been used in previous examinations. However, it need not have been known because the starting compound was mentioned as well as the product. It should then have been relatively straightforward to write the equation which the majority succeeded in doing. Yet there were answers where carbon dioxide was not produced.
- (c) (i) This question had two parts to be answered. The first part was spotted by most candidates which was the fact that the ethyl ester had a higher boiling point than the methyl ester which was well explained in terms of the van der Waals' forces. The second point was more difficult to spot which was the relatively high boiling points of the two esters which were over 200°C. The answer to this point was that the esters contained permanent dipole-dipole attractions. Sometimes this answer was thwarted by saying that hydrogen bonds also existed which they did not.
- (ii) The equation for the formation of the methyl ester was basic knowledge and well answered.
 - (iii) The catalyst was well known as concentrated sulfuric acid. The word concentrated was essential.
- (d) (i) Methanal was well known but methanone and methanol also featured as answers.
- (ii) The question stated in bold print that all the bonds in the structure should be shown. Of course, particular difficulties were shown mainly with the cyano group and then the ester group. The rest of the molecule was usually drawn correctly. The explanation for the lack of E/Z isomers was not as clear as it should have been. There was much mention of lack of rotation about the double bond but it was simpler and better to state that there were two hydrogens bonded to one of the carbon atoms of the double bond.
 - (iii) This question was a synoptic question. Condensation polymerism is in A22 and addition polymerism is in AS. There was a substantial number of candidates that attempted to form a condensation polymer by reacting the ester group with another part of the molecule. Candidates who wrote the letter n after the structure lost a mark because the polymer was for three repeating units. There was no need to include brackets with the structure.
- (e) (i) The equation for the dissociation constant of a weak acid is normally well written. However, on this occasion there was the feeling that the percentage success should have been higher. Added to this there were several very implausible answers. This has not usually been the case.
- (ii) It was the first time that the half-neutralisation of a weak acid had been asked. Naturally, questions which have not been seen before, apart from calculations, are not well answered as was the case with this question where less than 50%

of the candidates gave an acceptable answer. The answer should have been $pK_a = 2.6$ but answers in the range 2.6 ± 1 were accepted.

- (iii) The indicator phenolphthalein was the indicator which was inevitably chosen. It was essential that candidates stated that it changed colour in the vertical section of the titration curve but many answers talked about the range being appropriate or the theoretical situation.

- Q16 (a)**
- (i) The answer was simple but the answers seen were not. For example, “ethanolic potassium hydroxide was used as it has a different boiling point therefore can be removed more easily than the potassium hydroxide”. And, “ethanolic potassium hydroxide is easier to remove than aqueous potassium hydroxide”. Some answers said “it” acts as a solvent but they needed to explain further. Others said the hydrolysis was faster but did not explain why. Mention was made of equilibria or of the potassium hydroxide acting as a catalyst. At times examiners were confused whether an answer had any validity e.g. “the ethanolic potassium hydroxide may be more reactive so the fat will dissolve more rapidly”. This was judged not to be valid.
- (ii) This question was basically about why organic reactions are slow. Candidates tended to state that the fat needed time to hydrolyse or to be broken down. Activation energy/enthalpy was the most frequently correct answer given.
- (iii) Most candidates realised that porous pot was performing the same function as anti-bumping granules although a minority thought that it might have been a catalyst. Explanations of how anti-bumping granules worked were frequently wrong e.g. allowing air bubbles to form on the surface when it was ethanol vapour which was being formed. Such explanations lost the mark that could have been gained.
- (iv) Candidates often realised what was happening but their incomplete answers often let them down e.g. a reaction took place to form glycerol. But what else was formed? There was often utter confusion about the meanings of the words clear and coloured and dry or wet. For example, “removal of water by hydrolysis causes it to go clear” and “as the fat had been broken down into an alcohol and carboxylic acid salt which are colourless, there is no unreacted substance remaining”.
- (v) Saponification calculations are often well done. Apart from the first step this calculation was also well done and all candidates obtained marks.
- (b)
- (i) Fats and oils are examined virtually every year so it was a surprise that the responses to this question were more disappointing than expected. Apart from weaker candidates the oil/fat structures were largely correct. The major problem was in determining the structure of the hydrocarbon side chain. The formulae of oleic acid and palmitic acid were given in the introduction to the question. It should have been a relatively simple matter to take away the $-COOH$ from the acid to give the structure of the side chain but the majority of candidates somehow failed to do this. Despite the incorrect structure being drawn of the oil/fat, when two structures were drawn credit was frequently given for the second structure if the hydrocarbon chains were drawn in different places. Naturally, if one structure was given the mark was lost as it was for three structures.
- (ii) The explanation of an asymmetric centre was well known although occasionally it was said that four different functional groups were attached to the carbon atom. The optical isomer of the oil/fat was usually well spotted.

