

CCEA GCE - Chemistry
(Summer Series) 2013

Chief Examiner's Report

chemistry

Foreword

This booklet contains the Chief Examiner's Report for CCEA's General Certificate of Education (GCE) in Chemistry from the Summer Series 2013.

CCEA's examining teams produce these detailed reports outlining the performance of candidates in all aspects of the qualification in this series. These reports allow the examining team an opportunity to promote best practice and offer helpful hints whilst also presenting a forum to highlight any areas for improvement.

CCEA hopes that the report 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 paper was successful in giving 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 mark scheme was easy to follow. The candidates appeared to have ample time to complete the paper.

- Q11**
- (a)
 - (i) The majority of candidates lost one mark for assigning oxidation numbers for the charges on the proton and the electron. As previously noted charges should be 1+ or 1-. The use of e.g. +1 and -1 is reserved for oxidation numbers. It should be noted that this had little impact on the overall award as few candidates got this mark.
 - (ii) Most candidates gained full marks in this question. A small number of candidates appeared to read the number of neutrons as 117 instead of 177 and gave a mass number of 233 instead of 293.
 - (b) This definition was well known by most candidates. A number of candidates lost a mark by stating that an isotope was an atom instead of atoms.
 - (c) This calculation was very well done with the vast majority of candidates gaining both marks.
- Q12**
- (a) This was not well answered and proved a good discriminator. This was an emission spectrum so the two arrows had to go downwards between the correct levels. Arrows were often drawn going up and down and more than two arrows were often drawn. Arrows going downwards from the incorrect levels and to the incorrect level were common.
 - (b) This also proved a useful discriminator. Incorrect rounding was frequent and was marked accordingly. Many candidates failed to multiply by the Avogadro Constant. The conversion from J to KJ was often missing.
 - (c) This was a simple question but many candidates failed to use the formulae of the ions as instructed and so were penalised accordingly. When the formulae of the ions were used they were generally correct.
- Q13**
- This question was very well answered with many candidates gaining full marks.
- (a)
 - (i) This definition was well known with only a few candidates including the volume of the solution as well as the concentration.
 - (ii) This equation was also well known with few mistakes. The most common error was the incorrect formula for ethanoic acid.
 - (b) This calculation was very well answered. Any errors in the equation were carried through. The most common mistake was in part (v) when using the density of the wood vinegar.

- (c) The indicator was well known although the spelling of phenolphthalein is still problematical. The use of methyl orange was carried through and candidates could still obtain both marks for the colour change. If the colour change was given in reverse, one mark was awarded.

Q14 This question proved to be more difficult than expected and was a useful discriminator. Many of the explanations offered by the candidates were poor.

- (a) This was the best answered part of this question. Few candidates failed to gain both marks. The most common error was not stating that the outer electrons are in the p orbital, rather they simply stated that there are electrons in the p orbital. A small number of candidates stated that argon is a Noble Gas.
- (b) (i) This was poorly answered with a surprising number of candidates using van der Waals forces in their explanation. Many candidates recognised the increase in delocalised electrons but failed to relate this to the fixed cations. They did at least gain one mark.
- (ii) This was reasonably well answered. A few candidates described silicon as being molecular instead of giant covalent.
- (iii) This was poorly answered. Many candidates described the breaking of the bonds in the molecules rather than the van der Waals forces between the molecules. Only the better candidates recognised the difference between the phosphorus molecules and the sulfur molecules.
- (c) This was reasonably well answered although a few candidates did state that the atomic radius increased across the period. Many candidates correctly described the increase in nuclear charge without relating it to the shielding and vice versa.

Q15 This question was generally very well answered with many candidates scoring twelve or thirteen marks.

- (a) (i) Many candidates were unable to describe a covalent bond as the 'sharing of a pair of electrons between atoms'. They failed to state that one electron came from each atom as stated in the 'Clarification of Terms' support document.
- (ii) The explanation of the octet rule was very well known with most candidates gaining full marks.
- (b) (i) The dot and cross diagrams were generally very well drawn with the majority of candidates gaining four marks. The main errors were omitting the outer electrons on the chlorine atoms or placing a lone pair of electrons on the aluminium atom in the aluminium chloride.
- (ii) This was very well answered with most candidates gaining the mark.
- (iii) The diagrams were generally well drawn. Any errors in the dot and cross diagrams were carried through where possible. Some candidates had difficulty with the dot and wedge convention for the tetrahedral shape, although this was not essential. The names of the shapes were well known. A few candidates incorrectly described the aluminium chloride as triangular planar.

Q16 This proved to be the most difficult question on the paper with many of the explanations poorly expressed in chemical terms.

- (a) (i) This was a straightforward question and generally well answered with most candidates gaining the mark.
- (ii) Many candidates gained one mark for stating the increase in electrons and therefore van der Waals forces but failed to state that these forces were between the molecules.
- (iii) The explanation of electronegativity was extremely well answered.
- (iv) The explanations for the trend in electronegativity were often vague. Many candidates gained a mark for recognising the increase in atomic radius but failed to relate this to the bonding electrons.
- (v) This equation was generally well answered. A few candidates used Fl as the symbol of fluorine and some used the fluorine molecule in the equations. The majority of candidates gained at least one mark.
- (vi) The trend in ionisation energy was well answered with most candidates gaining at least one mark. The main error was the omission of the increased shielding or failure to relate the answer to the outer electrons.
- (b) (i) This equation was generally well known with the majority of the candidates gaining the mark.
- (ii) Where possible, any errors in the equation were carried through. The use of the oxidation numbers was well known and the most common error was a failure to explain which was oxidation and which was reduction. The majority of candidates gained at least two marks.
- (iii) This was a new type of question and the majority of the candidates gained at least one mark with many gaining two or three marks. Some candidates mistakenly referred to ultraviolet light in their answer and many did not mention the toxic nature of chlorine. Overall the examining team were pleased with the responses of the candidates. The vast majority of the candidates gained both marks for the 'Quality of written communication'.
- (c) (i) This was generally well answered with many candidates gaining two or three marks. Candidates are reminded that they should use the colours stated in the 'Acceptable Colours' support material.
- (ii) This proved to be the most difficult question on the paper. The majority of the candidates were obviously unfamiliar with the reaction and few examples of the correct equation were seen. Many candidates stated that solid iodine would be formed.
- (iii) This was the best answered of the group of three questions with the majority of the candidates gaining three marks. The most common error was the omission of the charge on the nitrate when it appeared in the equation. A few candidates gave cream as the colour of the precipitate.

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

Overall candidates performed very well on this paper. The multiple choice proved to be very accessible. Q8 was the most challenging with Q4 and Q5 the least challenging. The standard of answering in Section B was high and the paper was successful in allowing candidates of differing abilities to respond positively to the questions posed. Q11 and Q12 were less discriminating than Q13, Q14 and Q15.

Q11 This question proved to be less discriminating between candidates of differing abilities than anticipated. Candidates obviously knew these areas of the specification very well.

In (a)(iv) some candidates did not make it clear in their answers that the amount of shielding increases as Group II is descended. So although they made reference to shielding they did not get that mark.

In (b)(ii) some candidates gave correct facts/deductions rather than observations. (b)(iii) – (v) were well answered by the strongest candidates.

