



GCE

Chemistry B

Advanced Subsidiary GCE **AS H033**

OCR Report to Centres June 2016

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This report on the examination provides information on the performance of candidates which it is hoped will be useful to teachers in their preparation of candidates for future examinations. It is intended to be constructive and informative and to promote better understanding of the specification content, of the operation of the scheme of assessment and of the application of assessment criteria.

Reports should be read in conjunction with the published question papers and mark schemes for the examination.

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H033/01 Foundations of chemistry

General Comments:

This paper allowed candidates of all abilities to achieve success. Marks ranged from single figures to 68 marks. Candidates had sufficient time to complete the paper with “no responses” generally limited to very weak candidates.

The multiple choice section proved a departure from previous papers and allowed wide areas of the specification to be addressed. Centres need to provide guidance regarding the correct procedure when candidates change their mind. A number of candidates overwrote one choice with a second inside the box whereas it would be better for them to cross out their first choice and write their preferred answer alongside the box. A few candidates left some multiple choice questions unanswered.

In the structured response section, the majority of candidates were able to answer questions within the space provided with few making use of the additional blank page. Centres need to ensure that candidates use this space in preference to requesting additional answer booklets. When candidates do need to stray outside the allotted answer space they must clearly indicate where the rest of the answer is to be found whether this is on the additional page at the back of the question, in an additional booklet or somewhere else on the paper.

The quality of answers, especially to “recall” questions suggests that candidates had not put in the amount of preparation previously associated with first year papers of an A level qualification. By contrast calculations and equations which did not rely on simple recall were reasonably well done. Question 24(a(i)) allowed well organised candidates to plan and structure their answers.

Comments on Individual Questions:

Section A: Multiple choice questions (Q1-Q20)

Overall the multiple choice questions catered for the full range of ability and allowed for good differentiation.

Q1 - The majority of candidates of all abilities answered this question correctly.

Q2 - Most candidates answered this question correctly. The most common mistake was to give the electronic configuration of the potassium atom.

Q3 - Weak candidates found this question difficult but the majority identified the yellow precipitate as lead iodide.

Q4 - The majority of candidates answered this question correctly. The most common error was to assume that increasing temperature increased the equilibrium yield.

Q5 - Most candidates chose the correct answer but a number thought that the trend in boiling points was due to a trend in bond enthalpy.

Q6 - The majority of candidates answered correctly however a large number thought that a positive enthalpy change accompanied bond formation.

Q7 - Most candidates, of all abilities, answered this question correctly. A number of candidates thought that a two-fold change in two factors would only result in a two-fold change overall.

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Q8 - Less than half of candidates answered this question correctly with almost as many failing to recognise concentrated sulfuric acid as an oxidising agent.

Q9 - Few candidates answered this question correctly. There did not appear to be any preference among candidates for one of the other three options suggesting that they may have been chosen at random.

Q10 – This question was well answered by most candidates. Oxidation number rules seemed to be understood judging by responses to this question and Q.23(c)(i).

Q11 - This question was poorly answered by candidates of all abilities. The majority failed to recognise the role of hydrogen bonding and chose either a steady up or down trend.

Q12 - About half of the most able candidates gave the correct answer to this question but the other three choices were almost evenly chosen. A large number of candidates chose the “impossible” structure (2-chloromethylpropene). Candidates who had attempted to draw all four structures tended to be more successful. Centres should encourage candidates to make use of the space around the questions.

Q13 - Less than half of all candidates gave the correct response to this question. The most common incorrect response was sulfur dioxide.

Q14 - The majority of all but the least able candidates answered this question correctly. Almost all incorrect responses were due to a failure to calculate the square root.

Q15 - Less than a quarter of candidates gave the correct response to this question. More able candidates did slightly better. The most common incorrect answer was the interhalogen compound.

Q16 - The majority of all but the poorest candidates gave the correct response. The most common incorrect answer was 1-bromopropane.