- (c) (i) The equation for the reaction of silver carbonate with the carboxylic acid was written correctly by the majority of candidates although there were many AgCO_3 formulae used.
- (ii) The calculation was well done and most candidates scored three marks.
- (iii) Although Part (ii) was relatively well done many candidates did not know what to do with Part (iii) either leaving the answer blank or taking the wrong number away from 390.
- (d) The vast majority of candidates counted the double bonds from the wrong end of the molecule and gained one mark rather than two.
- (e) (i) Candidates needed to be careful with their answers to this question. Oleic acid is a polar molecule because of the carboxylic acid group. A common answer was to say that “oleic acid is insoluble as its long hydrocarbon chain sterically hinders its ability to hydrogen bond with water”. If candidates limited their answer they were often correct but saying too much led to errors.
- (ii) The simple answer was that sodium oleate is ionic but this was rarely mentioned. Sometimes one of the ions was mentioned but not the other one. Useful explanations were often given e.g. “form hydrogen bonds with water, the $\text{H}\delta^+$ of water bonds with the $\text{O}\delta^-$ of sodium oleate,” but without any mention of any ions being present.
- (iii) Questions on salt hydrolysis are frequently asked and frequently answered well as was this question but a higher success rate was expected in view of its straightforward nature.
- Q16 (a)** It might be argued that the theoretical explanation of extraction of solutes from aqueous solution is in the specification but the practical means of doing so is not. This argument is not accepted, solvent extraction is carried out frequently in organic chemistry. The question discriminated well. It was not unusual for some candidates to use 10 portions of 10 cm^3 of cyclohexane but they did gain the mark for using more than one portion of cyclohexane. Quite a few candidates wished to use the opening statement and attempted to precipitate out or to obtain the iodine by adding cyclohexene to the solution of iodine in cyclohexane. The usual errors were made of not shaking the separating funnel and not identifying which layer came out of the separating funnel first. However, what was surprising was the need to further purify the iodine once it had been obtained from the cyclohexane solution. As can be seen there were many opportunities for marks to be lost and they were taken.
- (b) (i) Candidates who mentioned and used the two equilibrium constants were inevitably successful. Despite long and convoluted arguments those who did not use two equilibrium constants were not.
- (ii) There was the choice of using colorimetry or an iodine titration to find the concentration of iodine present. The majority chose colorimetry and a small minority blended the two methods together! The question discriminated because candidates did not always make it clear that concentration was linked to absorbance and the marks ranged from one to three.
- (iii) This question was the best attempted on the paper. Not much to say and it was near enough always correct.
- (iv) The calculation was well done with the equilibrium constant of 13 being accepted for either the forward reaction or the reverse reaction. Even if a candidate made an error it was carried forward and it was difficult not to score at least one mark if the question was attempted.

- (c) This question has not been asked before and consequently there were many wrong guesses e.g. “it is a solid and takes longer to dissolve”; “it doesn’t show an obvious colour change”; “it does not give a clear colour change”; “it is toxic”; “iodine may require starch indicator”; “bromine has a more distinct colour change”; “iodine will break the C=C bonds but bromine will be added across it”; “iodine may react with saturated molecules as well”; “since its qualitative while iodine is quantitative”. Only a very few obtained a correct answer.

Assessment Unit A2 2 Analytical, Transition Metals, Electrochemistry and Further Organic Chemistry

The paper appeared to be very straightforward with the vast majority of candidates able to attempt all questions. There were many opportunities for candidates to demonstrate factual knowledge however these were not fully taken by all candidates.

