

CCEA GCE - Chemistry
(January 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 January 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 Chief Examiner Reports will be viewed as a helpful and constructive medium to further support teachers and the learning process.

This report 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

Most candidates found this paper quite straightforward although there were enough discriminating questions to allow the very best candidates to stand out. All the questions were attempted and all were answered correctly by at least some of the candidates. The candidates did not appear to have any problems completing the paper within the time and there were few answers left blank throughout the entire candidature.

The mark scheme was clear and easy to follow, needing very little clarification after the standardising meeting.

- Q11**
- (a) Despite the very obvious answer of nitrogen (7 electrons) a few candidates appeared to simply guess the answer with suggestions ranging from lithium (a logical error to use the mass number) to carbon and phosphorus.
 - (b)
 - (i) Candidates often described an increase in nuclear charge rather than effective nuclear charge and lost one of the marks. It was apparent that candidates did understand the concept being discussed but many could not articulate their answer in an acceptable manner. Most candidates gained at least 1 mark.
 - (ii) "Full shell" was essential. Most candidates referred to distance and shielding issues but only a minority noted the full shell. Again the majority scored.

The quality of written communication was generally very good and gained both marks.
- Q12**
- (a)
 - (i) This common question was generally well answered with candidates using previous mark schemes to guide their answer and hence they used very precise terminology. Most candidates gained at least 2 marks.
 - (ii) This was surprisingly poorly answered considering the frequency with which it has appeared in past papers. Most candidates described the ionisation of the atom rather than answering the question. Although it was not expected, this turned out to be a discriminating question.
 - (b)
 - (i) This was well answered with most candidates gaining both marks. A few candidates used "Ca" as the symbol for caesium. There were few errors regarding the state symbols.
 - (ii) Most candidates gained at least 1 mark for the first step, after this there appeared to be confusion amongst many candidates as to how to proceed. Many simply used $E=hf$ and stopped without using Avogadro's number or converting to kJ. Another seemingly straightforward and familiar question turned out to be discriminating.

- (iii) This was reasonably well answered with most candidates gaining at least 1 mark. Many candidates knew the concepts required but poor phraseology cost them marks. Many of them discussed trends down Group I but this is not what the question asked for. Trends could only score 1 mark unless the candidate specifically mentioned the position of caesium in the group.
- (c) Most candidates scored 2 marks with a few getting zero because they misread the question. Only a few candidates gained 1 mark due to incorrect balancing.
- Q13**
- (a) Most candidates had learned this definition word-for-word.
- (b) (i) Most candidates gained full marks. Those candidates who lost marks generally did not use the dot and cross notation or failed to show all the outer electrons of the fluorine atoms. A surprising number of candidates put an additional lone pair of electrons on the boron.
- (ii) This again was well known with many candidates gaining full marks. Marks were lost for the use of “triangular planar” rather than trigonal planar and for not referring to the bonding pairs in the repulsion. Some candidates lost both descriptive marks because they wrote about the “fluorine atoms” repelling.
- (iii) Again this definition had been memorised well.
- (iv) This was generally very well answered with most candidates gaining both marks. Candidates were penalised for the use of ‘fluorides’ or the word ‘ions’ when describing the atoms. Some candidates simply referred to the central boron atom and didn’t mention fluorine.
- (c) (i) This calculation rarely gained full marks. A common error was in calculating the number of moles of fluoride (RMM 38 used instead of RAM 19). Although most candidates coped well with ppm, a surprisingly large number couldn’t work with density. It was common to lose a mark at the end for units. By carrying errors through, virtually all candidates gained at least some marks with the most common mark being 3 or 4 out of 6.
- (ii) The mark scheme limited the acceptable answers (for instance, links to various medical conditions were not accepted) but this did not prevent most candidates from gaining the mark.
- (iii) Virtually all candidates described a flame test. The usual mistakes appeared such as the wrong acid or not using concentrated HCl. Although previous mark schemes insist on the use of a blue Bunsen flame, some candidates still describe it as ‘roaring’ and lost an easy mark. The colour had been well learnt with the only allowable answers being those in the “Acceptable Colour Changes” document.
- Q14**
- (a) (i) Often poorly answered. Many candidates described the colours of chlorine gas and bromine liquid despite the question requesting the colours “in solution”.
- (ii) Most candidates answered this question very well.