Q17 - This was the multiple choice question which attracted the least number of correct answers. The most popular choice was the alcohol and carboxylic acid even though the chain lengths were incorrect.

Q18 - Less than half of all candidates answered this question correctly. The most common mistake was to ignore the percentage yield.

Q19 - Less than half of more able candidates gave the correct response to this question. The most common answer indicated that candidates had calculated the number of moles but failed to take into account three ions in magnesium chloride compared to two in sodium chloride.

Q20 - Less than half of more able candidates gave the correct response to this question. The majority of candidates answered in terms of activation enthalpy.

Section B**Question 21**

Q.21(a) The majority of candidates answered this question correctly. Mistakes were mainly due to lack of knowledge rather than arithmetic errors.

Q.21(b) Most candidates knew the correct method for calculating A_r . The most common error was incorrect rounding to 2 s.f. Occasional answers below 28 indicated that a few candidates

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failed to understand that an average must lie between the mass numbers of the lightest and heaviest isotopes.

Q.21(c)(i) This question was not well answered. The question asked for the steps involved in making nickel sulfate from nickel carbonate but the majority of responses concentrated on purification using techniques more suited to organic synthesis. The need to evaporate water was rarely mentioned and references to filtration were often vague or confused as to whether the filtrate or residue was retained.

Q.21(c)(ii) This question was poorly answered. Many candidates found it difficult to make the link between final mass and calculated yield. Correct yes/no responses were often accompanied by confused reasoning.

Question 22

Q.22(a) The most able candidates answered this question well, although the most common correct answer was 2-methyl-1-propene rather than the simpler methylpropene. A number of weaker candidates mistook 'systematic' for 'homologous series'.

Q.22(b) Most candidates understood the concept of E/Z isomerism but often they had the two forms confused. A number of candidates lost the mark due to poor drawing of displayed formulae with one or more hydrogen atoms omitted. A small number of candidates provided a displayed formula for isobutylene.

Q.22(c)(i) This question was poorly answered with many references to water (on its own) or sodium hydroxide. When sulfuric acid was given in the answer the word 'concentrated' was often omitted. Very few candidates quoted phosphoric acid and steam.

Q.22(c)(ii) The majority of candidates gave a textbook definition of a tertiary alcohol.

Q.22(c)(iii) The test for alcohols was not well understood. A number of candidates referred to bromine water, iron chloride, mass spectrometry, IR spectrometry and boiling points. Candidates often omitted 'acidified'. Although many candidates indicated that the tertiary alcohol would not react they often failed to say how the test would distinguish it from primary and secondary isomers.

Q.22(c)(iv) Candidates struggled to identify the intermolecular forces involved, often suggesting that the difference in boiling points was due to the difference in strength between hydrogen bonds and instantaneous dipole- induced dipoles.

Q.22(d)(i) This question was generally well answered. The most common incorrect answer was 'ester' although 'aldehyde' and 'ketone' were also seen.

Q.22(d)(ii) This question was poorly answered. The most common mistake was due to a lack of understanding of 'molecular' formulae but quite a few candidates also failed to balance correctly or assumed it was a condensation reaction.

Question 23

Q.23(a)(i) The majority of candidates answered this correctly. The most common mistake was to try and produce an interhalogen compound.

Q.23(a)(ii) Few candidates were able to make the link between the relative reactivity and ability to accept electrons. References to electron shells and nuclear charge were common coupled with statements that bromine was more reactive than chlorine. Candidates appeared to be trying to apply knowledge of groups 1 and 2 to the halogens.

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Q.23(b)(i) The majority of candidates were able to identify sodium ions moving across the membrane and many also realised that chloride ions were stopped. Very few mentioned hydroxide ions. Both chloride and hydroxide were required for the second mark.

Q.23(b)(ii) A number of weaker candidates did not attempt this question. Those who did normally managed to produce a fully balanced equation.