- Q11** A minority of candidates scored full marks in this question. Most knew that the mobile phase in GLC was a gas but many did not state the gas as being inert or did not give an example of one. Many candidates incorrectly referred to silica gel, or water-based silica as the stationary phase for TLC.
- Q12**
- (a) (i) It was surprising that many candidates did not understand how to write a molecular formula. The other frequent error was the incorrect number of hydrogen atoms. The error was carried forward for the second mark.
- (ii) This was a straightforward calculation and was well answered by most candidates.
- (b) (i) This was correctly answered by the majority of candidates. In a small number of responses candidates circled the azo group but included other atoms, such as carbon atoms in the benzene rings, and were penalised.
- (ii) Given that this question has been asked before, it was disappointing that so many candidates did not score full marks. Many lost a mark for not mentioning extensive/enhanced delocalisation of electrons. Some candidates referred to electrons falling back to the ground state and light being emitted.
- (c) Most candidates answered this correctly, with a small number placing the positive charge on the wrong nitrogen atom or drawing the wrong number of bonds between the nitrogen atoms. Attempts were made to draw the bonding in the nitro group and these were not penalised as long as they were consistent with the number of covalent bonds that nitrogen and oxygen can form.
- (d) A straightforward recall question, however sodium nitrate was often seen in place of sodium nitrite.
- Q13**
- (a) This question posed few problems for candidates, although a noticeable number did not include the concentrations of the ions or quoted amounts in moles rather than concentrations. It should also be noted that if sulfuric acid is used then the concentration must be 0.5 M, not 1.0 M.
- (b) Generally well answered by candidates.
- (c) (i) Many candidates lost the mark here as reference was made to acidic impurities when the nitric acid was actually a reactant.
- (ii) The ionic equation was very well known by candidates.
- (iii) The use of starch in iodine-thiosulfate titrations was well known.

- (iv) The associated colour change was answered correctly by the vast majority of candidates.
- (v) The majority of candidates scored full marks in the calculation. Errors included using the wrong ratio or not including relevant ratios as well as not taking account of the dilution factor.
- Q14 (a)** (i) The colour was known by almost all candidates.
- (ii) Correctly answered by most candidates.
- (b) As the colour of this solution is not stated in the acceptable colours list, shades of green were accepted.
- (c) (i) Most candidates had no difficulty with the formula of the complex.
- (ii) Again, most candidates correctly identified the coordination number.
- (d) Generally well known, although some candidates lost marks by stating sodium hydroxide instead of potassium hydroxide. Most candidates correctly identified the use of glacial ethanoic acid.
- (e) (i) This part of the question proved most problematic for candidates. A number incorrectly referred to the use of lital as the reducing agent. Reflux was stated by a substantial number of candidates although it should be noted that in this reaction the addition of ethanol is exothermic so the emphasis is on controlling the temperature of the reaction as given in the mark scheme.
- (ii) This question posed no problem for most candidates; some did not include the correct signs and so lost the mark.
- Q15 (a)** (i) Well known by most candidates although some lost marks by not explicitly stating that both acids are concentrated.
- (ii) Candidates had no difficulty naming the ion although some had difficulty with the equation showing its formation; it was often not balanced correctly.
- (iii) The mechanism was generally answered well by candidates. Some did not use the correct compound, instead using benzene rather than nitrobenzene.
- (iv) Very well known by candidates.
- (b) (i) Well known, although a noticeable number of candidates did not include the use of alkali needed to obtain the free amine and so lost a mark.
- (ii) This was generally answered well by candidates. Some referred to hydrogen but did not specify it was an ion.
- (iii) This part proved to be discriminatory, with most candidates not obtaining the mark. Many answers referred to the stability of the lone pair and not the availability of the lone pair and so lost the mark.
- (c) (i) Well answered by candidates, however some candidates did not circle the amide bond.
- (ii) Most candidates answered this correctly, however many incorrect answers were noted.
- (iii) This part was discriminatory. Many candidates did not state that the polymer contained an amide bond. Most candidates did not score the second mark as they did not link hydrolysis with the action of microorganisms. It was often simply stated that the polymer was broken down by microorganisms.
- Q16 (a)** Most candidates answered this definition well, simply applying the similar definition in the official definition list to this type of ligand.

