CHEMISTRY

Overall grade boundaries

Higher level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 19	20 - 36	37 - 49	50 - 60	61 - 70	71 - 81	82 - 100

Standard level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 17	18 - 32	33 - 46	47 - 57	58 - 69	70 - 80	81 - 100

Higher/Standard Level Internal assessment

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 8	9 - 16	17 - 22	23 - 27	28 - 33	34 - 38	39 - 48

General comments

The November 2012 session was similar to November 2011 in terms of the suitability of the work submitted for assessment of the criteria and overall this was in advance of the May 2012 session. In comparison to the situation five or more years ago, the appropriateness of the assessed work has improved significantly and now most schools recognize that the Internal Assessment component requires special attention from both teachers and students alike. Generally the samples were well presented and most teachers gave feedback using the c, p, n or 2, 1, 0 notation, with a good proportion also giving at least a few written comments to explain their marking awards.

There are still areas to address. One remaining problem is that there are a number of schools who do not act on the feedback comments regarding the suitability of the tasks from moderators in the 4IAF form on IBIS year after year. Another problem is that some schools persist in sending material where no primary marking appears. This makes the moderation principle of trying to support teachers where they have made a sensible interpretation of the criteria more difficult since the teacher’s reasoning is not evidenced. Pleasingly compared to previous sessions there were less cases where all the candidates in a school had chosen essentially the same variables and designed near identical procedures.

The internal assessment marks secured by the majority of candidates will have benefitted the overall final grade even if the teachers’ marks were not always fully supported by the moderating team.

Candidate performance against each criterion

Design

Where the candidates had been set appropriate tasks the achievement level in the criterion was good. Many students were able to secure “complete” in the first aspect for phrasing a research question and identifying relevant variables. Instances of confusing the different kinds of variable were generally few. Also “complete” was correctly awarded in many cases for the third aspect regarding designing an experiment that will generate sufficient data, with most students planning to include repeats or to generate at least five data points in order to analyse graphically.

The second aspect continues to be the most challenging of the Design criterion. One common weakness as in previous years was that many students failed to identify any procedural methods to control or at least monitor the control variables that they had earlier identified as needing controlling. For example if in a kinetics investigation temperature is identified as a control variable then the reaction mixture temperature (and not the surrounding room temperature as was frequently stated) should be controlled through use of a water bath or at least monitored with a thermometer or probe. Unfortunately air conditioners continue to be a popular suggestion for controlling temperature when this is not appropriate.

Often the lack of detail in the designed procedure arises because many students are being assessed for Design as a theoretical exercise with no follow up action phase. Not including details on how standard solutions were to be made up, what volumetric glassware is to be used, not stating how to make up a salt bridge in an electrochemical cell or forgetting to think about drying an electrode in an electroplating investigation were among the common failings. The lack of an action phase in some school’s Design assessments probably was the main factor in an increased number of impractical conditions appearing in students’ designs, for example the use of extreme and unrealistic concentrations of acid up to 30M or the measurement of the mass gain in electroplating after only 15 seconds of current flow.

Data Collection and Processing

Achievement against this criterion was in line with last year and generally high. Where achievement was low it was often linked to the set or designed task not lending itself to full assessment of DCP. Often students had been over-rewarded for simply determining a simple mean, plotting the raw data on axes with no further quantitative processing or even presenting an inappropriate bar chart.

When recording raw data most candidates included uncertainties and relevant qualitative data so Aspect 1 was well fulfilled in many cases. The correct processing of data for Aspect 2 assessment was achieved to at least a partial extent by most students usually through the satisfactory working through of numerical calculations. Relatively few candidates had presented work where they had determined a quantitative result by graphically processing the data to find a gradient or intercept through extrapolation.

The propagation through a calculation of the uncertainties in the raw data was carried out by most candidates and although flawed most attempts were worthy of credit. As usual a significant number of students were quoting final calculated quantities to an unreasonably large number of significant figures. Disappointingly the construction of best fit lines seems to have dropped in quality with a lot of students using the polynomial trend-line function of Excel inappropriately.

Conclusion and Evaluation

Conclusion and Evaluation continues to be the most discriminating of the criteria and few candidates achieved the top level across all three aspects. Unsurprisingly in view of the wording of this criterion many students limited conclusions to a clear statement of methodology whereas it is encouraged that they also justify their conclusions in terms of whether it was coherent with accepted theory.

With respect to Aspect 1, it was common during this session for candidates to compare their results to literature values where appropriate. However only a minority of candidates were then able to state whether the deviation of their experimental result from the literature value was explainable solely by the calculated random error or whether it indicated the presence of systematic errors as well. Hence Partial was by far the most common award. For Aspect 2 many candidates identified a good number of relevant procedural limitations or weaknesses although few were able to make comment on the direction of error which limited achievement. In the final Aspect 3 assessment many candidates offered some clear and relevant suggestions as to how to improve the investigation and did relate to the weakness identified although a sizeable minority were only able to propose superficial or simplistic modifications such as simply more repetitions to be carried out or more precise apparatus be used.

Manipulative Skills and Personal Skills. All schools entered marks for these criteria.

Application of ICT. Most schools had checked the five ICT requirements at least once on the 4PSOW although the assessed work submitted rarely corresponded to these investigations so it is hard to evaluate the appropriateness of the tasks.

Recommendations and guidance for the teaching of future candidates

- Candidates should be made aware of the different aspects of the criteria by which they are assessed.

- Teachers should endeavour to give their students the opportunity to carry out the practical phase associated with their Design investigations.

- All investigations for the assessment of DCP must include the recording and processing of quantitative data. Solely qualitative investigations do not give the students opportunity to fulfill this criterion completely.

- Relevant qualitative data should be recorded when pertinent.

- All candidates, both Higher and Standard Level, need to record, propagate and evaluate the significance of errors and uncertainties.

- Teachers are encouraged to set some DCP assessment tasks that will generate a graph that will require further processing of the data such as finding a gradient or intercept through extrapolation.

- Instruction of appropriate use of graphing software especially the construction of best fit lines would benefit many candidates.

- Candidates must compare their results to literature values when relevant and include the appropriate referencing of the literature source.

- Teachers should ensure that they act on specific feedback given by the moderator in the 4IAF feedback that is released through IBIS shortly after the results release.

- Teachers are encouraged to provide written feedback providing valuable scaffolding to students and a clearer understanding of reasoning for moderators.

- Teachers should follow instructions and clarifications found in the Chemistry Subject Guide, the Teachers Support Material, and instructions provided in the up to date Handbook of Procedures for the Diploma Programme before submitting work for moderation.

Higher level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 10	11 - 16	17 - 23	24 - 27	28 - 30	31 - 34	35 - 40

General comments

This paper consisted of 40 questions on the Subject Specific Core (SSC) and Additional Higher Level (AHL) and was to be completed without a calculator or Data Booklet. Each question had four possible responses with credit awarded for correct answers and no credit deducted for incorrect answers. In the light of this it is surprising for examiners (who are all teachers or former teachers) to note that not all candidates answer every question.

The following are some statistical data based on 29 respondents.

Comparison with last year's paper

Much easier	A little easier	Similar standard	A little more difficult	Much more difficult
0	6	18	5	0

Suitability of question paper

	Too easy	Appropriate	Too difficult
Level of difficulty	0	28	1

	Poor	Satisfactory	Good
Clarity of wording	1	12	16
Presentation of paper	0	7	22

In the general comments, two respondents thought the paper to be straightforward, although one opined that it was still challenging. Another thought the questions to be clearer that last year's paper and focused on a student's understanding of the curriculum. One respondent thought the mathematical component to be a little more difficult.