In (c), $\text{Ra}(\text{OH})_2$ and RaSO_4 were accepted as alternatives to the official mark scheme answers. It was remarkable how many candidates gave the formula of a hydroxide in (c)(ii). The answers to (c)(iii) were very impressive. Although it is still the case that some candidates give very good explanations without actually stating the trend.

Many candidates gave an equation involving BaO in (d).

Q12 (a) the vast majority of candidates scored both marks. The idea that the peak moves to the right but drops to a lower level is essential. Careless mistakes were penalised e.g. the curve not starting at the origin, the curves crossing/touching more than once etc.

(b) was answered well with only a small number of candidates not making reference to E_a . There were a small number of very poor answers in (c). These candidates would be well advised to get the basics of written communication correct e.g. starting sentences with capital letters and finishing with full stops.

Q13 Many candidates had learned the definitions given in the support material and scored well on definitions. However, it was remarkable how many candidates were throwing away easy marks on definitions.

The difference between structural isomerism and stereoisomerism (geometric) was not well understood by many candidates and this question exposed a lack of understanding.

There are many structural isomers with the molecular formula C_6H_{12} . Not all structures and names are included on the official mark scheme. However, correct structures and names did get the marks. The standard of structure drawing and naming was often very poor.

Carbon atoms involved in three or five bonds were common. It was not unusual to see the E and Z isomers of but-2-ene obviously copied straight from the candidate's notes as an answer to (c)(iv). The best candidates gave excellent answers and showed a clear understanding of the topics.

Q14 (a) most candidates scored both marks by making both of the points which appear on the mark scheme. A small number of candidates only made the first point.

- (b) was answered well by most candidates with each error losing one mark. It is important that candidates show their working out in this type of question if they want to get any credit.

The answer to (b) was carried through into (c)(ii). Again a small number of candidates explained without “stating” in (c)(i) and (c)(ii). The answers to (d) and (e) were surprisingly very poor. The conditions for the industrial hydration of ethene were not well known. The percentage yield question caused problems for many candidates. Many candidates simply worked out 80% of 460Kg and gave that as an answer.

Q15 The electrophilic addition mechanism was not well known or understood. The idea that the H end (δ^+) of hydrogen bromide is attracted to the electron rich C=C was not well explained with some very strange suggestions given. Many candidates struggled to apply the mechanism to methylpropene despite being told that 2-bromo-2-methylpropane was the product. Linking names and structures seemed to cause problems.

- (b) (iv) did not require Markovnikov’s rule, just a realisation that the alkene is not symmetric and as a result there are two possible addition products. Most of the better candidates were able to apply their knowledge and gave the correct answer.
- (c) (ii) caused very few problems in general. Drawing the structure of the polymer caused a lot of problems with some very unusual suggestions given. Carbon atoms involved in five bonds were common.

Assessment Unit AS 3 Internal Assessment

The teacher marking in this unit was, in many cases, of a high standard. Again centres tended to fall into three categories, those who stuck rigidly to the mark scheme, those who had a more flexible approach and used some professional judgement and those who were unduly generous to their candidates. Several centres forwarded comments on the paper and mark scheme to CCEA. These comments were all noted and responded to and taken on board at the standardising meeting. In a number of cases amendments were made to the mark scheme in view of these comments. The standardisation process and remarking of all scripts means that candidates are not advantaged or disadvantaged in any way as a result of this variation. Centres are advised to stick rigidly to the mark scheme and if adjustments to the mark scheme are needed these will be done at the Standardising Meeting and taken into account during the remarking of the scripts.

Q1 Titration (Practical Examinations 1 and 2)

This question was similar to those from previous papers and candidates generally performed well.

- (a) Most candidates gained at least two marks on this question and many scored three or four marks. The main error was not stating that 2.90g/2.45g of the washing soda should be weighed out. Some candidates placed the solid directly into the volumetric flask without dissolving it in distilled/deionised water first.

A few candidates incorrectly described the transfer of 25cm³ of solution to a conical flask and the process of washing the burette and pipette.

- (b) The table was generally well drawn and labelled and the vast majority of candidates gained full marks. The most common mistake was to calculate the average titre outside the table and then omit the units. A few candidates used

the rough reading when calculating the average titre. A few candidates also had the rough titration equal to or less than the accurate values. A small number of candidates lost a mark for incorrect use of decimal places.

- (c) The colour change had to be from yellow to orange/red/pink and was very well answered by candidates.
- (d) The equation was generally well known but a small number of candidates gave NaHCO_3 or H_2CO_3 and lost a mark accordingly. Any error in balancing the equation was carried through.
- (e) The calculation was well answered with many candidates gaining full marks. Any errors in the equation or the calculation were carried through and resulted in five or six marks being obtained. Few candidates scored less than four marks in the calculation.
- (f) **Practical Examination 1**

This was poorly answered with few candidates gaining two marks. The most common answer was for droplets of a colourless liquid/condensation. Condensation was accepted although it is a physical process and not an observation; it will not be accepted as an observation in future years.

Practical Examination 2

This was generally well answered. The most common errors were not stating the use of a solution of magnesium ions or failing to pass the gas through the lime water.

Q2 Observation and Deduction (Practical Examinations 1 and 2)

Candidates were obviously well prepared for these exercises and the standard on both papers was high.

- (a) **Experiment 1:** A small number of candidates still fail to state that a compound or metal ion is present in the solid and lost a mark accordingly.

Experiment 2: The observations were generally very good and any errors in the deductions were carried through. In (a) Mg^{2+} , Al^{3+} and Zn^{2+} ions were all required for the first mark and then Al^{3+} or Zn^{2+} ions for the second mark. In (b) the Mg^{2+} ions were not essential but were not penalised.

Experiment 3: Many candidates are still failing to recognise that the initial use of the acid is to eliminate the possibility of carbonate or hydrogencarbonate ions being present. The presence of chloride/sulfate ions was almost always correct. A few candidates are still incorrectly using the term 'chlorine atom'.

A number of candidates incorrectly describe solutions as being cloudy white instead of a white precipitate being formed.

Experiment 4: This was well answered with the majority of candidates gaining four or five marks. The most common error was in describing the smell as sharp rather than pungent/choking as had appeared on previous mark schemes.

Any errors in the deductions were carried through to the naming of the salts.

- (b) This was again well answered and the use of ‘negative tests’ was again part of the exercise.

Experiment 1: Virtually all candidates gained both of the available marks.

Experiment 2: There was some difficulty with the flame in Practical Examination 1 and the examining team accepted a correct deduction for the flame observed. A blue flame was not accepted but yellow-blue was accepted. In Practical Examination 2 a mark was accepted for the colour of the flame.

Experiment 3: This was readily recognised as the test for unsaturation by most candidates and most gained both marks.

Experiment 4: This was recognised as a test for primary and secondary alcohols and the observations and deductions have appeared on previous mark schemes. This was generally well answered.

The deductions regarding the functional groups must relate to the experiments which have been carried out. Therefore the -COOH group cannot be awarded a mark since there is no evidence to support the conclusion. A few candidates gave hydroxide instead of hydroxyl. Aldehyde was accepted in place of hydroxyl.