- (iii) This was poorly answered and turned out to be the most discriminating question on the paper. A lot of candidates did not link this question with the equation given in the stem of (a). The point of the question was that if the reaction was complete, only chloride ions would be present. Many described the test for bromide ions with negative results rather than the test for chloride ions, although some did describe both tests and were awarded accordingly for correct explanations. There was frequently a lack of clarity regarding dilute ammonia solution.
- (b) (i) This was often poorly answered either through lack of knowledge or poor phraseology. To simply state that the HF bond was strong was not adequate – the candidates had to state that it was the strongest of the HX bonds. Candidates often tried incorrectly to give an explanation in terms of hydrogen bonding and polarity.
- (ii) This was a straightforward equation but was probably the weakest of the equations attempted with many candidates using S as the symbol for silicon and others confusing “tetra” to mean 3 and thereby ending up with “SiF₃”. Very poor.
- Q15** (a) (i) Generally well answered but quite a few candidates referred to electrons in the ‘s block’ rather than ‘s orbital’.
- (ii) This was very well answered with all but a few candidates gaining both marks. Those who lost marks usually got atomic number and mass number mixed up.
- (iii) A common calculation that only troubled a few candidates. Full marks were scored here by the vast majority.
- (b) (i) This was generally well answered with most candidates gaining full marks. Marks were lost for not using dot and cross, the use of an oxygen molecule and incorrect charges on the ions. Any notion of covalent bonding lost all the marks.
- (ii) This was very well known with few incorrect answers.
- (iii) Most of the properties accepted were, those that are common to ionic substances although, ‘solubility in water’ had to be qualified for magnesium oxide (e.g. ‘slightly soluble’). Candidates lost a mark if they did not qualify electrical conductivity by referring to state. Most candidates gained at least one mark.
- (c) (i) Back titrations have appeared commonly on AS1 papers in recent years and the candidates are now more skilled in dealing with the concept. The only error was describing it as an “acid-base” titration.
- (ii) Most candidates gained at least some marks due to carrying the error through and many gained full marks. Common errors were failing to use the 1:2 molar ratio and failing to divide by 5 for one tablet. It was surprising to observe the large number of candidates who could not convert grams into milligrams. Many thought they had to use a factor of 10 or 100 rather than 1000, and many of those who did use 1000 divided instead of multiplying. The most common mark for the calculation was again 3 or 4 out of 6.

- Q16**
- (a) This was the most poorly answered part of this question. Only a few candidates described the fixed or permanent hydrogen bonds in the ice and compared this correctly with the water. A common mistake was to state that the “hydrogen bonds were further apart” rather than the molecules being held further apart.
 - (b) This description is well known from GCSE work. Many candidates achieved both marks. Candidates had to use the term ‘delocalised’ or adequately describe delocalisation for the first mark. The second mark was awarded for stating that these electrons ‘move and carry charge’ or something similar.
 - (c) This was well known with many candidates gaining both marks. The most common mistake was failing to describe the bonds as covalent and failing to specify that they are strong.

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

More than 90% of the candidates sitting this examination were resit candidates. More than 50% of these candidates had already achieved a Grade C or better in this Unit. The standard of answering was very high and the paper proved successful in allowing candidates of differing abilities to respond positively to the questions posed. The average mark for the paper was slightly higher than for January 2012. There was no evidence that candidates had insufficient time to complete the paper.

- Q11** This question was considered to be a relatively gentle introduction to Section B. Typical grade A candidates scored 5 or 6 marks overall. There were some surprisingly poor responses by the typical grade E candidates with scores of 2 or 3 not uncommon. Candidates should be advised that a dot should always appear when representing a free radical but the position of the dot is not crucial.
- Q12** The definitions were very disappointing with many candidates giving inadequate definitions. Candidates should be made aware of the definitions provided in the “Acceptable Definitions” document available on the CCEA website. Easy marks were lost on the definitions. The calculation was, in general, well done. However, candidates should be made aware that questions of this type actually require a calculation. If candidates think they know the empirical or molecular formula they need to confirm their suspicions via the appropriate calculations. Many candidates struggled with the balancing of the equation. Responses from a minority of the strongest candidates were very disappointing in question 12.
- Q13** The definition and understanding of the term ‘stereoisomer’ was very disappointing. Many candidates seem to be unclear about the difference between stereoisomerism and structural isomerism. This was reflected in many responses. The catalyst for hydrogenation was well known and the equation proved easy for most, although many candidates gave an atom economy of less than 100% despite only having one product in the equation. Candidates seem to be getting better at addition polymerisation questions of this type. However, candidates should take care to show that the structure “continues” at each end. Overall, question 13 proved to be very discriminating.