The strengths and weaknesses of the candidates in the treatment of individual questions

The difficulty index (the percentage of candidates achieving each correct answer) ranged from 90.52% to 36.56% (November 2011 for comparison, 91.58% and 38.05%). The discrimination index, an indication of the extent to which questions discriminated between high- and low-scoring candidates, ranged from 0.74 to 0.10 (November 2011, 0.69 to 0.14), the higher the value, the better the discrimination.

The following comments were made on selected individual questions:

Question 12

This was found to be the most difficult question on the paper with D being the most common wrong answer followed by A. One G2 comment stated surprise that the equatorial beta F-S-F bond angle was quoted as significantly lower than 120^o, even though the repulsion is only from one non-bonding pair of electrons towards the two bonded-pairs of electrons. In this question candidates had to identify the bond angles for α and β from the four choices given. As it is correctly pointed out in the G2 comment, lone-pair/bond-pair repulsions are greater than bond-pair/bond-pair repulsions, according to VSEPR Theory. Hence as a result of this although the seesaw molecular geometry is based on a trigonal bipyramidal electron domain geometry involving five negative charge centres or five electron domains, the axial α bond angle will have to be greater than 180^o because of the greater lone-pair/bond-pair repulsion compared to the bond-pair/bond-pair repulsions. This immediately rules out choices A and D which have a cited bond angle for α of 180^o. In addition, the equatorial β angle cannot be 120^o due to the same greater lone-pair/bond-pair repulsion (as before), which means the F-S-F bond angle must be less than 120^o. The only possible answer then must be B, with α given as 187^o and β given as 103^o. Candidates can work this out solely according to the greater lone-pair/bond-pair repulsion argument stated above. The example itself, however, is an interesting one in terms of VSEPR Theory as lone pair repulsion is not the only factor that can contribute to such angular distortions. Other factors are multiple bonds, atomic size effects and electronegativity. The effects of electronegativity and atomic size effects often parallel each other. Typically the atom with the greater electronegativity can pull electrons towards itself and away from the central atom. This can reduce the repulsive effect of the bonding electrons. So often compounds containing fluorine can have smaller bond angles compared to those containing chlorine, bromine or iodine. Hence this is an additional contributory factor at play in the case of SF_4 which explains why the β equatorial bond angle reduces so low down to approximately 103^o. As an aside some literature value sources give this bond angle as 103^o (*Structural Inorganic Chemistry* by A.F. Wells) and some give it as 101.3^o (based on Tolles and Gwin structural determination – *Journal of Chemical Physics*). The electronegativity discussion, however, was not needed by candidates to answer the question, simply a knowledge of the lone-pair/bond-pair consideration as in the IB syllabus. The question certainly was quite challenging for candidates with only 36.56% of candidates getting the correct answer, B. The question had a corresponding discrimination index of 0.31. A similar example can be seen if one compares the bond angles in NH_3 (107^o), which is well known in the IB programme, NCl_3 (107^o) and NF_3 (which is clipped down to 102^o).

Question 17

This question related to assessment statement 15.1.1. The °C units in B and C were *not* errors and, in any case, temperature is not part of the definition of the standard state. IUPAC convention requires a pressure to be stated for a standard state, normally 100 kPa. This was the third most difficult question on the paper and may have caught candidates “off guard” since this part of the assessment statement has not examined in the past.

Question 20

The best answer is D; but we recognize that it might have been possible to confuse B with that of a second order reaction. In the event, nearly 70% of the candidates chose the correct answer (although the next most popular answer was indeed B). We aim to improve the presentation of 1st and 2nd order curves.

Question 25

There was concern expressed that we expect candidates to know the colours of universal indicator by rote learning. Far from it, we would expect candidates to have absorbed this information during regular lab classes and demonstrations.

Question 26

Two respondents expressed concern that this question was too difficult in these “calculators everywhere” days. We would expect candidates to note that dissociation has *increased* from that at 298K so the only possible answers are now those with pH<7, A and B. The candidate can them surmise that the negative log square root of the given K_w is somewhere between 6 and 7 – or ask if it is reasonable that increasing the temperature of water by only 25°C should increase $[H^+]$ by a factor of over 100.

Question 37

Over half the candidates gave the correct answer (and the question was the top discriminator) but it is accepted that the question would have been better to state *aqueous* sodium hydroxide.

Higher level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 17	18 - 34	35 - 45	46 - 55	56 - 64	65 - 74	75 - 90

General comments

In general the paper was found to be very accessible and there were a number of excellent scripts. Teacher's impressions of the paper were conveyed by the 37 G2 forms returned. 81% of the respondents considered the level of difficulty of the question paper appropriate, 8% too easy and 11% too difficult. In comparison with last year's paper, 54% felt that it was of similar standard, 16% thought that it was a little more difficult and the remainder found that the paper was easier. Clarity of wording was considered good by 54%, satisfactory by 43% of respondents and poor by only 1%. The presentation of the paper was thought to be good by 68%, satisfactory by 26% and only 5% thought that it was poor.

The areas of the programme and examination which appeared difficult for the candidates

- Lewis (electron dot) structures and shape
- Explanation of malleability
- Orbital diagram of a transition metal ion
- Buffer calculations
- Balancing of a redox equation in acidic medium
- Half-equations at electrodes in the electrolysis of aqueous copper(II) sulphate using platinum electrodes
- Definition of average bond enthalpy

- Definition of standard enthalpy change of formation

- Determination of activation energy graphically

- Rate expressions for a two-step mechanism

- Description of stereoisomers

- Determination of empirical formula from data involving CO_2 and H_2O

- Elimination reaction mechanism

The areas of the programme and examination in which candidates appeared well prepared

- Data-based and integrated topic question - Q1 in Section A exploring an unknown experiment/project
- Stoichiometry calculations
- Intermolecular forces
- Sub-atomic particles
- Explanation of colour of a transition metal complex
- Definitions of oxidation, reduction and oxidizing and reducing agents
- Deduction of hybridization schemes
- Factors affecting rate of reaction
- Graphical representations of zero- and first-order reactions
- Application of IUPAC rules to name organic compounds

The strengths and weaknesses of the candidates in the treatment of individual questions

Section A

Question 1

Q1 consisted of a linked data-based question based on a project investing some halogen chemistry which integrated a number of different topics across the curriculum. As it is often the case with Q1 in Section A, candidates are asked to look at an experiment/project problem which they may not necessarily have covered in the laboratory as an exact experiment, but the experiences gained from an associated comprehensive laboratory programme of the various experimental techniques (e.g. titrations etc.) and problem-solving training should serve as a strong foundation in approaching this type of question. In N12, several topics straddled Q1 including yields, significant figures, stoichiometry, titrations, intermolecular forces, VSEPR Theory, polymerization etc. In general this question was answered very well by a significant number of candidates and candidates appear to have performed better overall compared to previous sessions on this type of question which was encouraging. The general perception of teachers based on the G2 comments was that Q1 was quite demanding as it involved unfamiliar interhalogen compounds, but they did like the variety of topics covered and found that all parts in fact were reasonable, on the syllabus and hence liked the nature of the question asked overall.

In part (a) (i) several candidates confused significant figures and decimals places and it was surprising that some candidates fared poorly on such an easy first question on the paper. Significant figures are an integral part of experimental work and candidates should have performed better on the recognition of the appropriate number of significant figures. In parts (ii) – (iv) candidates managed these questions reasonably well. However, many students failed to read the question correctly in (ii) assuming that the chlorine was in fact in excess.