- (b) (i) Referring to the species as molecules was the main source of error in this part.
- (ii) This part was the most discriminatory in the paper. Although many candidates scored some marks for inclusion of key points, there was an obvious lack of detailed understanding of this particular procedure which resulted in few logical and coherent answers. This perhaps is down, in part, to limited practical experience on the part of the candidates. Many candidates discussed measuring absorbances of separate samples of copper ions and edta ions rather than mixtures of the two. The question was also confused with the procedure for determining an unknown concentration of a transition metal ion. The use of edta led some candidates to confuse this procedure with an edta titration. In many cases the answer given simply did not make sense.
- (c) (i) Most candidates had no problem with this equation.
- (ii) The type of catalysis was generally well known.
- (iii) A large number of candidates did not score the third mark as no reference was made to bond formation in the products.
- Q17 (a) (i) The main source of error in this part was the lack of a bond shown between the oxygen and hydrogen in the -OH group.
- (ii) Errors from Part (i) were carried forward into this part; the question was well answered by most candidates.
- (iii) Again, most candidates answered this well.
- (b) (i) Well known by most candidates.
- (ii) Reference to condensation was the main source of error in this part.
- (iii) It was expected that candidates would refer to the number of peaks in the spectrum of each molecule; many simply referred to the fact that there would be one less peak and so only scored one mark.
- (c) This part was problematic for candidates. Although most referred to the idea of hydrogen bonding, the explanation of how they arose was poor in many cases. It should be noted that hydrogen bonding arises between a lone pair of electrons on an atom such as oxygen, which is bonded to hydrogen, and a hydrogen from a neighbouring molecule. Many answers referred to the formation of the hydrogen bonds between partial charges of relevant atoms. Given that the molecule contained an amide group, hydrogen bonding could not occur between the lone pair on the nitrogen atom and a hydrogen atom from a neighbouring atom, due to delocalisation of the lone pair; this also explains the low basicity of amides and was not credited.
- (d) (i) The expected colour change was stated by most candidates.
- (ii) Some candidates had difficulty with the formula of the product although most answered this part correctly.
- (e) (i) The correct terms were given by almost all candidates.
- (ii) Well known by most candidates.
- (iii) Generally well answered; errors included no charge on the fragment or a bond coming from the carbon atom, giving the carbon four bonds.
- (f) A straightforward calculation in which most candidates scored full marks.

Assessment Unit A2 3 Internal Assessment

Practical One

- Q1** This question was extremely well answered with most candidates gaining full marks. A very small number of candidates lost a mark for failing to clearly indicate the units for the average titre. Other errors, such as having a rough titre which was more than 2.0 cm³ greater than the accurate values, were rare.
- Q2** As expected, candidates scored high marks in this question.
- (a)** Almost all candidates scored full marks in Tests 1, 2, 3 and 4. A very small number of candidates gave an incorrect colour for the precipitates in Tests 3 and 4. Most candidates scored at least one mark in Test 5. Some candidates indicated that a precipitate formed, that the solution remained green on addition of water or that the solution turned colourless. The emphasis in Test 6 was on the formation of a deep blue solution and that the deep blue solution remained on addition of water. It is true that, when the ammonia is added slowly, a precipitate will form. Many candidates mentioned this but any suggestion that the precipitate was deep blue was penalised. It was also noted that many candidates use the term “redissolves” to describe the disappearance of a precipitate. This was not penalised but the validity of the term was called into question.
- (b)** In Test 1, there was one mark available for describing the colour change for the litmus paper. The other mark was for the observations. There are many observations which can be made in this reaction. It was surprising that so many candidates only included one observation. The emphasis in Test 2 was on the effervescence. This test was repeated on several occasions and the reaction was not found to be noticeably exothermic.

Practical two

The mean mark for this paper was higher than last year.