Q.23(b)(iii) Responses to this question were mixed. Many candidates answered the question with almost textbook precision but a large number clearly failed to look back at the information in Q.23(b)(ii) and tried to produce an atom economy based on chlorine as the only useful product. A number of weaker candidates did not attempt the question. Candidates should be encouraged to produce numerical answers to questions of this type and avoid the use of words such as high, low etc.

Q.23(b)(iv) Few candidates achieved full marks due to either failing to convert kg to grams correctly or not producing an answer in standard form. A small number of candidates attempted to use the gas equation

Q.23(c)(i) The majority of candidates answered this correctly. The most common error was in determining the oxidation state in the bromate ion. In general + and – signs were used correctly and placed on the correct side of the relevant number.

Q.23(c)(ii) Some candidates used precise language to identify the bromine in the bromate ion and link it to the reduction in oxidation number. A number of candidates lost the mark due to incorrect use of “bromide” rather than “bromine”. The most common incorrect response was to identify hydrogen.

Question 24

Q.24(a)(i) This was generally well answered with many candidates gaining over half marks. The most common error was to refer to breaking bonds within chlorine molecules rather than between carbon and chlorine. The definition of a radical was well understood although some candidates used the term ‘single electron’ rather than ‘unpaired electron’. A few candidates attempted to describe the catalytic breakdown of ozone rather than the formation of the chlorine radical.

Q.24(a)(ii) The first equation in which chlorine radicals react with ozone was quite well known but few candidates followed this with the reaction between ClO and an oxygen atom. Those candidates who correctly stated the first two equations generally produced a correct overall equation. Most candidates who gave an incorrect second equation were able to carry this error forward to produce an overall equation gaining one mark. A few candidates failed to remove chlorine radicals from the reactant and product side of the overall equation.

Q.24(b)(i) Candidates of all abilities were able to score full marks. Point plotting was generally within acceptable tolerance and a straight line of best fit drawn. The x-axis was almost always scaled and labelled correctly. Marks were lost due to incomplete labelling of the y-axis (‘molecules’ missing or replaced by ‘mol’ being the most common error). The majority of candidates scaled the y-axis appropriately but a number used a scale which crowded all the plotted points into a small vertical space.

Q.24(b)(ii) The majority of candidates produced an answer to 4 s.f. within the accepted range. Some achieved this despite their y-axis scale in Q.24(b)(i) being incorrectly drawn. It is assumed that in these cases the answer was derived by interpolation of values in the table rather than by use of the graph. The most common error was omission of the standard form component.

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Q.24(b)(iii) Few candidates answered this question correctly linking the linear gradient to constant rate. Many made no reference to the graph but tried to construct an answer linking reduced concentration to reduced probability of collisions. A few candidates failed to understand that minor fluctuations would be built into the computer model and assumed that the deviations from the best fit line were significant.

Q.24(c) Although the vast majority of candidates attempted this question a significant number failed to score any marks. Most candidates showed some working in the space provided but this was sometimes poorly presented. The rearrangement of the gas equation was rarely explicitly stated and occasionally incorrect. Incorrect or lack of conversion of the volume from cm^3 to m^3 was common and many candidates failed to convert moles into molecules.

Q.24(d) Many weak candidates did not attempt this question but good candidates normally scored all three marks. The most common mistake involved incorrect, or lack of, interconversion between kJ and J.

H033/02 Chemistry in depth

General Comments:

This paper allowed candidates of all abilities to achieve success. Marks ranged from single figures to 67 marks. Candidates had sufficient time to complete the paper with “no responses” generally limited to very weak candidates.

The majority of candidates were able to answer questions using the space provided with few making use of the additional blank page. Centres need to ensure that candidates use this space in preference to requesting additional booklets. When candidates do need to extend their responses beyond the allotted answer space they should be encouraged to use the additional pages provided, rather than requesting an additional answer booklet. In addition, it would be beneficial to candidates if they could ensure that they clearly indicate on the additional response the exact question, including the sub-question, that the written material refers to. There were a small number of candidates who provided additional information but who had not indicated either on the question paper, or in the additional space, which question the written work referred to.