In part (b) candidates often did not express their responses in the correct chemical terminology e.g. referring to intramolecular instead of intermolecular. Some candidates only scored one mark for this question and did not score M2 which required stating the fact that the dipole-dipole forces are stronger than the London forces. In part (c), (i) was generally answered correctly and usually part (ii) also. A small minority did however express their answer in dm^3 instead of cm^3 meaning that they failed to read the question carefully. In part (iii), a common incorrect answer was 1.21 mol instead of 1.21×10^{-3} mol. Parts (iv) to (vi) were often done well, though again some did not adhere to the instructions in part (vi) which required candidates to express their answer correct to three significant figures. A typical feature of Q1 in Section A of HLP2 is the inclusion of a hypothesis type question or a question where students have to suggest a possible answer based on the information given. In N12, this was tested in part (d), where students were asked to suggest the identity of the brown liquid based on the reactions involved, which was linked to AS 1.3.1. This question turned out to be a very good discriminator. The top candidates were able to identify this product as iodine monochloride. A hint might also have been picked up from the stem at the beginning of Q1, if students read the project information carefully. However, even without this, careful analysis of the reaction involved would have lead candidates to suggest the regeneration of iodine monochloride as the product. Many candidates just were not prepared to 'work out' the identity of the brown liquid and common incorrect answers included chlorine and even unrealistic answers such as bromine even though no bromine was involved in the reaction! Part (e) was by far one of the most disappointing questions on the entire paper with only the top-end candidates scoring all four marks.

Many mistakes were seen, such as the usual mistakes of omitting lone pairs on terminal atoms and not including square brackets and the negative charge for the Lewis structure of the anion. The biggest problem however for candidates was failing to realise that for Lewis structures based on five negative charge centres or five electron domains, the lone pairs are inserted in the equatorial position and not the axial position, resulting in a T-shaped molecular geometry for ICl_3 and a linear shape for ICl_2^-. Candidates may benefit in class from a careful discussion of the various angles resulting from LP-LP, LP-BP and BP-BP repulsions for such structures emanating from five electron domains. As a result of poor comprehension of this aspect of VSEPR Theory, a common incorrect molecular geometry of trigonal planar was often cited for the molecular geometry for ICl_3. In part (f), the better candidates gave the correct full electron configuration for iodine. Surprisingly some of the weaker candidates gave electron arrangements which scored no marks and a few candidates gave rather sloppy configurations, either putting subscripts instead of superscripts or not putting the number of electrons as superscripts, which was rather disconcerting to see at HL. In part (ii), the stronger candidates gave the correct balanced equation for the reaction of chlorine with water. The weaker candidates often did not correctly balance the equation or more often or not gave incorrect products such as hydrogen. In part (iii), a large number of candidates stated chloroethane instead of chloroethene for the monomer. Plastic was often given as a use of PVC. This however was not allowed for M2 and a more precise answer was required.

Question 2

Most candidates did well on this question. In part (a) (i), most candidates could distinguish between a group and a period. (ii) was also usually answered by the majority of candidates though some weaker candidates only got the number of protons and electrons correct. In part (iii), a common mistake involved candidates drawing the lobe of electron density around the y or z axes for the p_x orbital. Some candidates drew three dumbells for the s-orbital. Other candidates incorrectly drew hybrid orbitals. In part (b) (i) most candidates identified the delocalized electrons, scoring M1 but struggled to explain why metals were malleable i.e. namely that the atoms slide over each other. A number of candidates stated nuclei instead of cations. The orbital diagram in (ii) also proved to be quite a good discriminating question. Many candidates failed to realise that the electrons are removed from the 4s level before the 3d for a first-row transition metal ion. In addition, a significant number of candidates showed poor understanding of Hund's Rule of Maximum Multiplicity which states that when degenerate orbitals are available, electrons fill the orbitals singly before filling them in pairs. Hence, in many cases incorrect representations were seen for the 3d which involved three pairs of electrons of opposite spin being inserted in three 3d orbitals. Most candidates stated the Co^{2+} ion, though a common incorrect answer was Co^{4+}. Part (iv) involved candidates having to explain why the complex $[Co(NH_3)_6]Cl_3$ is coloured. This question was asked a number of times in previous examinations and previously was typically really very poorly answered. In N12, the explanations certainly were better though some candidates mixed up the principles of the line emission spectrum of hydrogen with the d to d transitions involved in the explanation of colour pertaining to a transition metal complex.

Question 3

This question was based on buffer solutions and was found to be quite challenging for candidates. In part (a), some candidates again failed to read the question, which asked for a description of an acidic buffer solution. Many did not state explicitly that a weak acid is involved (acid alone was not sufficient). In part (b), only the best candidates scored all five marks. In addition to conceptual errors, there were also a number of transcription errors (molar mass and arithmetic errors). Candidates also were required to express their answer to two decimal places. A number of candidates used the Henderson-Hasselbalch equation, but often an incorrect equation was given.

Section B

Teachers in general stated that Q4 might be slightly easier for candidates in Section B, followed by Question 7.

Question 4

This question was answered by a significant number of candidates. In part (a), most candidates could easily define oxidation and reduction in terms of electron loss or gain in (i). One G2 comment stated that perhaps 4 marks was a lot on oxidation numbers, which in hindsight is probably a fair point. However, in (ii), although many scored full marks, other often lost marks and frequently gave incorrect oxidation numbers for H_3AsO_3 and N_2O_3. A minority of candidates also put the signs after the number e.g. wrote 3+ instead of +3. It should be emphasised for best practice that when writing oxidation numbers the sign is placed before the number. Distinction between oxidizing agent and reducing agent was well answered. However, part (iv) was another question on the paper which caused lots of difficulty, albeit testing a fundamental skill, namely balancing a redox equation. Even the better candidates often struggled in getting the correct answer here. The coefficients were often incorrect and charge balance once the H^+ was introduced appeared to have thrown several candidates. So although Q4 on paper may have looked like a straight-forward question as indicated by the G2 comments, there certainly were parts such as (a) (iv) which surprisingly candidates really found quite challenging. In part (b), the most common mistake involved the incorrect direction of electron flow. Some candidates also failed to include a battery for the electrolytic cell. The weaker students drew voltaic cells with salt bridges. In part (ii) and part (iii) the very best students often scored full marks. However, a significant majority of candidates only gained partial marks on these two parts and the correct half-equation at the anode in part (ii) was particularly troublesome. Other mistakes included writing equilibrium signs and half-equations involving platinum which showed weak overall understanding of the two processes.