- Q14** This question also proved to discriminate between candidates of differing abilities. Candidates should be encouraged to learn definitions to avoid losing “easy” marks. Enthalpy changes should be accompanied by the appropriate units. It is also very important for candidates to think about the sign of the enthalpy change when calculating a value based on experimental results. Many candidates explained the difference between the experimental value and the theoretical value using arguments involving average bond enthalpies.
- Q15** This question did not discriminate between candidates of differing abilities. Part (a) was very well answered by most candidates. A significant number of candidates did not give any observations in Part (b) despite each question beginning, “What is observed when ...”. Many candidates suggested adding the solids into acid. This would destroy the carbonate and hydrogencarbonate ions and would mean that any subsequent tests would not give a positive result. The ionic equations were often disappointing. Part (d) was very well answered by most candidates.
- Q16** This question proved to discriminate between candidates of differing abilities. The general formula and classification were well understood by most. However, the difference in the nucleophilic substitution mechanism for primary and tertiary halogenoalkanes was not well understood. The elimination reaction was not well known. The definition of structural isomer and the explanation for the difference in the boiling points was well done by most candidates.

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

- Q1–10** Candidates performed in a similar way in the multiple choice questions on this paper as they have in the past.
- Q11**
- (a) The meaning of the term entropy gained marks if it was short; there was a tendency to supply an incorrect answer if there were more words added than was necessary. An example of this was stating that, ‘entropy was the disorder involved in a reaction or a compound’. These examples were too specific and therefore were not accepted. The most succinct answer seen was, “a measure of disorder”.
 - (b) The one mark for ΔG being negative was readily obtained but there were often problems with regard to the second mark. Essentially, this was gained by stating that the entropy value was increased. Often this was presented as $T\Delta S > \Delta H$ which was in order because $T\Delta S$ was subtracted from ΔH .
 - (c) There was less success with this part of the question. Very often the positive value of ΔG was quoted and frequently this was said to be not less than zero and thus secured the mark. The second mark was often not obtained because the ΔH , which was positive, being added to the $T\Delta S$, which was always positive, was not stated. More care was needed with the second part in this question than with the second part in (b).
 - (d) (i) Candidates were either given two marks or zero for this part of the question. It was very difficult to give one mark because candidates had either sensed the meaning of the question or not.

- (ii) With the possibility of carrying an error through, there was every possibility that an error carried through to Part (ii) would earn the two marks available but rather frequently the second mark was lost because units were omitted and therefore penalised.
- (iii) Again, errors were carried through and most candidates obtained the two marks available. Frequently there were errors with the units. Despite carrying the errors through the mark for units was sometimes lost. Candidates occasionally used the units of kPa rather than Pa which was acceptable but then candidates were confused with regards to the correct power of ten to use.

- Q12**
- (a) It was felt on setting the examination paper that this would be a straightforward question and relatively easy but in action this question proved to be rather difficult and inevitably discriminating. It was commented on that the approximate pH of solution should have stated the concentration of the solution. It was felt that this was not appropriate. In demonstrating the properties of the chlorides of period 3 it might be expected that either a test tube or a beaker of water would be used with one or two spatulas of the solid added. Of course it is possible to obtain a neutral pH for any solution if the dilution is sufficiently great. Although the pH of sodium chloride was frequently stated as 7, there were many instances where a value of 8 or greater was stated. However, this value was the one which was normally given correctly. The acidity values for the rest of the solutions were higher than was deemed acceptable. The formulae were usually correct with the exception of the formula for aluminium chloride which was frequently given as AlCl_3 , despite it being referred to as a dimer in Part (d). The bonding was often correct if a description of structure was omitted. Hence, whilst covalent was correct, molecular covalent was not.
 - (b) The most common error was to omit the value of chlorine despite the fact that it was stated in the question. This was understandable as questions are often set where only the positive values are asked for.
 - (c) There are two accepted equations for the reaction of phosphorus pentachloride with water. Both were seen but the most popular was the equation with the formation of phosphoric acid. A tiny number of candidates actually added the two equations together and gained the two marks.
 - (d)
 - (i) The explanation of the meaning of the term dimeric was well answered but weaker candidates tended to work backwards from their structure in (d) (ii). e.g. “dimeric means a structure which contains two coordinate bonds” and “contains a mixture of two different bonds, covalent and coordinate”.
 - (ii) The dot and cross diagram for aluminium chloride was well drawn even by those candidates who had written AlCl_3 in Part (a). Marks were frequently lost because candidates did not label the coordinate and covalent bonds as instructed in the question. Candidates who drew the structure for AlCl_3 received no marks.