The quality of answers, especially to “recall” questions suggests that candidates had not put in the amount of preparation previously associated with first year papers of an A level qualification. By contrast calculations and equations which did not rely on simple recall were reasonably well done.

Weaker candidates did find the open-ended nature of the calculations on Q1(f) and 2(d)(iii) rather taxing and struggled to organise their thinking, resulting in a rather poorly organised response that made it difficult to look to award credit for appropriate steps in the calculation when the final answer was incorrect.

The main extended writing questions, 3f and 4e, allowed well organised candidates to plan and structure their answers, and clearly demonstrated that candidates had benefitted from this type of question having been posed at GCSE.

Comments on Individual Questions:

Question 1

Q1(a) Most candidates were able to score at least one mark here, often gaining credit for correctly attributing the state symbols to the reactants and products.

Q1(b) In this calculation candidates had learnt the appropriate equation to use to calculate the enthalpy of combustion, and many successfully calculated the appropriate correct value. Where candidates struggled was either in using the mass of fuel burnt in the initial first step calculating the heat transferred to the water, or giving an incorrect sign for the final calculated value.

Q1(c)(i) Most candidates scored this mark successfully, identifying the appropriate value. The only consistent error here was a failure to include the appropriate sign.

Q1(c) (ii) This was a well answered question demonstrating that many candidates were familiar with this procedure having probably carried out the practical work and were able to translate their learning from the lab practical to the theoretical situation. Most candidates correctly cited incomplete combustion of the fuel and loss of butane by evaporation as the main reasons for the difference in the value calculated compared to the data book value.

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Q1(c) (iii) Again, the link to the required practical was evident in that most candidates were able to suggest a suitable method e.g. use of draught shielding for reducing the heat losses in the practical.

Q1(d) Only the most able candidates correctly made the link from the equation that this reaction could not proceed under standard conditions. Weaker candidates tended to refer to the idea of being unable to measure the changes because butane was a gas.

Q1(e) This question was generally well answered. The most common reason for candidates not scoring this mark was that they had drawn the full structural formula rather than the skeletal formula as asked for in the question.

Q1(f) This was a multi-stage calculation. Those candidates who had spent time practising this type of calculation were clearly at an advantage as they set out their calculation in a clearly organised manner. They made full use of the balanced equation provided in identifying the energy required to break bonds in the reactants, identifying the energy released when new bonds are made in the products, and in both stages using an appropriate symbol for the OH bond enthalpy. These candidates then correctly wrote an expression using these two halves of the calculation and the overall enthalpy change for the reaction in order to create an expression, in x (or OH), that could be resolved to make x (OH) the subject of the expression, and thereby determine an appropriate value for the bond enthalpy. Weaker candidates often struggled to identify the type and number of each bond in the equation e.g. using the C-O value of 358kJ/mol for the bond enthalpy for C=O when it should have been 805kJ/mol, or stating that there were 2 x OH bonds on the products side when there should have been 4 OH bonds from 2 water molecules, and consequently struggled with the rest of the calculation. Centres should ensure that candidates have sufficient time to practise this type of calculation, and should try to ensure that they are aware of the need to attempt to structure their calculations in an appropriate manner.

Question 2

Q2(a) A very straightforward question, well answered by most candidates.

Q2(b) Most candidates correctly calculated the mass of magnesium hydroxide in the suspension, and calculated the Mr value, and then converted their calculation of the number of moles into the required number of significant figures to score all 3 marks. The most common error was a failure to carry out the final step and consequently many candidates scored 2 marks.

Q2(c)(i) Where candidates failed to score here was in not correctly identifying sulfur as the element.

Q2(c)(ii) Many candidates struggled with this question, suggesting that they are unfamiliar with the appearance of the Group 2 hydroxides, since magnesium hydroxide is sparingly soluble and the solution often appears to be cloudy. Centres should try to use some of their practical time to carry out titrations of an acid-base reaction for Group 2 compounds other than calcium hydroxide.