Q3 Planning (Practical Examinations 1 and 2)

- (a) The calculation was generally well done with most candidates gaining five or six of the available marks in Practical Examination 1 and four or five of the available marks in Practical Examination 2. In Practical Examination 1 the main error was the use of ethanol as the limiting reactant instead of phosphorus(III) iodide. In both Practical Examinations the lack of units was penalised once, as was any errors in rounding.
- In Practical Examination 2 part (vii), side reactions was also accepted as a reason for the yield being less than 100%.
- (b) (i) The explanation of reflux is in the ‘Clarification of Terms’ support material and so should be well known. Many candidates incorrectly used evaporation instead of boiling and were penalised accordingly.
- (ii) Most candidates recognised that the cold water was to remove heat from the reaction mixture.
- (iii) Most candidates were able to name at least one inorganic impurity and many named two. A reasonable number of candidates incorrectly named organic impurities.
- (iv) The use of sodium hydrogencarbonate was also accepted for removing the acid. It was also agreed to accept both the solid and the solution. Most candidates answered this question very well. Some candidates incorrectly described the separating of layers with no mention of the sodium carbonate or sodium hydrogencarbonate.
- (v) This was well answered. Anhydrous calcium chloride and anhydrous magnesium sulfate were both added to the mark scheme. Most candidates gained both marks.
- (vi) This was poorly answered. The boiling range of the distillate was given in part (vii) and this should have helped the candidates to realise that this was below the boiling point of water. Only the most able candidates gave this answer and so it was an excellent discriminator. It

was agreed to accept an answer on grounds of safety as long as it was correctly explained e.g. ethanol is flammable.

- (vii) Most candidates were able to gain at least one mark in terms of the purity or yield of the product. Many candidates incorrectly stated that the range given was the boiling point of the distillate rather than stating that it boiled within this range.

Q4 Practical Examination 1

- (a) The candidates should know from the titration exercises in 1.9.3 on the specification that Group II carbonates are insoluble. Therefore they should be able to deduce that dolomite is insoluble. The test for carbonate ions using a solution of magnesium ions will not work and was not awarded any marks. Most candidates used a named acid and tested for the presence of carbon dioxide as per the mark scheme. The main error when this was used was not to pass the gas given off through the lime water.
- (b) The flame test was well known and well answered. A small number of candidates are still not using concentrated hydrochloric acid before dipping the nichrome wire in the solid. The nichrome wire should be held in a blue Bunsen flame not a roaring Bunsen flame. Both of these points have been noted in previous mark schemes.
- (c) The test for magnesium ions was well known and the examining team accepted the use of either sodium hydroxide solution or ammonia solution without referral to the other. Common errors were not using a solution of the dolomite or dissolving the dolomite in water and not using a solution of sodium hydroxide or ammonia. The need to use solutions in precipitation tests has been noted in previous reports and candidates should be aware of this.

Q4 Practical Examination 2

- (a) The flame test was well known and well answered. A small number of candidates are still not using concentrated hydrochloric acid before dipping the nichrome wire in the solid. The nichrome wire should be held in a blue Bunsen flame not a roaring Bunsen flame. Both of these points have been noted in previous mark schemes.
- (b) The test for aluminium ions was well known and the examining team accepted the use of either sodium hydroxide solution or ammonia solution without referral to the other. Common errors were not using a solution of the alum and not using a solution of sodium hydroxide or ammonia. The need to use solutions in precipitation tests has been noted in previous reports and candidates should be aware of this.
- (c) The test for the sulfate ions was well known. The examining team decided that the use of a named acid was not essential in this instance and that a solution of barium ions or a suitable named barium salt was acceptable. The same problem with the use of solutions was again noted.

Q5 Practical Examinations 1 and 2

- (a) **Practical Examination 1:** Surprisingly not all candidates gained both marks for the test for oxygen. The most common error was using a burning splint instead of a glowing splint.

Practical Examination 2: Most candidates were able to give the correct test for chlorine. The most common error was not using moist indicator paper. A reasonable number of candidates gave the test for hydrogen chloride.

- (b) This calculation was done extremely well in both Practical Examinations. The main error was in the incorrect use of the molar ratio and any error was carried through. Most candidates gained three or four marks.

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

The paper was slightly less challenging than the one set in January but many candidates dropped marks on questions that at first glance appeared to be fairly undemanding for A21.

Q11 This question was almost all recall from topic 4.10 from the specification and was answered well by the majority of candidates.

- (a) The question asked for the name but correct formulae were also accepted. Most candidates got this correct. The most common mistake was “sodium dioxide”.
- (b) The question asked for a formula so names were not accepted as names are not a higher order skill. A common error, that seemed to stem from confusion with aluminium chloride, was to write the formula as Al_2O_6 .
- (c) This part of the question caused most bother. Many candidates did not know that sodium sulfite was produced and frequently lost both the marks for writing an answer that involved sodium sulfate instead. There are several equations in topic 4.10 that simply need to be learned for recall but the evidence from this question would indicate that the majority of students are not very thorough about this aspect of examination preparation.
- (d) Most candidates scored both marks here. Those that lost a mark usually lost it for the structure.
- (e) As with part (a) correct formulae were accepted as well as names. Well answered.
- (f) This equation was more familiar to the candidates than the equation required in part (c) but it still proved difficult for about half of them. Again it is recall so candidates need to learn it more thoroughly.
- (g) Almost all candidates were able to name phosphoric acid.

Q12 (a) Very well answered. Almost all the candidates got this right.

- (b) (i) Around a quarter of the candidates lost the mark here because they did not include H_2O in the K_c expression. Others lost the mark because they were careless with formulae e.g. $\text{CH}_3\text{COOC}_3\text{H}_{11}$ was seen occasionally.

- (ii) Considering how frequently calculations like this appear on the A21 examinations, this was surprisingly poorly answered. A very common error was to use masses in the calculation instead of converting to moles. Most candidates still managed to score at least two marks and this calculation proved to be a good discriminator even though it was quite straightforward. Any errors from (b)(i) were carried forward in the marking process although candidates were expected to state units if their incorrect answer for (b)(i) would yield units.
- (iii) Most candidates scored at least one mark here. To score both marks the candidates had to specify that the forward reaction was being favoured (or something similar) at higher temperatures. Some candidates simply stated that it was “endothermic because K_c increases at higher temperatures for endothermic reactions”, but this was not deemed adequate to “explain” the answer.
- Q13** (a) (i) A lot of candidates dropped marks here because they left out some of the oxidation numbers. The question asked for the oxidation numbers of all elements before and after. Hence if a candidate omitted one element (frequently oxygen) then he/she had two oxidation numbers missing and lost both marks. It was common to see the oxidation number of oxygen at the start reported as being -6 . Unexpectedly a lot of candidates dropped marks on what is in effect an AS1 question. It was quite rare to see a candidate scoring both marks. Candidates also need to be careful to write oxidation numbers precisely – the sign must go before the number (the oxidation number of oxygen is -2), whereas for ions the sign must go after the number (the charge of an oxide ion is $2-$).
- (ii) Answers were quite careless here. In light of the wording of the question, “in terms of oxidation numbers”, a candidate could not score both marks without referring to oxidation numbers in their response. Nor could they score both marks if they failed to mention the specific elements that were being oxidised and reduced. A lack of precision overall in part (a) will have cost some candidates three or four marks. This is very surprising given the fundamental nature of the material being examined.
- (b) This was possibly the most poorly answered question on the paper. Only a handful of candidates scored four marks here. Most did not discern the limiting reactant correctly and many just picked one reactant and worked with it rather than working out the number of moles of all the reactants. Another common error was to only work out the volume of one gas (nitrogen or carbon dioxide) rather than working out the “total volume of gas”. A surprising number of candidates merely worked out the number of moles of each reactant, totalled them and multiplied them by 24 dm^3 and therefore did not calculate any values for the “gas produced” – it is the frequent lament of many teachers that their candidates don’t read questions properly and this was well demonstrated here. A good discriminator and again something that A21 candidates should have been competent at yet most only scored two or three marks.