Question 5

This also was a popular question. General G2 comments liked the inclusion of page referencing in (b) (iv) and (c) (ii). In part (a), which asked for the definition of average bond enthalpy, some candidates omitted to mention the gaseous state and quite a large majority did not score M2 which required reference to the average calculated from a range of similar compounds. It was somewhat surprising that more candidates did not score full marks here as this definition has been asked a number of times before and the mistakes alluded to here have been flagged several times in precious subject reports. In (b) (i), very few scored full marks, with even the better candidates failing to get M4, for a final answer of -78.5 kJ. In part (ii), although many gave ammonium as an example of a nitrogen-containing positive ion which has dative covalent bonding, a significant number gave examples of anions instead of cations. In part (iii), descriptions of the difference between sigma and pi bonding often were good. The better students described sigma bonds resulting from head-on or end-on overlap of orbitals. Some mentioned axial overlap here, which was accepted, but this designation might be somewhat confusing for students as this is really axis dependent in the context of sigma bonding. In contrast the description of pi bonds resulting from sideways overlap of orbitals was usually well cited. Some respondents thought that candidates were likely to make mistakes in part (iv) though based on evidence this certainly was not the case and this question was usually well answered. In (v), although many got the correct hybridization scheme, few were actually able to give a precise explanation of hybridization i.e. the mixing of atomic orbitals to form new/molecular orbitals (for bonding). In part (c), (i) proved no difficulty for candidates. However, the definition of standard enthalpy change of formation proved problematic. Change was often omitted and many did not score M2 failing to mention either standard states or 10^5 Pa. 1 atm was allowed but 10^5 Pa should be encouraged in teaching in line with current practice by the global chemical community. In the thermodynamics series of questions in parts (iii) to (vi) inclusive, the main errors stemmed from incorrect units in the calculation of the standard free energy change for the reaction.

Question 6

This was the most popular question in Section B of the paper. Part (a) was very well answered. In (b) (i), some candidates failed to mention minimum/least/smallest energy in the definition of activation energy. In part (ii), again candidates often dropped easy marks here for poor representations of the Maxwell-Boltzmann energy distribution curves. In some cases the curves were drawn symmetrically, which was incorrect. In addition, incorrect labels were often given for the x- and y-axes. Some candidates mixed these curves up with enthalpy level diagrams. It was nice to see more candidates giving a more precise label for the y-axis as probability/fraction of molecules rather than just number of molecules. The latter was allowed but is less precise (although does tend to be used in many IB textbooks). Part (c) however was very well answered. In part (d), many candidates also scored highly though the units of k in (ii) did cause a problem for some candidates. In (e) (i), the most common mistake was candidates stating ethyl methanoate instead of ethyl ethanoate. In part (ii), a number of candidates stated incorrectly that T is directly proportional to k, which is incorrect. Proportionality is a concept embedded in AS 11.3.1 in Topic 11, and may be worth some further discussion in the light of the Arrhenius Equation. The most difficult part of Q6 however involved (e) (iii). Very few candidates scored full marks here and simply did not know how to manipulate the equation to get the activation energy. Others even gave incorrect units. One respondent stated that part (f) (ii) would be difficult for candidates. (f) certainly did prove challenging and the rate expression for step two was often given incorrectly. This question became a good discriminating question in Section B. However the better students did manage to score all three marks in part (f).

Question 7

This was the least popular question in Section B. In part (a) (i), some candidates gave a definition of structural isomers instead of stereoisomers. Parts (ii), (iii) and (iv) were usually well answered. Some candidates forgot to include the hydrogens however. Although many were able to describe the S_N mechanism in part (v), mistakes were still quite glaring – such as curly arrows coming from the H in HO^-, incorrect origins of the curly arrow showing the Br^- leaving etc. In the S_N2 mechanism, some candidates represented the HO···C···Br at an angle less than 180 degrees. Due to the Walden inversion this angle will be 180^o since attack is on the flip rear-side, so acute angles should not be represented. This is a common mistake in some textbooks and although candidates were not penalized, it is worth emphasising the correct nature of the angle in relation to the partial bonds here in the teaching programme. In part (vi), candidates were asked to deduce the structural formula of the organic product. Surprisingly many did not give $CH_3COCH_2CH_3$, and an extra H was often seen as –CHO–. Part (b) (i) proved to be very challenging for candidates. A large majority of candidates in fact did not know how to even commence the problem. There were a number of G2 comments all of who stated that it would have been better if the ratios of the amounts of C, H and O were in fact closer to whole number ratios. In part (ii) of the question the molar mass of the ester was given as 116.18 g mol^{-1}, which meant that taking the experimental data given in (b) (i), the empirical formula is in fact C_3H_6O, with the associated molecular formula of $C_6H_{12}O_2$. The better students realised this and typically gave an answer of C_3H_6O. However, a very small minority did in fact use a scaling factor to suggest an empirical formula of $C_{19}H_{38}O_6$, which was also accepted. In general however for this question, candidates tended to score either scored full marks for parts (i) and (ii), or zero. In part (iii), perfumes was typically given as one use of esters. Part (c) involved candidates having to given the mechanism of an elimination reaction. This continues to be quite a challenging mechanism for candidates, a trend seen in recent sessions. Typical mistakes included curly arrows originating on H in HO^-, curly arrows starting at atoms instead of bonds, failure to write H_2O as a product etc. Only the very best students in fact scored all four marks though most managed to score at least one or two marks. Part (ii) was usually well answered. In part (iii), some candidates did not show the 3D nature of the two enantiomers which was necessary for M1 and only gave 2D representations. It was encouraging to see a greater percentage of candidates however using tapered (wedge/dash) representations. For M2, many did not mention the fact that the two optical isomers rotate the plane of polarized light in opposite directions. Some did not state plane.

Recommendations and guidance for the teaching of future candidates

- Candidates should be given guidance to the depth of the question observing command terms and the amount of marks a question allocated to the question in each case.

- Candidates should ensure that problems are answered with the correct number of significant figures and the correct units.

- Candidates should be fully prepared to give precise definitions for all those stipulated on the syllabus. The allocation of marks given to a definition on an examination paper should be carefully noted. For example in this paper, the definition of Average Bond Enthalpy required two parts, corresponding to the two allocated marks.

- Teachers should use past examination papers and their corresponding markschemes to prepare the candidates for the examination.

- Candidates should be fully prepared for all the organic reaction mechanisms stipulated on the syllabus. Aspects of mechanisms such as the use of curly arrows should be emphasised.

- Attention needs to be directed to drawing neat labelled diagrams when required. In N12, many candidates drew sloppy diagrams for the Maxwell-Boltzmann energy distribution curves in particular.

- Candidates should acquire more skills in reading and interpreting graphs. In N12, the determination of activation energy was particularly weak.

- The use of tapered (wedge/dash) bonds in the 3D representation of optical isomers should be encouraged.

- Candidates should NOT in general have to require the use of additional sheets in answering questions. Candidates should answer the questions in the boxed spaces given which provides candidates with a solid idea of the length of the required answer expected. Teachers should emphasise this point to students preparing for examinations.

Higher level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 8	9 - 17	18 - 21	22 - 27	28 - 33	34 - 39	40 - 50

General comments

On the whole the cohort was strong and performed very well in the exam. Most candidates seemed very well prepared and most attempted every part of their chosen Options. Each Option is supposed to be twenty two hours study, and each is subdivided into about ten or twelve sections of approximately two hours study each. It is not possible to examine all the syllabus content in one exam but efforts are made to ensure there is no over emphasis on certain parts. However, to set meaningful questions it is deemed appropriate to set 3/4 mark questions on topics with 2 or more hours of study.

The areas of the programme and examination which appeared difficult for the candidates

Options A and G were generally very well answered. In Option B few candidates knew the correct buffer equations and many were not sure about V_{max} or K_m for enzymes. Only a few of the candidates attempting Option C were able to write some equations and examples from the syllabus were not well known. In Option D few were familiar with the fuel cell intoximeter. Few candidates attempted Option E with any success and most had little idea of the chemistry involved. In Option F some candidates did not have enough factual knowledge to think their way through the questions. Some confused microbial spoilage with oxidative rancidity.