- (e) The hydrolysis of salts is a feature of this module despite an almost complete lack of knowledge of this fact by candidates. Questions of this nature can be answered either by stating strength of base compared to the strength of acid or explaining the polarising power of the cation based on the charge density concept. Very few answers gained full marks.
- (f) (i) The name for the enthalpy value ΔH_1 was well understood but occasionally the answer endothermic was given in response to the positive sign on the ΔH value.
- (ii) Although strictly speaking this enthalpy value was for the solvent water and hence the answer was enthalpy of hydration, other answers such as enthalpy of solvation were accepted. However, enthalpy of hydrolysis was not accepted.
- (iii) Although all the text books show the answer to this question in the form of energy level diagrams, it was surprising to see so many answers which used a Hess's Law diagram which was also acceptable. Errors tended to be with arrows pointing in the wrong direction and with states of matter omitted.
- (iv) The calculation was correctly done but there were a small minority that wished to add the numbers rather than subtract them.
- Q13** (a) The definition of monobasic is in the list of published definitions and there should have been little difficulty in extending this definition to that of the meaning of tribasic. There was much direct evidence that the definition had been learnt by some but those that had not, had a variety of guesses e.g. "three carboxylic acid groups joining together forming a tricarboxylic acid".
- (b) (i) Candidates were easily distracted by the data presented at the start of the question e.g. water of crystallisation disappearing at 130 °C. There were few correct answers. Although the mark scheme refers to the use of the melting point temperature, and this was the most popular answer, there were better answers that could have been given. Candidates should have realised that just boiling a solution of a chemical does not affect that chemical. No answer was seen that involved the $-\text{COOH}$ groups reacting with each other.
- (ii) Only very good candidates were able to work out the corresponding structure for the salt using a dipositive cation. Naturally the question was discriminating.
- (iii) Any error made in Part (ii) was carried through to Part (iii) i.e. the incorrect structure could be credited if the correct products were given in the equation. Some candidates tried to balance the equation using calcium hydrogensulfate but then wrote the formula CaHSO_4 and thus lost the carried through mark.

- (c) The reagents were not all well known. Reagent A was often given as chlorine but if it was given as hydrochloric acid, the correct strength was needed and it was not sufficient just to say hydrochloric acid. Reagent B was correctly given and usually with the description of “acidified” potassium dichromate as mentioned in the specification for this module. Hydrogen cyanide was the most popular answer for reagent C. Reagent D produced a range of answers but acids and alkalis were the most frequent. The use of sulfuric acid suffered the same problems as those mentioned for reagent A.
- (d) (i) The equation for the complete dissociation of citric acid was well done.
(ii) There were many good fully correct answers for the calculation of the pH value. Errors were usually made with handling the numbers involving the square root of the equation.
- (e) The definition of a tertiary alcohol was correctly stated. Sometimes candidates thought that the alcohol was secondary because the carbon attached to the alcohol group was attached to two CH₂ groups which was given one mark.
- (f) Many of the diagrams drawn in answer to this question were badly drawn with the bonds from the C=C group pointing to the wrong atoms even though all other aspects of the answer were correct. Most candidates obtained marks for this question but there was some confusion over which were the E/Z isomers.
- Q14** (a) Many answers were accepted that did not resemble the definition provided in the definitions booklet. Some of these answers were weak and were on the verge of ambiguity. Candidates are advised to base their answers on those definitions provided by CCEA. They need not be an exact repetition of the provided answer but should be similar in structure.
- (b) It was usual for candidates to succeed with Part (b) if Part (a) was correct but this was not always the case.
- (c) The flow scheme for the addition of HCN to a carbonyl group was well done as in previous exams. It was only awarded two marks because the first step had been given in the introduction to the question.
- (d) (i) The answer for the reaction of propanone with hydrazine was one of the better answered questions in this section with candidates applying the rule of elimination of water from the NH₂ group and the C=O group.
(ii) Only a handful of candidates had any success with the mechanism despite the fact that it was mentioned at the start of Q14. Candidates should be encouraged to realise that many questions have “clues” which are not always apparent but can be found. All that candidates needed to do was to substitute NH₂ for R in the second equation at the start of the question.
(iii) Of course, candidates were familiar with the structure of 2,4-dinitrophenylhydrazine and the mark was frequently obtained but there are still weaker candidates that make mistakes with the hydrogens around the nitrogens.