- (c) This was well answered. Candidates who lost marks here usually failed to take into account the balancing numbers in the equation when they were doing the calculation but still managed to score one or two marks.
- (d) (i) Well answered. Again any errors involved the omission of balancing numbers. Some candidates lost marks here because they wrote the wrong units which is careless considering they were given in the table.
- (ii) Most candidates scored one or both marks on this question. Errors in previous calculations were carried forward as much as possible. The most frequent mistake here was to state that a reaction was feasible if the value of ΔG was less than *or equal to* zero, when in fact it has to be less than zero.
- Q14** (a) (i) Equations like this have become quite common and the candidates are good at writing them. A frequent mistake was to write the equation with potassium hydroxide instead of sodium hydroxide. Some marks were lost as well for incorrect structures e.g. a CH_2 in the centre of the three carbons instead of CH.
- (ii) It wasn't anticipated that many A2 candidates would get this wrong, but some did. The structure is given at the top of the page and they had to count up the total number of carbons, hydrogens and oxygens. Errors in the formula were carried forward to the RMM and, again, it was surprising to see how many candidates could make mistakes in a simple RMM calculation.
- (iii) Some candidates may have been confused by the wording of part (a) as their definition was written for either sodium hydroxide or potassium hydroxide. However this is a standard question on an A21 examination and it should have been well known especially with the 'Clarification of Terms' support document now in use. The usual lack of precision about a 1g sample and mg of potassium hydroxide cost many candidates one or both marks.
- (iv) This was well answered and errors were carried forward from parts (ii) and (iii) meaning candidates could score all four marks for the calculation even if they used sodium hydroxide. The ($\times 1000$) conversion from grams to milligrams still causes problems with a few candidates who either multiply by 10 or by 100, or else divide by 1000.
- (b) (i) This definition was also taken straight from the CCEA 'Clarification of Terms' booklet and was well answered by the majority of candidates although (as with the definition of saponification value) a mark was frequently lost for failing to specify that the mass of iodine is in grams.
- (ii) Most candidates were able to score this mark although some lost it through a lack of precision because they stated that there were "no double bonds" instead of specifying that there were "no $\text{C}=\text{C}$ double bonds". It was also acceptable to simply state that the molecule was saturated.
- (iii) Most candidates answered this well but marks were frequently dropped for failing to specify a known mass at the start and failing to state that the sodium thiosulfate solution was "standard". When describing the titration candidates had to state that the starch was added when the solution was pale yellow and also give the colour change at the end point. The quality of written communication was excellent.

- (iv) Most candidates went with an argument involving RMM and van der Waal's forces. A mark was awarded for van der Waal's forces but the RMMs of glyceryl tristearate and glyceryl trioleate only differ by six (less than 1%) and this is not sufficient to explain the difference in their physical states at room temperature. The second mark was awarded for some mention of the unsaturated trioleate chain preventing it from packing closely due to the kinks caused by the C=C bonds. Some candidates were heading in the right direction with this second mark but they incorrectly said that it was due to "branching" rather than kinking/packing.
- Q15**
- (a)
- (i) Most candidates scored at least one mark for the name. Numbers were frequently mixed up and hyphens sometimes appeared in incorrect places (e.g. between hydroxy and butan...). It was also common (and incorrect) to see "hydroxyl" instead of "hydroxy".
- (ii) The location of the hydrogen bonds had to be specified to score both marks e.g. between the O of H₂O and the H of the OH on acetoin.
- (iii) Most candidates had no problem with the 2,4-dinitrophenylhydrazine derivative or the nitrile. The diol produced after reduction with lithium was frequently incorrect and the product with PCl₅ was usually wrong as candidates simply replaced the H of the hydroxyl group with Cl rather than replacing the whole OH group.
- (iv) Well answered. Occasionally nucleophilic substitution was seen.
- (b)
- (i) About half the candidates were able to write this equation very well although some dropped a mark for omitting water. Those who wrote the equation using structures rather than formulae usually had more success with it.
- (ii) Almost everyone got this answer correct which is not surprising as it is AS2 material.
- (iii) There were a lot of mistakes here that didn't seem to follow any pattern.
- (iv) Most candidates scored this mark as errors were carried forward from their answer to (b)(iii) but some lost the mark for failing to write "Rate = ..." as the question had asked for the rate "equation".
- (v) Again errors were carried forward and most candidates scored at least one mark. Some struggled with units.
- (c)
- (i) This is a remarkably common question and it was very well answered. Candidates need to use the word "plane" twice in their answer to be sure of two marks. It was pleasing to see almost all candidates using the word "rotate" rather than other incorrect terms (e.g. bend, reflect) that had appeared frequently in the past.
- (ii) To simply use the terms "asymmetric" or "chiral" was not sufficient for two marks. Candidates had to give their answer "in terms of structure" meaning they had to specify that the carbon was bonded to four different atoms or groups. Some candidates lost a mark because they stated that the carbon was bonded to four different *functional* groups.

- (iii) Most candidates scored both marks here. The shape had to be clearly tetrahedral rather than plus-shaped. Dash and wedge structures were not insisted upon but are preferable and if used they need to be correct. This can be a difficult question to mark as it is possible to draw two structures that are not mirror images *on the page* but are optical isomers nonetheless. It is handy for examiners to quickly make models to check answers as some candidates' representations of the isomers are almost impossible to interpret but turn out to be correct.
- (iv) The most frequent mistake here was to state that there was "no rotation" rather than stating that "the rotations cancel out" or that "there is no overall rotation".
- Q16**
- (a) This was possibly the easiest question on the paper with all but a tiny minority of candidates scoring all four marks.
- (b) A straightforward Born-Haber calculation that involved no multiplying or dividing. The only error being made by a few candidates was to introduce a factor of two at some stage.
- (c)
- (i) Both parts of (c) caused problems for many candidates. In (c)(i) most candidates got the correct three energy changes but lost a mark for a lack of precision in their terminology. For example, the electron affinity of "the halide" was not accepted – it should be the electron affinity of "the halogen". A lot of candidates scored two marks here.
- (ii) This was very poor. After much deliberation the mark scheme was finalised to be as candidate-friendly as possible but even then only a few candidates scored more than one mark. The difference in enthalpy of atomisation had to be explained in terms of bond length/strength/energy/enthalpy. The difference in electron affinity of the halogen was due to atomic radius and shielding (only one was required). The difference in enthalpy of formation was due to the different reactivities of the halogens. This was a new question with a fairly generous mark scheme but even then, candidates found it challenging.
- (d)
- (i) The most common error here was to write H_2O on the left hand side of the equation. Water is not a reactant in this case and hence cannot be written in the equation. H_2O written above the arrow was accepted. (aq) could be written above the arrow or on the left hand side. About half the candidates were trying to react potassium chloride with water and were producing potassium hydroxide, hydrogen chloride and various other products. State symbols were almost universally correct.
- (ii) This was well answered. Some candidates lost a mark as they used their answer from part (b) rather than using the lattice enthalpy quoted in (c)(i) and a few subtracted the enthalpies of hydration from the lattice enthalpy rather than adding them.