The areas of the programme and examination in which candidates appeared well prepared

In Option A candidates were well prepared and showed a good knowledge of Modern Analytical Chemistry and spectroscopic methods. In Option B candidates had a good knowledge of dietary fibre and fats, but struggled completing the equations. The structure and functions of proteins seemed to be well known. In Option C candidates fared better when they were asked to think, for example in evaluating intermolecular forces in C3, than they did when trying to recall detail from the syllabus. Most were very well prepared for Option D, read the questions properly, and gave considered answers. In Option F some candidates were able to think their way through parts of the questions very well, but factual knowledge was often thin. Most candidates were well drilled for Option F and were very good at writing correct equations.

The strengths and weaknesses of the candidates in the treatment of individual questions

Option A - Modern analytical chemistry

Option A proved to be very popular. Some candidates had difficulty explaining the purpose of the monochromator and some muddled Qualitative and Quantitative, but a reasonable proportion explained the latter. Many students were able to describe the practical method of column chromatography but were not able to explain the process in terms of adsorption, partition and retention. While many candidates knew about 'd' orbital splitting some forgot to explain the change in magnitude of the splitting, and a significant few thought that fewer 'd' electrons in the Cr^{3+} ion would cause less repulsion and so less splitting.

Option B – Human biochemistry

Option B was a very popular, and question 1 was well answered. In question 2(c) a number of candidates drew the ester group the wrong way round, or gave cholesterol instead of steroids. The comparison of the lipids was not always well done and evidence suggests that this topic deserves some more attention as often answers included wrong concepts. In question B3(a) the positive charge was sometimes put on one of the H atoms; a mark was more often gained for the anionic form. In (b) only the most competent candidates knew that $H_2NCH(CH_3)COO^-$ is the most predominant ionic form of alanine at pH 7 (above its isoelectric point of 6) and wrote the correct equation to form $H_3N^+C(HCH_3)COO^-$ (as the amine group is a stronger base than the -COO^- ion). M2 alone was more common. In question B5, the values were generally correct but candidates tended to be unclear about the relevance of V_{max} and K_m, although the majority of candidates did define these correctly. The wording of the question possibly could have been a little clearer.

Option C – Chemistry in industry and technology

Option C was one of the least popular options. A surprising number did not know the purpose of the raw materials put into the blast furnace, some thinking scrap iron was a common raw material. There were few correct equations, but many would have been mark-worthy had they been balanced. Very few candidates appreciated the role of limestone or calcium oxide in neutralising the acidic impurities in iron ore, i.e. silica, and could write the equation for the formation of calcium silicate slag. Most candidates knew that reducing the carbon content of iron to form steel makes it less brittle, but a substantially lower proportion gave annealing, while others threw in tempering and quenching for good measure. Annealing continues to be a challenging notion for many students. Sections C2 and C4 of the syllabus account for 3.5 hours of study but candidates often seemed to be guessing whether the processes in question C2 used homogeneous or heterogeneous catalysts. The properties of polymers were generally well known but some of the explanations were a bit thin. The solubility of Kevlar in sulphuric acid was little known but a substantial number of candidates were able to state that it is non-biodegradable, and/or that an inefficient combustion leads to the formation of pollutants. Only stronger candidates identified dioxins as pollutant. The connection with landfills was rarely seen.

Option D – Medicines and drugs

Option D was a very popular option. Many wrote well about the development of drugs but the tendency was to omit some of the discovery/design stages. Transdermal was relatively unknown as a method of administration, but there were only a few spurious answers about the effects of aspirin and diazepam. Most identified oxidation and reduction correctly but the most common way of losing the marks was ignoring the electrons. Few, it seemed, had studied the fuel cell intoximeter and most wrote about IR machines. For those who read question D3 properly time and cost were the most common answers. Most candidates stated that polar drugs are more soluble in blood, and some suggested turning the drugs into a salt but didn't describe how. Most also had a pretty clear understanding of THC and its effects.

Option E – Environmental chemistry

Option E was one of the less popular options. Candidates were not all sure about water pollution, often giving atmospheric pollutants, and many were unsure about the three stages of water treatment. Many gave correct, detailed explanations of eutrophication (more than required) but quite a few thought that (photosynthetic) algae use up oxygen. Thermal pollution was sometimes only discussed in terms of increased metabolic rate of fish. When discussing landfills the difference between candidates that approached the topic with solid subject specific knowledge and those from a journalist position was quite patent. The role of ammonia in acid deposition was little known by all but a few candidates. Similarly, few could state the meaning of CEC, and only a few more mentioned clay for the second mark. Also, very few had any idea about the effect of pH on nutrients in soil. In E6 a handful of candidates scored three marks, but most knew nothing about accelerated ozone depletion in Polar Regions.

Option F – Food chemistry

Option F was one of the less popular options. A surprising number of candidates did not give ester as the main functional group in fats, but were able to relate saturation and chain length to the physical properties of chocolate. While a good number of candidates knew about oxidative rancidity few knew what molecules give the rancid odours. Answers about methods of preventing oxidative rancidity were not generally very precise. The polarity of anthocyanins was commonly recognised but the role of hydrogen bonding in their solubility was usually missed. Few noticed that structure A was the protonated form. (The integration between core/AHL and options is important and should be encouraged on a regular basis.) In the Maillard reaction many candidates were able to give water as the condensation product but few gave the correct organic product, whereas many candidates, perhaps helped by the structure in the equation, were able to score two or three marks for the CORN Rule. Only a few seemed to have studied the use of optical isomerism to test the authenticity of foods.

Option G – Further organic chemistry

Option G was both popular and extremely well answered, most candidates giving only correct equations. In G2 only occasionally did the Br atom get put onto the wrong carbon atom, but quite a lot forgot to compare the acidity of phenol with the nitrophenols. In G5 the most common mistake was using H_2O instead of ^{-}OH for the base hydrolysis of ethanoyl chloride. Mechanisms seem to have improved over the years and many were correct, but quite a few candidates didn't know what they were doing.

Recommendations and guidance for the teaching of future candidates

The majority of candidates were very well prepared and performed exceedingly well, but it was quite obvious that some candidates had been left to study the Options on their own and they were not at all well prepared for the exam. At times candidates need to be more specific in their answers, with the properties of individual drugs for example, and not give a number of general properties in the hope that one or two may be correct.

Standard level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 7	8 - 11	12 - 16	17 - 19	20 - 22	23 - 25	26 - 30

General comments

This paper consisted of 30 questions on the Subject Specific Core (SSC) and was to be completed without a calculator or Data Booklet. Each question had four possible responses with credit awarded for correct answers and *no* credit deducted for incorrect answers. In the light of this it is surprising for examiners (who are all teachers or former teachers) to note that not all candidates answer every question.

The following are some statistical data based on 32 respondents.

Comparison with last year's paper

Much easier	A little easier	Similar standard	A little more difficult	Much more difficult
0	11	17	3	0

Suitability of question paper

	Too easy	Appropriate	Too difficult
Level of difficulty	0	31	1

	Poor	Satisfactory	Good
Clarity of wording	1	14	17
Presentation of paper	0	10	21

In the general comments, one respondent thought there to be enough testing questions that many SL candidates would not find this an easy paper. In fact the statistics show that, in general, candidates scored marginally better this year than last. Although it was thought that the calculations might have stretched a candidate's mathematical ability, there were not too many calculation type questions in the paper. Finally, one respondent commented that the paper was very SL focused, as per the subject guide and another that the questions were only SL, unlike last year's paper which included some borderline HL questions.

The strengths and weaknesses of the candidates in the treatment of individual questions

The difficulty index (the percentage of candidates achieving each correct answer) ranged from 92.28% to 23.59% (November 2011 for comparison, 82.11% and 20.84%). The discrimination index, an indication of the extent to which questions discriminated between high- and low-scoring candidates, ranged from 0.64 to 0.14 (November 2011, 0.68 to 0.28), the higher the value, the better the discrimination.