Q2(d)(i) This was very well answered, almost all candidates could identify that repeat 2 was an outlier, or that repeats 1 and 3 are concordant, and so should not have been included in the calculation of the mean.

Q2(d)(ii) This calculation proved difficult for candidates as many used the concentration of the acid rather than the concentration of the alkali in their initial calculation, or they incorrectly rounded their final answer.

Q2(d)(iii) Weaker candidates often left this question blank, as they had struggled in the previous parts of the question. Where candidates did attempt this final step, many failed to appreciate that

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the final step required them to multiply by 10 to get the final value for the mass of magnesium hydroxide in 250cm^3 , and instead gave a figure for the 25cm^3 used in their average titre calculation.

Q2(d)(iv) The most common incorrect answer here was 0.24% rather than 0.2%, candidates failing to give their answer to an appropriate number of s.f as asked for in the question.

Q2(e)(i) There were a variety of incorrect responses here, suggesting that candidates had either not appreciated what a half-equation is, or could not identify the species undergoing oxidation. A very common response saw candidates giving an equation for the discharge of chloride ions to produce chlorine molecules, Cl_2 , with the loss of 2 electrons. Unfortunately, in the reaction given the chloride ions remain unchanged and so this equation was incorrect here.

Q2(e)(ii) In this part of the question many candidates correctly stated that oxidation involved the loss of electrons, or if they incorrectly identified the species undergoing oxidation in (i) if this involved the loss of electrons then they could still score this mark.

Q2(e)(iii) Candidates who had scored well in parts (i) and (ii) scored this mark also. Candidates who had struggled in the first two parts of this question often failed to score here as they suggested that it was either the magnesium, or chlorine, that was the oxidising agent.

Q2(f)(i) Many candidates failed to read the question carefully and wrote a full symbol equation rather than the ionic equation asked for. In all cases candidates could have scored the second mark for the state symbols, and many candidates correctly identified the magnesium hydroxide as a solid, (s).

Q2(f)(ii) Few candidates scored this mark as they failed to appreciate the trend in solubility down Group 2. Common incorrect responses included “Barium is more soluble” omitting the word Hydroxide, “Barium hydroxide is soluble” omitting the word “more” which is underlined in the markscheme to emphasise the point that the Magnesium Hydroxide is soluble (sparingly).

Question 3

Q3(a)(i) The correct structure was often drawn, incorrect structures included water, H_2O , or Carbon Dioxide, CO_2 .

Q3(a)(ii) The correct group was usually identified, the most common incorrect response was to identify the functional group as an ether.

Q3(a)(iii) Many candidates scored at least 1 mark, with the most common error being to incorrectly calculate the value for the Molar mass of aspirin, but then using this in a correct evaluation of the expression required.

Q3(b) This question was not well answered. Candidates often referred to ‘phenol’ being the impurity rather than 2-hydroxybenzoic acid, which contains an OH group attached to the aromatic ring which is a phenol group, which was an acceptable response. Phenol on its own was not allowed as this is the name of a different chemical in its own right, and one that is not involved in this reaction.

Q3(c) By contrast this question was very well answered. Most candidates scored at least three marks, the most common omission being to omit one of the final three points of ‘filter, wash and dry’ the recrystallized product.

Q3(d) Again this question was very well answered. Candidates showed a good awareness of the effect of impurities on the melting point of a solid and often quoted the range as being wider and that the value would be lower.

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Q3(e) Candidates struggled to appreciate that they needed to use the balanced equation from (a) to determine the theoretical mass of aspirin that could be made from the 1.15g of 2-hydroxybenzoic acid, in order to determine the % yield and instead simply used the figures of 0.68g and 1.15g to calculate a figure of 59% that is incorrect.