- (iv) This question was unfamiliar although the reasons for using such a large molecule such as 2,4-dinitrophenylhydrazine should be appreciated. The question was very discriminating. The major error was to assume that hydrogen bonds were a major factor. There was also the problem that candidates tended to talk about 2,4-dinitrophenylhydrazine before it had reacted to form 2,4-dinitrophenylhydrazone. A minority of candidates obtained the full three marks.
- (e) Quite a few candidates avoided giving the structure of the product by converting the structures to formulae and thus often gained the marks. The major error was to write the product as an amine. They had incorrectly reacted the –OH group of hydroxylamine with the H of the aldehyde. Few candidates gained the two marks available.
- (f) (i) The table was correctly completed by the great majority. Some candidates presented the metal/ions the wrong way round and some used compounds.
- (ii) Both reagents were correctly given for the reagents that give a positive test for ethanol. Often acidified potassium dichromate was included as well but it was ignored.
- (g) It was unfortunate that most candidates interpreted the word “technological” differently to what was intended. After the examination it was suggested that “instrumental methods” could have been used. Indeed if the difficulty had been anticipated both words would have been used although it has to be said that neither of these words are used in the specification and they were expected to be part of general language. Although module A2-2 deals with nmr there was only one mention of nmr seen in scripts. The specification deals with IR in module 2 and has a whole section, 2.7, devoted to Infra-red spectroscopy. In section 2.7.3, it states “use infra-red spectra to elucidate molecular structure by identifying functional groups using tables of characteristic wave numbers”. There were a few correct responses to this question but they were very few.
- Q15** (a) (i) The general formula of a carboxylic acid was well known but a small minority quoted RCOOH rather than the correct $C_nH_{2n}O_2$.
- (ii) The reason for the gradual increase in the melting point of the carboxylic acids was well understood and well explained.
- (iii) There have been many mark schemes for the experimental determination of melting points previously published and the one used this year was not too dissimilar from those used in the past. Despite such assumed familiarity with previous mark schemes candidates were often a mark short of the maximum. This was despite a surplus of marks available in the mark scheme. The major reason was that the details of the apparatus used were missing.
- (b) (i) By asking for the empirical formula in examination after examination there is a visible improvement in the success rate. What is disappointing is that such a frequently asked question does not have the complete success that it deserves.

- (ii) The equation was well done. There is often the problem of drawing the ester structure with the -CO-O- bonding not correctly linked to the alkyl chain but this was infrequently seen.
 - (iii) The definition of saponification value is one of the best known in the specification. Candidate after candidate obtained full marks.
 - (iv) The success with Part (iii) was continued into Part (iv). The vast majority obtained full marks. A very small number of candidates used NaOH and several others did not multiply by three but they obtained two marks for making one error.
- (c)
- (i) The meaning of the term saturated was extremely well known. The mark scheme penalised a general definition of double bonds but most candidates avoided this error.
 - (ii) The definition in Part (i) flowed well into Part (ii). Any ambiguity in Part (ii) was often resolved by the clarity of Part (i). Consequently candidates usually obtained maximum marks.
 - (iii) This question has been asked several times before. In view of the responses before, many answers which have been biologically based were limited in how many marks could be awarded. The answers resulted in a modicum of success because very few answers deviated from the formal mark scheme. There might be many examples of different types of cholesterol but in chemical terms cholesterol is cholesterol and this principle was applied and it did not appear to affect the marks awarded. This is a question which has a possibility of a multitude of answers but the mark scheme limits those that are acceptable but does not exclude future answers.
- (d)
- The problems mentioned with the description of hydrochloric acid mentioned earlier in the paper were not applicable here because both dilute and concentrated hydrochloric acid were acceptable. However, sulfuric acid was not treated in the same way. There were some surprising answers one of which was water. It was not acceptable.

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