The following comments were made on selected individual questions:

Question 5

Two respondents commented on "oxygen ion" rather than "oxide ion". The former was chosen when the paper was set to draw attention to the particular nature of the isotope in question.

Question 7

The term "energy level" was used in this question in order to be consistent with assessment statement 2.3.3.

Question 16

The examination normally uses *kJ* when an equation is given as here; if it were to quote a value, say, for the heat of formation of a compound, then this would be given in $kJmol^{-1}$.

Question 18

Although one respondent was concerned about the circles being confused with bubbles and the use of the word "pellet", this turned out to be the easiest question on the paper. "Pellet" is a word that the examiners would expect candidates to understand.

Question 19

One respondent felt that this question required too much mathematical analysis. 61.21% of the candidates, however, gave the correct answer. It is not too much of a step from $[C] / [A]^2 = 1.1$(Assessment statement 7.2.1) to realizing that [C] must be larger than [A] – and then there is only one possible answer.

Question 22

There was concern expressed that we expect candidates to know the colours of universal indicator by rote learning. Far from it, we would expect candidates to have absorbed this information during regular lab classes and demonstrations.

Question 29

We recognize that this might be a language problem. "Incomplete combustion" is not the same as "burned in a limited supply of oxygen". Candidates may also have not read “could” correctly. The correct answer was D. This was the “hardest” question on the paper.

Question 30

One respondent remarked that it was good to see a more demanding Q30. This was born out by the statistics where it appeared as the second hardest question on the paper. It is important that lab work breeds familiarity with errors, both random and systematic.

Standard level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 7	8 - 15	16 - 22	23 - 28	29 - 35	36 - 41	42 - 50

General comments

This paper identified a very broad range of candidate capabilities. Some candidates struggled with even the most basic concepts and factual knowledge while others demonstrated an excellent depth of understanding of the standard level material. In general, candidates appeared well prepared. There were some schools where the candidates seemed unfamiliar with some of the subject material and left many areas of the question paper blank. Answers lacked precision in terms of the wording used and explanations were often vague and lacked chemical concepts and key points.

The 38 G2 forms that were returned conveyed teachers' impressions of this paper. The comments received on the G2 forms are considered very important feedback by the IBO and are reviewed thoroughly during the grade award meeting.

In comparison with last year's paper 68% of respondents felt that it was of a similar standard and 14% considered it a little more difficult while 14% and 3% felt the paper was a little easier and much easier respectively. 90% of respondents thought the level of difficulty was appropriate while 10% thought that it was too difficult. Clarity of wording was considered good by 63%, satisfactory by 34% of the respondents and poor by the remainder. The presentation of the paper was considered good by 73% and satisfactory by 27% of the respondents.

The areas of the programme and examination which appeared difficult for the candidates

The examination revealed the following weaknesses in candidates' knowledge and understanding.

- Definition of average bond enthalpy

- Maxwell-Boltzmann energy distribution

- Malleability of metals

- Hydrogen spectrum and difference between line and continuous spectrum

- Redox equations
- Explanation of molecular shapes and polarity
- Drawing mechanisms with curly arrows

The areas of the programme and examination in which candidates appeared well prepared

The areas which seemed well understood by candidates were:

- Quantitative chemistry
- Bond enthalpy calculations
- Equilibrium
- Atomic structure
- Oxidation numbers
- Acid-Base definitions
- Empirical and molecular formula calculations

The strengths and weaknesses of the candidates in the treatment of individual questions

Section A

Question 1

This was a data based question based on quantitative chemistry. Majority of candidates were able to gain almost full marks with some candidates failing to recognise that chlorine is the limiting reagent in part (a) (ii). Some candidates calculated percentage experimental error instead of percentage yield whereas some other candidates did not pay attention to significant digits. In part (b), explaining the difference in the boiling points of Br_2 and ICl in terms of the intermolecular forces presented a challenge to many candidates. Explanations were vague or unclear and in some cases incorrect in terms of the intermolecular forces present. In part (c), calculations of moles of iodine occasionally saw the erroneous use of Avogadro's constant. Part (d) proved difficult for majority of candidates where the most common wrong answer was iodine.

Question 2

The definition of *average bond* enthalpy in part (a), proved challenging even though it has appeared on recent examination papers and very few scored two marks. A good number of candidates omitted gaseous and did not state that it is the energy needed to break 1 mol of a bond in a gaseous molecule and many did not understand that it is the average calculated from a range of similar compounds. In Part (b) (i), the typical errors were using the incorrect bond enthalpies from the Data Booklet and using the sum of the bond enthalpies of bond forming (products) minus bond breaking (reactants) instead of the reverse. In Part (b) (ii), instead of NH_4^+, candidates identified a range of incorrect answers including NH_3^+, NF, CN^-, NO_3^-, N_2 and even NaCl, although the question asked for a nitrogen containing positive ion.

Question 3

The equilibrium question was generally well answered, but some candidates suggested that the forward reaction equal the reverse reaction without reference to the rates, while some other candidates incorrectly stated that the concentration of reactants and products are equal. In part (b) (i), the Kc expression was usually written correctly. Part (b) (ii) was done well and candidates showed a good understanding of the effect of temperature and catalyst on an equilibrium system; however, weaker candidates incorrectly identified a change in the value of K_c on increasing the pressure. In part (c), the word *minimum* was often missed in the definition of activation energy. In the Maxwell–Boltzmann energy distribution curves, many candidates labelled the axes incorrectly. Also in some cases, the curves did not start at the origin or the curve for T_2 was drawn incorrectly at the same level on the y-axis. The weaker students drew an enthalpy level diagram instead of a Maxwell-Boltzmann distribution.

Section B

Question 4

This was the second most popular question answered in Section B.

Many candidates defined the atomic number, mass number and isotopes correctly although the weaker candidates incorrectly used the term element instead of atom and others defined mass number in terms of molar mass instead of sum of protons and neutrons in the nucleus. Distinguishing between a group and a period and deducing the electron arrangements of Li^+ and boron was handled well by majority of candidates. Many candidates struggled to calculate the percentage abundance of the lighter isotope whereas in part (v), most candidates correctly deduced the number of protons, neutrons and electrons in the two isotopes of lithium. Distinguishing between a continuous and line spectrum in part (b) proved difficult for many candidates. Similarly, drawing a diagram to show the electron transitions between energy levels in a hydrogen atom was challenging for many candidates. Common errors seen were: starting incorrectly at n = 0, not showing convergence or mixed up between the ultraviolet and visible lines. In Part (c), although the explanation of why metals are good conductors of electricity was answered well, some candidates did not refer to delocalized or sea of electrons. Explanation of why metals are malleable proved to be difficult for many candidates. Identifying the two most common ions of iron and deducing chemical formulas was correctly answered by majority of the candidates.

Question 5

This was the most popular question answered in Section B.