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

Although the paper was more challenging than last year the mean only decreased by 5 marks out of 120 indicating that candidates performed better than anticipated. There were fewer marks in the 80-90% range but the highest mark scored in section B was actually 96%.

The difficulty of questions in section A varied greatly but most were discriminating.

Q11 (a) (i) It might have been better to ask for a mechanism rather than a flow scheme. Both ways of asking this type of question have been used in the past. There was no evidence that candidates were confused by this expression, indeed the word mechanism was mentioned in the introduction to the question. All mechanisms involve flow schemes and all candidates answered the question using a flow scheme.

It is correct to say that this was an unusual mechanism because it is not listed as knowledge in the specification. However, all reactions with benzene involve electrophiles and this reaction was not unusual in this respect. It might be thought that there was an excessive examination of bromination in the paper but there was a need to state that the electrophile was $\text{CH}_3\text{CH}_2\text{CH}_2^+$ and to compare it with a known electrophile. The mechanism was for alkylation and not bromination.

Candidates performed well on the question. The major mistake was to attach the CH_3 group to the ring, more than 20% of the candidates did this. If the electrophile had been written as $\text{CH}_2^+\text{CH}_2\text{CH}_3$ then there is no doubt that there would have been more success. Other errors seen were to have excess positive charges and to use dotted lines for bonds. In the transition state normal bonds exist.

(ii) The question asked for “suggest”. Most candidates obtained the three marks ie. catalyst, high temperature and high pressure. Any pressure above one atmosphere was regarded as high and a temperature greater than 100 °C was also high. Also accepted were absence of air and the use of a finely divided catalyst. Catalytic cracking is in the specification and the use of nickel as a catalyst is in A2-2.

A small number of candidates wished to use zinc oxide as an oxidising agent.

(iii) Candidates usually obtained the correct answer of hydrogen bromide but hydrobromic acid, implying an aqueous solution, was wrong. The incorrect answer frequently supplied was bromine.

(b) (i) The amine was correctly described as being a primary amine by most candidates. The second mark was harder to obtain but it could be said that either the amino group was NH_2 and therefore primary or because it was attached to one carbon atom or words to that effect. Any mention of a secondary amine lost both marks. Tertiary amine was never mentioned.

(ii) Again, virtually all candidates stated that benzedrine was a stronger base than phenylamine. Several facts had to be mentioned for the second mark. It was essential to mention the lone pair and it had to be on the nitrogen atom. Unfortunately several good answers were not

precise with the location of the lone pair e.g. stating that it was a stronger base due to its larger electron density *near* the lone pair of electrons *in* the NH₂ group.

- (c) (i) Candidates continue to have problems when brackets are needed to double the number of anions or cations in a formula. This can lead to charges being omitted and the wrong formula being presented. Frequently errors were seen with drawing the protonated amino group as NH₄⁺. One mark was allowed for the formation of the hydrogensulfate but it was rarely seen.

Very weak answers produced hydrogen and other extraneous chemicals. The question proved to be very discriminating.

- (ii) Similar questions have been asked in the past and the response was approximately the same this time. The expected answer was that the sulfate salt being ionic was far more soluble than benzedrine itself and thus would be more effectively taken. Some answers were not quite correct e.g. “salts are easily ionised in the acidic conditions of the stomach”. It was accepted that benzedrine might be thought to be a liquid and the formation of the ionic salt led to a solid which was more easily handled but an answer such as “the salt is a solid and being ionic it is not easily broken down” was not acceptable and neither was “it’s easier to store”.

- (iii) Although most answers were correct in saying that sodium hydroxide should be used there was a problem sometimes with the conditions. So many were quoting a low temperature such as 5 °C or below 10 °C. It appeared candidates were confusing amine liberation with diazotization. Very incorrect answers used tin and concentrated hydrochloric acid.

- (d) (i) Candidates had learnt their definitions quite well and the answer which was seen was “four different groups attached to a carbon atom” but there was a problem with the use of the word ‘chiral’ because it is not mentioned in the specification. Saying that benzedrine has a chiral carbon or chiral centre was not sufficient but it was quite a frequent occurrence.

- (ii) It was felt that the phrase “biologically active” should have been understood. Indeed, enzymes are described as biological catalysts in section 5.15.8 of the specification and biodegradable is mentioned in sections 5.16.4 and 5.16.8. The question also said that the variation in activity is explained in a similar way to that of enzyme activity. The lock and key mechanism is stated in the specification in section 5.15.8. It was expected that one isomer was the key and the enzyme was the lock. This question has been asked before with regard to drugs and was then answered very well but it was not answered well this time round which was surprising.

It appeared so often that the benzedrine molecule itself was the active site e.g. “one structure could provide an active site for reactants to enter and so is similar to enzyme activity” or “one enantiomer of benzedrine may be in a better orientation than the other so be more biologically active” or “it has a specific active site which undergoes the lock and key theory mechanism” or “the arrangement of one suits the orientation of biological molecules better and so can react more

efficiently” or “one isomer acts as an enzyme which is a biological catalyst”.

- (e) Eventually it was thought that this question could have been ambiguously worded because there were so many long descriptions of how GLCs were actually constructed. Perhaps the question would have been better if “many drugs” had been replaced with “benzedrine”. Indeed, there were many answers that described mobile and stationary phase and many other things which were irrelevant to the question asked.

It is perfectly possible to measure retention time and to compare different retention times with known drugs. The use of different columns and different temperatures makes the process very reliable. Although the specification mentions “the reasons for linking mass spectrometry to GLC” in section 5.1.4, there was no reason to use mass spectrometry in this question. GLC can be used for identification.

- Q12**
- (a) (i) Carboxylic acids are part of the specification and the - COOH group should be easily recognised and the structure of the ion was presented in part (c). In previous years questions have been asked about citric acid which also presents the problem of dealing with more than one carboxylic acid group in a formula. Despite this many candidates had difficulty in writing the formulae of the oxalates. Often they were writing two Fe atoms in the case of iron(II) oxalate when only one was needed. Of course if oxalate was regarded as $C_2O_4^{2-}$ the question became easier.
- Writing formulae should be a relatively easy task for A2 candidates.
- (ii) The colours of the iron(II) and iron(III) oxalates were readily deduced from the colours of the iron(II) and iron(III) ions as green and yellow.
- (iii) Similarly with this part question the colours of the precipitates were well known. It was very rare to state that either of the hydroxides would dissolve in excess sodium hydroxide solution.
- (b) It was possible to carry an error through from (a)(i) to this question. What was not realised by most candidates was the fact that equations are balanced. Hence if you add the products together ie. $FeO + CO + CO_2$ the answer obtained is FeC_2O_4 which is the formula of iron(II) oxalate which would have been a way to solve (a)(i). The question directly stated what the products were.
- (c) (i) Questions on iron(II) oxalate titrations have been asked before. The specification states in section 5.3.4 “deduce titration equations given the half equations for the oxidant and the reductant”. But it also says in section 5.3.3, “titrate acidified potassium manganate(VII) with iron(II) and other reducing agents”. It was thought that it was better to present the iron(II) oxalate as two separate equations. Again, it was thought that it was perfectly reasonable for an A2 candidate to work out the formula of iron(II) oxalate from the ions presented.

