May 2013 subject reports

CHEMISTRY TZ1

(IB Latin America & IB North America)

Overall grade boundaries

Higher level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 16	17 - 31	32 - 43	44 - 54	55 - 66	67 - 77	78 - 100

Standard level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 16	17 - 30	31 - 42	43 - 52	53 - 62	63 - 72	73 - 100

Time zone variants of examination papers

To protect the integrity of the examinations, increasing use is being made of time zone variants of examination papers. By using variants of the same examination paper candidates in part of the world will not always be taking the same examination paper as candidates in other parts of the world. A rigorous process is applied to ensure that the papers are comparable in terms of difficulty and syllabus coverage, and measures are taken to guarantee that the same grading standards are applied to candidates' scripts for the different versions of the examination papers. For the May 2013 session the IB has produced time zone variants for Chemistry.

Higher 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

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

The range and suitability of the work submitted

The moderators reported that the range and suitability of the work submitted was at least similar to the previous couple of sessions and possibly showed a slight improvement in terms of appropriate task setting and application of the assessment criteria by the teachers. Within this general picture there was of course great diversity but this current assessment model has now been in place for five May sessions and it is clear that a significant proportion of teachers have reached a level of competence and confidence in designing an appropriate practical scheme of work and satisfactorily applying the criteria that is pleasing. There is still a learning curve to be followed though for teachers new to the IB Diploma who are still finding the internal assessment requirements unexpectedly exacting and demanding. Support through IBO authorised face-to-face and online workshops, plus of course the Forum and Teacher Support Material on the Online Curriculum Centre, cannot be recommend highly enough for teachers inexperienced in the internal assessment component.

Generally the samples were well presented and the procedures were followed. Most teachers gave feedback using c, p, n or 2,1,0 notation with a good proportion giving at least a few written comments to explain where the candidate can make improvements. This providing of feedback on the marking awards is not only valuable for the students but is of great support in allowing the moderator to understand and hopefully support the teacher’s decision making. There are still a number of schools who send in work with no marking evidenced on the report at all, simply with the grades entered on the 4PSOW. This is extremely unwise and presumably is a result of confusing internal assessment regulations with those of the Extended Essay.

In the May 2012 Subject Report a concern was voiced that increasingly schools were submitting Design assessments which were purely theoretical exercises and there had been no follow up experimental phase. Although this is permissible by the regulations it is seen later in this report that this trend has led to a lowering of quality of Design achievement. Happily the impression this year was that this trend has been reversed and students were being given the opportunity for experimental follow up. Two common concerns regarding the Design assessments were related by moderators though. Firstly, often teachers set a whole class a single narrow brief such as to investigate a factor affecting the rate of reaction of a specified reaction system. This often saw all students choosing the same independent variable, typically the concentration of one of the reactants, and design essentially identical procedures. The temptation for collusion in such cases is of course great and teachers should attempt to frame the assessment in a manner that allows individual students to produce an individual design. The second concern was that some school’s carried out two Design assessments in the same narrow area of the syllabus most typically kinetics or energetics. Students essentially produced the same design twice with just the change of identity of the independent variable. This then fed through to CE where students in some cases reproduced word for word the same evaluation and suggestions for modification. Although it is not strictly plagiarism since it is the student’s own work originally it is most certainly very poor assessment practise and teachers should eliminate it at source. The advice here is to ensure that students two assessed Designs relate different syllabus areas.

The tasks being assessed for Data Collection and Processing have significantly improved during the cycle of the current internal assessment model. No longer do we see a large number of inappropriate non-quantitative tasks nor teachers supplying students with pre-prepared data tables and step wise guides to calculations. The remaining issue though is that many of the data processing tasks are quite simplistic such as simple averaging. Certainly last year's comment that there are still too few assessments that challenge students to determine a quantity from a graph rather than make a simple qualitative comparison still applies.

Some moderators reported a significant number of cases where students are responding in very similar manners to even open ended prompts implying that they are not working independently which of course raises the issue of malpractice. Most frequently this is manifested through very similar designed procedures or extremely similar evaluations. Strategies should be developed in how assessments are administered to ensure students complete the assessed components of the tasks for themselves.

The length of the students' reports is also increasing but rarely to good effect in terms of clarity of communication. All too often students reproduce pages of datalogger data when the graphical output is a clearer record. Also students use the cut and paste function to reproduce pages of procedure when they change the value of just one variable.

A continuing concern is that there are a number of schools who do not act on the same feedback comments from moderators in the 4IAF form on IBIS year after year. Through the OCC Forum and workshops some teachers are relating that their DP Coordinator is not forwarding the feedback supplied via IBIS to them which is such a pity for all concerned, especially the students.

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. The one common failing was that students incorrectly identified the dependent variable as the derived quantity (e.g. 'rate of reaction' or 'enthalpy of reaction') rather than the actual measured variable such as time for a given volume of gas to be produced or the temperature increase of the reaction mixture. 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.