The definition of oxidation and reduction, deducing oxidation numbers (although some forgot the + sign) and distinguishing between an oxidizing and reducing agent was answered very well by a majority of the candidates. However, a surprising number of candidates were unable to balance the redox equation or identify the correct oxidizing and reducing agents in the given reaction. In part (b), most candidates defined an acid according to the Brønsted–Lowry and Lewis theories and identify the shorter bond in the Lewis structure given of HNO_2. Many candidates were able to deduce the approximate value of the H—O—N bond angle, however, some candidates were unable to explain in terms of the greater space occupied by the non-bonding electron pairs compared to the bonding electron pairs. Distinguishing between strong and weak acid in terms of their dissociation in aqueous solution was handled very well. The Lewis structure and shape of ammonia was done correctly by most candidates. However, the weaker candidates stated triangular planar instead of triangular pyramidal and that the molecule has no symmetry instead of unsymmetrical distribution of charge giving rise to a net dipole moment. The change in concentration with the change in pH was done well while an overwhelming number of candidates did not write the correct formula of ammonium sulphate.

Question 6

This was the least popular question answered in Section B.

This question was focussed on organic chemistry and attempted by few candidates. The stronger candidates stated two uses of ethene correctly such as manufacture of ethanol and polythene instead of alcohol, plastics, fuel or margarine. Meaning of the term *structural isomers* was well defined with the weaker candidates referring to similar instead of same molecular formula but different arrangement of atoms. Many candidates stated the IUPAC name of the isomers of C_4H_8 and deduced correctly the structural formulas of the two other isomers. Most candidates were able to write the chemical equation for the reaction of the isomer of C_4H_8 with HBr and identify the alcohol formed by the reaction of that product with NaOH. In part (a) (iv), the mechanisms proved a problem for majority of candidates. The use of curly arrows in reaction mechanisms continues to be poorly understood, the arrow often pointing in the wrong direction. Candidates must take care to accurately draw the position of the curly arrows illustrating the movement of electrons. In part (b), the ester functional group was drawn correctly and it was pleasing to see that the majority of candidates handled the calculation of the empirical and molecular formulas extremely well.

Recommendations and guidance for the teaching of future candidates

- Teachers are strongly advised to refer to past examination papers and the corresponding mark schemes to assist candidates with examination preparation.

- Teachers should ensure that candidates read the questions carefully to ensure they answer appropriately and to avoid missing parts of the question. Candidates must know the meaning of the different command terms that appear in the assessment statements and in the examination papers.

- Candidates should use the number of lines and the marks as a guide as to how much to write. It should be possible to write the answers in the boxes provided and if the answer does not fit in the box, indicate that the answer is continued on a separate sheet. However, the use of continuation sheet is not encouraged and candidates should use the space provided.

- Candidates need to practice on the data-response question, which involves different facets including experimental work, uncertainty measurements, hypothesis, Aim 8 and linking of different topics across the curriculum.

- The experimental nature of chemistry should be brought to the forefront of the teaching programme including key experimental skills. There should be greater emphasis on core chemical concepts and definitions covered in the assessment statements for each topic

- Candidates should set out calculations logically and legibly and “keep going” with calculations because error carried forward in the later part is usually awarded full marks if the method is correct. All steps in the calculation should be shown and attention must be paid to significant digits and units.

- Candidates must be instructed to use the latest chemistry Data Booklet during the chemistry course so that they are familiar with what the data booklet includes.

- Some candidates are writing more than one answer hoping the examiners will pick up the correct answer. This is not encouraged because a correct response followed by an incorrect response nullifies the mark of that question. Candidates should avoid writing rambling statements, hoping that they will pick up marks somewhere in their answer.

- Candidates should write legibly so examiners can read responses.

Standard level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 6	7 - 12	13 - 17	18 - 21	22 - 26	27 - 30	31 - 40

General comments

The following are some statistical data based on 37 respondents.

Comparison with last year's paper

Much easier	A little easier	Similar standard	A little more difficult	Much more difficult
1	2	25	7	1

Suitability of question paper

	Too easy	Appropriate	Too difficult
Level of difficulty	1	32	4

	Poor	Satisfactory	Good
Clarity of wording	2	14	22
Presentation of paper	0	10	27

There was a wide range of ability and preparedness exhibited by candidates although the overall standard was higher than last year (and the paper was found to be more accessible). One examiner noted a number of candidates attempting more than two options, a strategy that is not recommended. Candidates are urged to attempt only the two options that they have been taught. Options C and G were the least popular.

Within the general G2 comments, there were some that are addressed below:

1) We are not examining the "core" of the Programme so "simple calculations" are difficult to set.

2) The examiners set a range of questions in each option, ranging from simple to much more challenging and demanding (and thus, discriminating).

3) While examiners follow the general subject guide timings in allocating marks, it is, of course, impossible to examine every assessment statement in every session. We aim for a balance over several sessions. This is why, for instance, four marks were allocated to MRI in option A when two would have been a more accurate reflection of the guide timings.

4) One respondent commented that there is too much reliance on memory and that there are insufficient opportunities (particularly in options C and E) to display reasoning and chemical understanding; we recognize that this can be improved.

The areas of the programme and examination which appeared difficult for the candidates

There was considerable variation in performance but some of the repeated weaknesses were:

- Explaining how the components of a mixture interact with mobile and stationary phases in column chromatography

- Drawing zwitterions and anionic forms accurately with particular regard to the placement of charges. Writing equations for these forms reacting with strong acid and strong base

- Stating the functions of carbohydrates

- Drawing an ester link correctly

- Knowing the reactions in a blast furnace

- Knowing how catalysts are chosen

- Explaining how a fuel cell intoximeter works

- Long term effects of nicotine

- Knowing ways of decreasing acid deposition

- Knowledge of primary pollutants and sources

- Clearly explaining how rate of rancidity can be minimized
- Drawing curly arrows in just the right place.

The areas of the programme and examination in which candidates appeared well prepared

The areas which seemed well understood were:

- The components of an IR spectrometer

- Identifying bonds in an IR spectrum

- Examples of fatty acids

- Knowledge of dietary fibre

- Creation of a new pharmaceutical product

- Identifying a tertiary amine group

- Equations for the production of H_2SO_3

- Identifying aerobic and anaerobic reactions

- Knowledge of reaction types in Option G

The strengths and weaknesses of the candidates in the treatment of individual questions

Option A - Modern analytical chemistry

This was one of the most popular options and generally answered well.

Question 1

Part (a) was generally answered well although some candidates were clearly muddling the IR spectrometer with Atomic Absorption spectroscopy. The most common error in (b) was to write recorder or similar.

Question 2

In (a), the spectrum was well interpreted and few had little difficulty in gaining three marks. The three possible compounds were given in the stem so candidates did not score the last mark if the “absent” bond included an atom not present. One G2 respondent commented that asking students to locate bonds in the fingerprint region is questionable; as it turned out, the candidates had no difficulty with this. Most were then able to progress through the rest of the question without difficulty although several gave compounds in (c) that were not in the stem of the question. In (d) the answer given was generally consistent with the answer given in (c).

Question 3

Most realized that radio waves are lower in energy than X-rays and so less harmful and in (b) quite a number of possible answers were accepted.

Question 4

In (a), there was clearly some confusion between the two terms. Candidates who had studied the May 2012 papers were at an advantage in (b) and showed a good understanding of the partition between mobile and stationary phases. Many answers were about column chromatography rather than how it worked; others were simple answers based on paper chromatography.

Option B – Human biochemistry

This was another of the most popular options.

Question 1

Part (a) was poorly answered with many wrong examples being given. Most, however, had a good understanding of what *dietary fibre* is and, because, *constipation, obesity, diabetes* and *bowel cancer* were separate marking points, most scored well.