Q3(f) Candidates often produced a detailed response to this question, but often had to use the additional pages provided at the end of the question paper as they spent a lot of time discussing how to prepare the tlc plate in great depth, and then discovered that they had not left themselves with enough space to address the rest of the question. In many cases candidates did not score the marks for the analysis of the tlc plate as they tended to discuss how to develop the plate (not required in the question) and how to calculate R_f values. There was no need to do this as this is a generic response to this type of question. The question wanted candidates to look at the diagram provided and to analyse the diagram by stating that both the crude product and the recrystallized product still contained some unreacted 2-hydroxybenzoic acid, using the spot pattern on the diagram. Then having done this to suggest what should be done next, i.e. further recrystallization of the product. Many candidates having described how to run the tlc plate, did latch onto the need for further recrystallization without making reference to the tlc plate, so did score 4 marks. Very few candidates did not attempt this question, and almost all who did scored at least 2 marks.

Q3(g) A common error in this question was that candidates stated that the paracetamol would react with the sodium carbonate, which is not the case. Those who did get the reaction correct also usually correctly identified the carboxylic acid group on the aspirin as being responsible for the reaction that occurred.

Question 4

Q4(a)(i) This question was often well answered, candidates need to be made aware that if they give a formula, or include roman numerals in the name, that these need to be correct or they will negate their answer e.g. potassium(VI) dichromate was marked incorrect on several occasions as the (VI) is referring to the potassium in this naming convention, which is incorrect. Similarly KCr₂O₇, K₂CrO₇, etc. are incorrect formulae for the oxidising agent.

Q4(a)(ii) Very few correct answers here, many candidates failed to balance the equation, either by not including a 2 in front of [O], or by omitting H₂O from the products.

Q4(b) This question was generally quite well answered as candidates often gave alternative, but correct, equations to identify incomplete combustion of ethanol that included C and CO as products.

Q4 (c) This is a question that is common at this level, but continues to give candidates problems. Where candidates struggled here was in two areas. Firstly, many candidates failed to identify the correct type of intermolecular bond in ethanal, quoting induced dipole : induced dipole, or instantaneous dipole : induced dipole rather than permanent dipole : permanent dipole from the C=O present. Secondly, candidates having identified hydrogen bonding as being present in ethanol and in ethanoic acid simply stated that these had a higher boiling point, but did not make the link to hydrogen bonds being the strongest type of intermolecular bond present and so required the most energy to break them. There was clear evidence that candidates had the desired knowledge concerning the different types of intermolecular bond, but struggled to articulate their ideas in a clear and logical manner.

Q4(d)(i) A varied question, many candidates scored both marks, but equally many candidates only scored 1 mark for calculating the number of moles of oxygen as being the same as the moles of ethanal and arrived at an answer of 300cm³.

Q4(d)(ii) This question was generally well answered, and most candidates scored this mark.

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Q4(e) This final Level of Response question was well attempted by many candidates. There was little evidence that candidates did not have time to answer this question, and most candidates scored at least 2 marks, with a significant number correctly identifying the compound as an ester, correctly naming it as ethyl ethanoate, and using all of the available evidence to support their decisions. These candidates were rewarded for their efforts by scoring full marks on this question. Where candidates did not score full marks but did achieve 4 marks was either that they identified the ester link from the IR data; C=O at 1740cm^{-1} , and C-O at 1250cm^{-1} , along with the molecular formula using the mass spec data but showed no evidence of calculating the empirical formula. The alternative response that did occur regularly was in the identification of Ethanal as the molecule. This was mainly due to two pieces of evidence being used, the first was the strong peak in the IR spectrum at 1740cm^{-1} for a carbonyl group, and then linking this to the tallest fragment in the mass spectrum at 43 having a structure of CH_3CO^+ , which was interpreted as being the aldehyde minus one Hydrogen atom. Allied to this candidates had usually calculated the empirical formula as $\text{C}_2\text{H}_4\text{O}$, which would be equivalent to the fragment at 43 minus one hydrogen atom.

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