- Q1 (a)** Most candidates scored at least four of the five marks. When to add the indicator, the name of the indicator and the colour change were very well known. The most common error was an incorrect initial colour. Only a relatively small number of candidates suggested phenolphthalein.
- (b) (i)** Although the 1:2 ratio was well known, the ionic equation for this reaction was, in general, not well known. The formula and charge for the thiosulfate was often incorrect.
- (ii)** Despite some very poor attempts in Part (b)(i), many candidates scored both marks since they knew the 1:2 ratio. Many candidates also scored marks by carrying an error forward.
- (c) (i)** Overall the standard of answers for this question were very poor. Electrons were often missing.
- (ii)** It was surprising that many candidates who could not provide the correct answer in Part (i) were then able to give a perfect answer in Part (ii). This would suggest that these candidates had simply learned the equation but didn't really have an appreciation of its origin.
- (d)** Again, despite many very poor attempts at the equations in Parts (b)(i) and (c), candidates performed well in this part of the question since they often knew the correct ratios. Many candidates also scored marks by carrying previous errors

through. A common error was the use of an incorrect value for the RFM of potassium iodate(V).

- Q2 (a)**
- (i)** In Test 1, the vast majority of candidates gave three or four possible ions. Some candidates simply said that a transition metal ion was present. In Tests 3 and 4 some candidates did not include the charge on the ion stating that “nickel” and/or “cobalt” ions were present. Correct formulae which clearly suggested the presence of nickel(II) and/or cobalt(II) were accepted. Candidates should be careful when giving the symbol for cobalt. It should be “Co” and not “CO”.
 - (ii)** Formulae which included four water ligands were common and acceptable. Square brackets were not essential.
 - (iii)** Some candidates suggested that only four of the six water ligands were replaced.
 - (iv)** Again, some candidates suggested that only four of the six water ligands were replaced.
 - (v)** The equation required an equilibrium sign to indicate that the reaction is reversible. Many candidates did not balance the equation with respect to the replaced water ligands and many enclosed the chloride ligands inside “curly” brackets.
 - (vi)** Many candidates realised that the six water ligands were replaced with just three bidentate ligands and gave the correct overall charge. The full formula for the incoming ligand was acceptable. A significant number of candidates gave formulae which suggested only partial replacement of the water ligands. Overall, knowledge of the appropriate formulae for complexes in Part (a) was disappointing.
- (b)**
- (i)** In general the responses were excellent with candidates showing a clear understanding of the relevant chemistry. It was however disappointing to see many references to “keytones”.
 - (ii)** Almost all candidates gave the structure of propanone. A small number gave butanone which was also acceptable. Some candidates scored a mark here by carrying an error through.
- Q3 (a)**
- (i)** Most answers were of a high standard and structures rather than formulae were used. The most common errors were the absence of the equilibrium sign and the absence of water as a product.
 - (ii)** Some candidates did not include the word “concentrated”.
 - (iii)** This was very well answered.
- (b)** 2-hydroxypropane was acceptable as an alternative to propan-2-ol. Most answers to this question were incorrect with some very exotic sounding molecules.
- (c)** The answers to this question were, in general, excellent. Even some candidates who struggled with the calculation in Question 1(d) were able to get full marks here. Candidates are obviously very tuned in to this type of calculation when preparing for the Booklet B examination.
- (d)** Most candidates realised that distillation was required.
- (e)**
- (i)** Many candidates gave a bullet point “support material” answer without adding any detail. The method for releasing pressure often lacked detail and some methods would have resulted in the product emptying onto the bench/floor.

- (ii) Again, many candidates gave the “support material” answer and included, for example, the phrase “suitable container”. Candidates should be advised to name the “suitable container”. Many candidates referred to the final product as a “solution” and others failed to recognise that, during the process, the calcium chloride changes from “anhydrous” to “hydrated”. Some answers made reference to the two “layers”.
- (f) There were many excellent answers to this question. Some candidates failed to recognise that both types of O-H absorption (carboxylic acid and alcohol) would be absent. There needed to be a clear reference to a spectroscopic term such as “peak”, “absorption”, or “trough”. Some candidates suggested that the C=O absorption would be absent.
- (g) A significant number of candidates scored the mark. Others did not realise that two of the methyl groups are identical. Despite the wording of the question, some candidates gave additional information about the splitting pattern and chemical shifts. A small number did not understand the term “integration pattern” and only gave a splitting pattern which was normally incorrect.

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