Although the question was difficult it was discriminating. Only the better candidates were able to balance the equation. All the necessary information was provided. Although much depended on the correct formula of iron(II) oxalate, candidates were able to carry any error through to (c)(ii). The ratio of iron(II) to permanganate ions was carried through to (c)(ii) and most candidates obtained marks for the calculation. Indeed, even without the correct equation it was possible to obtain four marks and this was frequently done.

- (d) (i) The meaning of the term ‘complex’ has been defined in the list of definitions. Answers were good but slightly worse than expected.
- (ii) With this definition and the one of complex in part (i) there were several things to be said and occasionally the definition was less than perfect and a mark was lost.
- (iii) It would be expected that candidates were able to draw the structure of an octahedral complex based on a bidentate ligand especially if its formula was given. In the specification bidentate ligands are mentioned in section 5.7.6 i.e. $\text{NH}_2\text{CH}_2\text{CH}_2\text{NH}_2$ and polydentate ligands such as edta. Candidates should explore the many possibilities of drawing structures of complex ions which incorporate both bi and mono-dentate ligands. Section 5.7 of the specification does not exclude such structures. The correct way of drawing octahedral structures has been explained in many ways in many reports before.

Candidates had difficulty because they could not interpret what was meant by the term “trioxalato anion” which was $\text{Fe}(\text{C}_2\text{O}_4)_3^{3-}$. Most candidates thought that the potassium ions were involved. There were very few correct answers.

- (iv) It is accepted that optical activity of transition metal compounds is not mentioned in the A2-2 specification. However, it is possible to ask the question “why is a substance optically active?”. The answer often is because the molecule has a carbon atom attached to four different groups but it is also correct to say that a molecule is not superimposable on its mirror image. Very few candidates were able to opt for the second answer and gave the first which is incorrect because the oxalate ion does not satisfy the first definition. Hence an answer based on the rotation of the plane of plane polarised light was accepted. Many candidates stated this but lost a mark because of also stating four different groups attached to a carbon atom.
- (e) This question was based upon section 5.7.8 of the specification. It was not possible to accept an equation for the answer and one was not asked for in the question. Equations were often presented that involved potassium ions. Candidates realised that it was a ligand replacement reaction but often did not realise that oxalate ions were being replaced and when they were written the formula was incorrect with the charge being omitted.

Often, the number of molecules on the LHS was stated compared to the number on the RHS but this was usually irrelevant especially if potassium ions were in the equation.

- Q13**
- (a) (i) The equation for the reaction of propanoic acid with ammonia was correctly stated except for a small minority that insisted on writing the positive charge for the ammonium part but then left out the negative charge for the rest of the salt.
- (ii) Any error such as a missing charge was carried through and candidates performed better on this part than the first part.
- (b) (i) Section 5.2.2 of the specification states “understand the reasons for the use of TMS as a standard”. Note that the specification asks for more than one reason. Despite this being direct knowledge from the specification the answers given were not good. A mark was given for there being a single peak but few candidates could correctly advance upon this. Answers seen were: “all of its hydrogens are chemically equivalent so it would give a singlet and has a reading of zero”; “it has four groups in the same environment”; “it is a neutral molecule”; “TMS has no hydrogens and so it will exhibit no splitting”.
- (ii) Answers were universally correct.
- (iii) Answers were universally correct.
- (iv) Answers to questions dealing with deshielding have been well answered in previous years. The difficulty in this case was that there were two electronegative atoms to choose from. Incorrect answers mentioned both nitrogen and oxygen and thus were inevitably wrong. Simply mentioning that the nitrogen was electronegative was not sufficient, deshielding also had to be mentioned.
- (v) The nmr of ethanol is in the specification and thus candidates should be aware that the hydrogen attached to the oxygen cannot split the hydrogens on the carbon atoms through the oxygen atom. Similarly in this case the hydrogen on the NH group cannot split the hydrogens in the CH₃ group. There were many other correct statements to make as can be seen in the mark scheme. Ultimately the question proved to be very discriminating with the full range of marks being obtained.
- (c) (i) The formulae of the fragment ions were correctly given in the main. More problems were seen with the second ion. Ions which are incapable of being formed are not accepted.
- (ii) The term fragmentation is explained in the list of definitions. Few candidates obtained the two marks, most obtained one mark because they did not mention the molecular ion. Often it was referred to as the molecule.
- (iii) The base peak was correctly identified as 44.
- (d) (i) Candidates had few problems with the equation and the vast majority obtained the two marks.
- (ii) Very few candidates obtained the correct answer to what was a new question. The question had been carefully explained. It was linked with the idea that the hydroxide ion, a nucleophile, was better at reacting with an amide group than the hydrogen ion, an electrophile. Only one mark was available and was for the nucleophile attacking the δ^+ of the carbonyl group which was expected to be a discernible reason in view of the many reactions of carbonyl groups with nucleophiles in the specification.

- (e) (i) The question was as exactly stated i.e. a section of the nylon molecule and candidates reacted appropriately. The usual mistakes were made such as omitting the formation of water and not leaving both ends of the section with bonds. A small minority drew structures based on terephthalates.
- (ii) The specification does not ask for major or minor uses of nylon. It was expected that decisions would have to be made at the standardising meeting but the answers were very similar i.e. mainly fabrics or rope. No contentious uses were seen.
- (iii) This question was taken directly from section 5.16 of the specification. Despite a generous mark scheme many candidates were limited to three marks. Terms were used which were not explained. The specification states landfill and incineration for polythene and also states that polyamides can be hydrolysed. Often peptide was stated instead of amide.
- Q14** (a) After many years the meaning of ‘empirical formula’ is becoming understood at A2. This was a relatively simple case and all the answers were correct.
- (b) Candidates should have been wary of using one word to describe the shape of benzene although there was only one mark available. It is possible to say several things about the shape of benzene but the two most important things are that the molecule is flat and hexagonal. It was decided that flat was more important than hexagonal and most candidates obtained the mark.
- (c) (i) The overall equation for the reduction was given correctly by the great majority of the candidates most of them using either H_2 or H , both of which were accepted.
- (ii) Considering the great success obtained with part (i) and thus the knowledge that the benzene ring could be reduced and that cyclohexane was the final product in the reduction as stated in the question, it came as a great surprise to see the lack of success achieved with part (ii). Perhaps if the question had asked for the formula or structure of each of the reduction products the answers may have been better.
- A handful of candidates obtained two marks. A major answer seen was to gradually reduce the size of the circular ring within the benzene ring or to reduce it from a full ring to a half ring to a quarter ring.
- It is agreed that there is no mention of cyclic compounds in the specification but benzene itself is cyclic and reduction of benzene creates cyclic compounds. No question was asked about the chemical nature of these compounds. Seeing as all the double bonds were reduced in part (i) it should not have been a great step to deduce the structure of each compound at each step of the reduction.
- (iii) This question was back to basics and has been asked many times before and the mark scheme has been honed down to a basic three lines for three marks. Of course the problem often is that candidates are trying to reproduce previous mark schemes and they give two facts covered by one line and omit an essential fact covered by another line. But on the whole good candidates scored three marks and weaker candidates scored two. Errors, as explained, tended to result in one mark. No marks at all were very rare indeed.