Question 2

Most candidates were able to transfer the required information for part (a) correctly from the Data Booklet. In (b), the mark for *three* molecules of water was more often gained than the mark for the correct drawing of the ester link which was often the wrong way round (glycerol–COO–R rather than glycerol–OOC–R) – or just wrong. In (c), cholesterol was most often given in place of steroids. On reflection, *composition* might not have been the best word to use in (c)(ii), but it seemed to cause candidates little difficulty and the mark-scheme allowed candidates to score well. Candidates need to consider the best way to set out answers asking for a *comparison*.

Question 3

In (a), the anionic form was more often correct than the zwitterion where the positive charge was frequently not on the N atom. Part (b) was set as a discriminator and only the most competent candidates knew that $H_2NCH(CH_3)COO^-$ is the most predominant ionic form of alanine at pH7 (above its isoelectric point of 6) and wrote the correct equation to form $H_3N^+CH(CH_3)COO^-$ (as the amine group is a stronger base than the –COO^- ion). M2 alone was more common. Whilst many understood part (c) very well, there were others who lost M1 because they did not mention the *sequence* of amino acids in the primary structure – and there were others who thought that primary proteins and secondary proteins are different kinds of proteins.

Option C – Chemistry in industry and technology

This was one of the least popular options and there were few good submissions.

Question 1

Part (a) was generally well answered (although some forgot the ore and others gave scrap iron as a raw material) but many could not give two correct equations in (b). There were very few correct answers to (c) and many thought in (d) that tempering would produce ductility.

Question 2

There were few three-mark answers; perhaps many candidates guessed.

Question 3

Many candidates were able to score three marks in (a) and most gave a good account of (b). Many, however, neglected to mention intermolecular forces, specifically requested in the question.

Question 4

This was related to assessment statement C.4.3. It proved to be challenging; candidates did not show a good understanding and answers were not well organized.

Option D – Medicines and drugs

Question 1

Part (a) was generally well answered although a lot of candidates seem to think that ED_{50} is established on animals and a few, even more worryingly, linked LD_{50} with human trials! In part (b), descriptions were often missing but in (c) most understood the importance of frequency and regularity of drug administration.

Question 2

Most understood that aspirin might cause stomach bleeding (rather different from *internal* bleeding which some wrote) but Diazepam was less well answered. Part (b) was surprisingly poorly answered, some apparently confused by "$-4e^-$" on the left hand side of the equation. Candidates should be familiar with this way of writing a redox equation. Although the assessment statement D.4.3 includes the word "or" in the last line of the Teacher's notes, candidates are expected to be familiar with *both* types of intoximeter. Few recognized the significance of the fuel cell in (ii) and most did not know the importance of the C–H bond in the infrared determination of ethanol concentration, (iii).

Question 3

There were many correct answers in (a) but (b) produced very few good answers. Most had a good understanding of the short-term effects but the long-term effects were normally confused with those of smoking (lung disease and cancer).

Option E – Environmental chemistry

This was one of the less popular options

Question 1

This was generally answered well although in (a) some thought the natural acidity of rain, caused by dissolved CO_2, was what was required. Part (b) was answered well (although the number of candidates who wrote elemental sulfur as a diatomic molecule was worrying) and there were some good discussions in (c). Many candidates misinterpreted the question as asking about the effects of acid rain – credit was given.

Question 2

In (a), few candidates seemed to understand what the question was asking. They fared better in (b), the most common error being not to mention both air/oxygen and bacteria in the secondary stage. In the primary stage there seemed to be a preoccupation with removing condoms!

Question 3

It was rare to encounter a candidate who did not score both marks in (a) – probably O_2 in the equations was a bit of a hint! If a mark was to be lost in (b), it was usually for not making the connection between a *rise* in temperature and a *decrease* in *solubility* of oxygen gas.

Question 4

Candidates who presented their answers in a table (good for comparisons) tended to do better than others who wrote in a less focused way. Many mentioned cost but if it were mentioned then it had to be justified in terms of land prices, or the cost of fuel for incineration or similar.

Option F – Food chemistry

This was quite a popular choice.

Question 1

In (a) the ester in fats was less well known than the carboxylic acid in fatty acids. Although candidates found it tough to present their explanations in (b) in a logical fashion, most scored two of the three marks.

Question 2

The answers to (a) were patchy with many giving "hydrolytic rancidity" (and then not giving "ester" for an *ECF* mark); those who did give "oxidative" correctly must be careful to give *carbon to carbon* double bond for the functional group (some would just write carbon double bond). In (b) the answers tended to be disorganized and unfocussed. Candidates should be referred to assessment statement F.3.5.

Question 3

In (a), A was often correctly given – but, judging by the M2 answers, it must have been an educated guess. Very few explanations approaching a mark were given, most being of the form "it has O^+ so it can accept a proton". In (b), many candidates scored two marks. Vitamin was only accepted once (as it was adjudged that vitamin A and vitamin C, for example, are the same *type*); some gave "anthocyanin" which was, of course, in the stem of the question. There were some good answers to (c) but candidates need to learn the correct terminology; red light is reflected, not transmitted or emitted (it would make ripe strawberries easier to pick in the dark!), and the term "opposite" does not double for "complementary".

Question 4

In (a), the "water" mark was most often gained; very few deduced the product formed with the correct C=N bond. In (b) the answers were patchy.

Option G – Further organic chemistry

This was the least popular option in the paper but quite well done by those who submitted it. A marked improvement in the presentation of many organic mechanisms has been seen.

Question 1

The good candidates answered all parts of this well with many giving four good points for (e) – maximum three marks. Others were unable to give the correct name in (c) and the weak candidates scored very poorly overall.

Question 2

In (a), M1 was often scored and if a mark were to be lost, the Br atom was on the wrong carbon for M2. Part (b) was answered well by many candidates. The mechanism in (c) was either done well – or not. Candidates need to refer back to past papers and the published mark schemes to see what is required. As commented above, where the mechanisms have been learnt and understood, there has been a marked improvement.

Question 3

Most candidates were able to establish the increase in acidity in (a) and that nitro groups have an electron withdrawing effect – but not all used subject specific vocabulary which is a source of concern. In (b), many candidates (including strong candidates) carelessly lost the mark by not including phenol in the comparison. Most candidates gained the mark in (c) where there was a very generous allowed range.

Recommendations and guidance for the teaching of future candidates

- Sufficient time must be allocated to the teaching of the Options; it is recommended that the options are taught and not allocated to self-study.

- Teachers should stress the importance of correctly writing balanced chemical equations and formulas.

- Candidates must pay particular attention to the “command term” used in each question and use this as a guide to the depth of the answer required. Questions should be answered from the point of view of a chemist, using appropriate vocabulary. Vague answers are seldom given the benefit of any doubt.

- Candidates must pay particular attention to the number of marks allocated in each part and use this as a guide to the detail required in the answer.

- Candidates should prepare for the examination by practising past paper questions and carefully studying the mark schemes provided.

- Candidates must use the chemistry Data Booklet during the chemistry course so that they are familiar with what it includes.

- Candidates must be fully familiar with organic reaction mechanisms in Option G and pay special attention to the correct use of curly arrows in mechanisms. They should also pay attention to the *beginnings* and *ends* of both curly arrows and covalent bonds.

- Candidates should pay close attention to the correct placing of charges on organic molecules. Lone pairs may well also be expected though not necessarily specifically requested.

- Teachers should ensure that definitions covered in the assessment statements for each option are well known by candidates.

- Candidates should be reminded of the new format with boxes and be told not to write outside the box but on a separate sheet of paper when the box does not have enough space. If a question does continue on a separate sheet, the *exact* question part must be stated on the continuation sheet. Candidates should write **legibly** and in ink that is suitable for scanning.