- (d) (i) It was difficult to understand why an answer was given in words when the question had stated a value in numbers. Of course some candidates gave a correct answer but they were few.
- (ii) Whatever the answer given in part (i) it was compensated for by the answer in part (ii) where the usual and expected answer with regard to the stability of benzene was given.
- (e) On reflection, as a matter of the aesthetics of the paper, this question could and perhaps should have come earlier as an introduction to the double bonded structure of benzene. However, it was felt that a routine question offering some basic marks even though it was synoptic would be welcomed.

The structures seen were on the whole good but there were many who drew structures without hydrogen atoms which posed a problem for examiners. But most candidates obtained the available three marks.

- (f) (i) The specification, section 5.12.3, refers to the *catalysed* bromination of benzene and when the paper was written this was the answer expected. In fact there were few candidates that stated the catalysed mechanism and hence marks were awarded with its absence. Candidates are expected to know the catalysed mechanism for bromination which is knowledge stated in the specification. The fact that this question became a matter of overlap with the starting question was the result of the generosity in the mark scheme which accepted a perfectly given mechanism involving the bromine cation.
- (ii) Whatever is thought about the economy of the truth in this question with regard to the use of the bromonium ion the matter is that the question was “doable” and many candidates could do it but the weaker candidates were indeed perplexed and the answers revealed this. Candidates should always answer the question asked.
- The question proved to be very discriminating. Indeed candidates could score three marks on part (i) and obtain zero on part (ii).
- (iii) The purpose of asking for the two mechanisms was revealed in this part of the question. In the specification, in section 5.12.2, it is stated “explain the reactivities of benzene and alkenes related to the relative stabilities of the pi electron systems e.g. the resistance of benzene to the addition of bromine compared with an alkene”. Answers were very good with regard to benzene but little was said about the addition of bromine to ethene that was worthy of a mark despite this being directly transferable from the specification.

- (g) The specification states in section 5.13.15, “explain the colour of compounds *such as* dyestuffs and indicators based on the extent of delocalisation”. The words “such as” mean that other compounds can be included but based on the extent of delocalisation. Pentacene satisfies these requirements. Candidates responded well and most candidates gained marks, many quoting directly from section 5.13.15. The question was not as tough as it might have first appeared. The usual errors were seen i.e. electrons returning to the original energy level giving out a colour. Several candidates even referred to the fact that pentacene was a diazo dye.

Assessment Unit A2 3 Internal Assessment

- Q1**
- (a) There were many emails from centres after the Apparatus & Materials list was sent out. This was not unexpected as an edta titration has never appeared on a practical paper before but despite the initial concerns the titration went very well on the day of the examination and there were no further emails regarding the practical aspect of it.
- The method was accessible for most candidates yet proved to be a good discriminator as only the top 20% of candidates made mention of the reference sample in their method. This was required in the method as it was clearly mentioned in the “you are provided with” list and it was sitting on candidates workbenches. Candidates cannot score full marks for a method that ignores something that has been listed as having been provided for them and it is highly unlikely that any candidate ignored the reference sample on their workbench throughout the titration itself. The best candidates referred to it after seeing it in the list or else amended their method after carrying out the titration when they had made use of the reference.
- (b) Candidates have become very good at presenting their results in an acceptable table. Only a few marks were lost due to errors in decimal places or absence of units. The rough titre had to be higher than the accurate titres.
- Only two accurate titres are required and candidates who choose to do more than two must include all accurate titres in the calculation of the average titre. The supervisor’s value was not required this year in the interest of fairness.
- (c) The colour change is listed in the CCEA booklet of ‘Acceptable Colour Changes’ and some minor variations in shade were accepted e.g. pale/dark red. However any variations in the colour itself were not accepted (e.g. “pink” was not accepted).
- (d) This is a new question that was answered well by many candidates. The answer had to make mention of the fact that the buffer removed H^+ ions for the first mark and hence kept the equilibrium moving in the forward direction (or similar) for the second mark. This was application of knowledge and most candidates coped with it very well.
- (e) There was quite a lot to do in this calculation but many candidates have become very competent at dealing with this type of calculation and scored all five marks. The most commonly seen error was failing to scale up from 25 cm^3 to 1000 cm^3 .
- (f) A flame test was the only accepted answer. The question asked for the test to be named so “flame test” was all that was required but if a candidate correctly described the full method for a flame test then the mark was awarded.
- Q2**
- (a) Test 1. Although candidates are familiar with this type of question there are still a large number of them who deduce that a “transition metal” is present rather than a “transition metal *ion*”. Powder was not accepted in the observation.

Test 2. The colour of the solution had to be given. No mark was awarded for stating that the solid dissolves as it is referred to as a “solution” in Test 3. The deductions for Tests 1 and 2 were merged in the mark scheme and many candidates scored both marks for what they wrote for Test 1 as they correctly stated a transition metal ion was present and in the same statement they correctly suggested at least two possible ions.

Test 3. Three marks were available for this deduction and most candidates scored at least two. The third mark that eluded some candidates was for stating that the colour of the solution remained green after the white precipitate fell to the bottom of the tube. Almost all candidates made the correct deduction of chloride ions.

Test 4. Various colours and shades were accepted for the precipitate but “green” on its own was not accepted as this did not distinguish the colour of the precipitate from the colour of the original solution. Centres were concerned that candidates would not be allowed to stray from the ‘Acceptable Colour Changes’ booklet at this point but because this was an observation in a practical examination any viable colour was accepted. Two deduction marks were awarded for identifying the chromium ion and stating that the hydroxide had been formed. The more challenging third mark was only attained by a small number of candidates who correctly deduced that the hydroxide precipitate must be amphoteric.

Test 5. Several centres pointed out that “condensation” was accepted on the AS practical mark scheme and hence should be accepted on the A2 practical.

This was granted on this occasion *but “condensation” will not be accepted in future.* Condensation is a change of state rather than being something that is observed. The more precise, yet rarely seen, description is that a colourless liquid has been formed. To record water as the observation was not accepted.

The deduction for Test 5 had to be that the solid was hydrated or contained water of crystallisation. To merely state that water was present was not acceptable. The name of compound X had to include “hydrated” if a valid deduction had previously been made that led to this conclusion.

- (b) Test 1. This was another new question for this paper and the majority of centres reported no problems with it. The observation for Test 1(a) had to include steamy/misty fumes for one of the marks because Test 1(b) went on to test the gas that had been given off. If the fumes were described as white at this point the mark was lost. Various logical alternatives were accepted for the second observation mark in Test 1(a). The deduction for Test 1(a) could not specify that Y was a carboxylic acid, only that the OH group was present or that Y could be either an alcohol or a carboxylic acid (both had to be mentioned). Test 1(b) was straightforward and well answered by the majority of candidates.

Test 2. A much simpler test than Test 1 and well answered by most candidates.

The name of the homologous series and the use of the mass spectrum to identify Y did not pose any problems.

- Q3**
- (a) This was an unfamiliar equation but candidates who had read the question carefully had no problems with it. PbOH was seen occasionally for lead(II) hydroxide and there were a few errors in balancing but most candidates scored both marks.
- (b) Candidates have done many of these percentage yield calculations on past papers and the vast majority of them scored all four marks.
- (c)
- (i) Well answered.
- (ii) Candidates struggled with this. The primary concerns in choosing a solvent for recrystallisation is that the desired product is soluble when the solvent is hot but practically insoluble when it is cold, and the soluble impurities remain in solution even when the solvent is cold. This was poorly answered even though the mark scheme was relaxed when the scripts were remarked by examiners.
- (iii) This posed problems for some candidates but was generally better answered than (c)(ii). Most were able to convey the idea that too much solvent would result in some product remaining in solution even when cool.
- (iv) A substantial proportion of candidates thought that a suction filtration would not only remove the crystals but would also dry them. Although suction filtration gives a *drier* product it is not adequate to completely dry the crystals.
- (d) Most candidates scored two marks here for describing how to obtain the melting point of the crystals. It was fine to use a “melting point tube” but a few candidates dropped a mark for using a capillary tube without specifying that it must be sealed at one end. The third mark became a good discriminator. A sharp melting point would be observed at 133°C. To simply state that the melting point was sharp was not adequate as it could have been lower than the stated value. “Crystals melt (sharply) at 133°C” was entirely adequate for the third mark.
- (e) Candidates distinctly lacked precision in their answers to this question. The question required the use of “infrared spectroscopic data” so any answer that did not quote the wavenumbers given in the table could not score all three marks. A lot of candidates gave their answer in terms of “bonds” rather than “peaks”. In fact it was hard to believe how many candidates did not use the word “peak” anywhere in their answer. Initially a peak would be observed at 2100 cm⁻¹. This would diminish and peaks would appear at 1650 cm⁻¹ and 3200–3500 cm⁻¹.

Q1 Paper 2

- (a) There were many emails from centres after the Apparatus and Materials list was sent out. This was not unexpected as an edta titration has never appeared on a practical paper before but despite the initial concerns the titration went very well on the day of the examination and there were no further emails regarding the practical aspect of it.

The method was accessible for most candidates yet proved to be a good discriminator as only the top 20% of candidates made mention of the reference sample in their method. This was required in the method as it was clearly mentioned in the “you are provided with” list and it was sitting on candidates workbenches. Candidates cannot score full marks for a method

that ignores something that has been listed as having been provided for them and it is highly unlikely that any candidate ignored the reference sample on their workbench throughout the titration itself. The best candidates referred to it after seeing it in the list or else amended their method after carrying out the titration when they had made use of the reference.

- (b) Candidates have become very good at presenting their results in an acceptable table. Only a few marks were lost due to errors in decimal places or absence of units. The rough titre had to be higher than the accurate titres.

Only two accurate titres are required and candidates who choose to do more than two must include all accurate titres in the calculation of the average titre. The supervisor's value was not required this year in the interest of fairness.

- (c) The colour change is listed in the CCEA booklet of 'Acceptable Colour Changes' and some minor variations in shade were accepted e.g. pale/dark red. However any variations in the colour itself were not accepted (e.g. "pink" was not accepted).

- (d) This is a new question that was answered well by many candidates. The answer had to make mention of the fact that the buffer removed H^+ ions for the first mark and hence kept the equilibrium moving in the forward direction (or similar) for the second mark. This was application of knowledge and most candidates coped with it very well.

- (e) There was quite a lot to do in this calculation but many candidates have become very competent at dealing with this type of calculation and scored all five marks. The most commonly seen error was failing to scale up from 25 cm^3 to 1000 cm^3 .

- (f) Most candidates scored at least one mark. A lack of specificity regarding the observation for hydrogencarbonate ions frequently cost candidates the second mark. A lot of candidates simply stated that a white precipitate was observed for carbonate ions without explicitly stating that nothing was observed for the hydrogencarbonate ions.

Q2

- (a) Test 1. Although candidates are familiar with this type of question there are still a large number of them who deduce that a "transition metal" is present rather than a "transition metal *ion*". Powder was not accepted in the observation.

Test 2. The colour of the solution had to be given. The colour is an extremely pale pink so "colourless" was also accepted. No mark was awarded for stating that the solid dissolves as it is referred to as a solution in Test 3. The deductions for Tests 1 and 2 were merged in the mark scheme and many candidates scored both marks for what they wrote for Test 1 as they correctly stated a transition metal ion was present and in the same statement they correctly suggested the two possible ions.

Test 3. Three marks were available for this deduction and most candidates scored at least two. The third mark that eluded some candidates was for stating that the colour of the solution remained colourless/pale pink after the white precipitate fell to the bottom of the tube. Almost all candidates made the correct deduction of chloride ions.

Test 4. Various colours and shades were accepted for the precipitate as long as the candidates were explicit about the precipitate darkening on standing. Centres were concerned that candidates would not be allowed to stray from the 'Acceptable Colour Changes' booklet at this point but because this was an observation in a practical examination any viable colour was accepted. The two deduction marks were awarded for identifying the manganese ion and stating that the hydroxide had been formed.

Test 5. Several centres pointed out that "condensation" was accepted on the AS practical mark scheme and hence should be accepted on the A2 practical.

This was granted on this occasion *but "condensation" will not be accepted in future.* Condensation is a change of state rather than being something that is observed. The more precise, yet rarely seen, description is that a colourless liquid has been formed. To record water as the observation was not accepted.

The deduction for Test 5 had to be that the solid was hydrated or contained water of crystallisation. To merely state that water was present was not acceptable. The name of compound X had to include "hydrated" if a valid deduction had previously been made that led to this conclusion.

- (b) Test 1. This was another new question for this paper and the majority of centres reported no problems with it. The observation for Test 1(a) had to include steamy/misty fumes for one of the marks because Test 1(b) went on to test the gas that had been given off. If the fumes were described as white at this point the mark was lost. Various logical alternatives were accepted for the second observation mark in Test 1(a). The deduction for Test 1(a) could not specify that S was a carboxylic acid, only that the OH group was present or that S could be either an alcohol or a carboxylic acid (both had to be mentioned). Test 1(b) was straightforward and well answered by the majority of candidates.

Test 2. A much simpler test than Test 1 and well answered by most candidates.

The name of the homologous series and the use of the mass spectrum to identify S did not pose any problems.

- Q3**
- (a) (i) Well answered.
- (ii) Several alternatives were accepted here and most candidates scored both marks.
- (b) (i) This was very poorly answered given that it is first encountered in AS2, it is defined on the CCEA 'Clarification of Terms' booklet and it has been asked many times before. Again a lack of precision was to blame as candidates clearly knew what refluxing was but could not accurately define it. The word "repeated" was frequently omitted but the most common error was to use the word "evaporation" instead of "boiling". At least a third of the candidates made this error.
- (ii) The usual errors appeared here: some candidates did not leave the top of the condenser open, some had the water going in at the top and out at the bottom, and a heat source was frequently missing. Most candidates scored two or three marks.

- (c) Most students were able to find the reactants and products in the method at the start of the question.
- (d) Well answered.
- (e) Well answered.
- (f) Most candidates scored two marks here. The error that was seen most often was stating the wrong solvent (or none at all) when the method clearly stated that the solvent was water. The best candidates noted this as they read the method, mentioned it in their answer to part (f) and were duly rewarded.
- (g) Candidates have done many of these percentage yield calculations on past papers and the vast majority of them scored all four marks.

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