Aspect 2 is consistently the most challenging of the Design aspects and partial was the most frequent award. There were two common weaknesses.

One is that 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.

The second common failing for this aspect is that students simply did not include enough detail in their designed method. 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 guiding principle to relate to students is that their design should be communicated in sufficient detail to allow the reader to reproduce their experiment if desired.

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. Please note that the reward for the successful propagation of uncertainties is confined to DCP Aspect 3 as a discriminator between the partial and complete descriptors. Some teachers were also assessing the success of the uncertainty propagation in Aspect 2 and students were getting penalised twice. As usual a significant number of students were quoting final calculated quantities to an unreasonably large number of significant figures. Also the construction of best fit lines was of variable quality with a lot of students using the polynomial trend-line function of Excel inappropriately. For the first time this year it was seen that a number of schools were encouraging more sophisticated statistical analyses such as standard deviation calculations and chi-square tests. This is acceptable but really it is beyond the realm of Chemistry IA where we rarely generate sufficient data for such treatments. Overall it is a concern that so much effort (often with no reward) is going into treating uncertainties with sometimes pages of calculations which end up obscuring the true outcomes of the investigation.

Conclusion and Evaluation

Conclusion and Evaluation continues to be the most challenging of the criteria and few candidates achieved the top level across all three aspects.

With respect to Aspect 1, most candidates compared their results to literature values where available. 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.

An issue for teachers is how to assess this aspect when the investigation does not involve the determination of a quantity that can be compared to literature and a percentage error calculated but instead involves the determination of a trend such as is commonly seen for example in many kinetics investigations. In such cases the student should try and describe the nature of trend. For example even a SL student can conclude whether the rate of a reaction increases in direct proportion with concentration of one of the reactants or not. This can then be compared to the literature expectation and the likely impact of systematic or random errors discussed.

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 and relative significance of the source of error which limited the achievement to Partial in many cases. 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 suggesting 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.

Recommendations for the teaching of future candidates

Teachers should set open-ended questions to facilitate the assessment of Design and should strive to ensure that as an outcome there is a diversity of Designs produced.

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

The two highest marks per criterion for each student should come from two different types of task. Students should not receive double reward for two very similar designs or data processing tasks or evaluations.

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 fulfil this criterion completely.

All candidates need to record, consider during processing (by propagating through calculations or most simply constructing a best fit line in graphical analysis) and evaluate the significance of errors and uncertainties.

Teachers are encouraged to set some DCP tasks, especially to HL students 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 should compare their results to literature values when relevant and include the appropriate referencing of the literature source.

Students should evaluate sources of error as random or systematic and should be able to show an awareness of the direction and significance of the error.

Suggested modifications should realistically address the identified sources of error.

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 should provide feedback to candidates in terms of the separate aspect awards and any further brief comments on the reports explaining the mark awarded is equally useful to the moderator and student.

Higher level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 10	11 - 15	16 - 21	22 - 26	27 - 30	31 - 34	35 - 40

General comments

This paper consisted of 40 questions on the Subject Specific Core (SSC) and Additional Higher Level (AHL) material 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. Teachers' impressions of this paper were conveyed by 49 G2 forms that were submitted. 87.8% reported the level of difficulty to be appropriate, 10.2% thought it was too difficult and 2.0% thought it was too easy. In comparison with last year's paper, 60.4% considered it to be of similar standard or a little easier, 31.3% considered it to be a little more difficult and 4.2% much more difficult. Clarity of wording was considered good or satisfactory by 95.9% and the presentation of the paper was considered good or satisfactory by 100%. These statistics were mirrored in the general comments, where it was generally felt that the paper was well rounded and good with solid coverage of the syllabus and a good mix of easier and more difficult questions.

One respondent stated that there was a too high percentage of multiple completion questions (7 out of 40). 4 multiple completion questions out of 40 is indeed the norm. 7 does seem a little high but the paper was authored before the change in rules.

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

The numbers in the columns A–D and Blank are the numbers of candidates choosing the labelled option or leaving the answer blank. The correct option is indicated by a grey cell. The *difficulty index* (perhaps better called facility index) is the percentage of candidates that gave the correct response. A high index thus indicates an easy question. The *discrimination index* is a measure of how well the question discriminated between the candidates of different abilities. In general, a higher discrimination index indicates that a greater proportion of the more able candidates correctly identified the key compared with the weaker candidates. This may not, however, be the case where the difficulty index is either high or low.

The difficulty index ranged from 93.53% to 24.31%, and the discrimination index ranged from 0.65 to 0.11.

The following comments were made on selected individual questions:

Question 4

One respondent stated that the question was tricky as the emission spectrum of hydrogen is normally shown the other way round. The emission spectrum of hydrogen may be given the other way round in books, but in Table 3 of the Data Booklet the electromagnetic spectrum shows increasing wavelength towards the right, so candidates should be familiar with this and the inverse relationship of wavelength and energy or frequency. 46.07% of the candidates chose the correct answer B and another 46.07% opted for answer D.

Question 5

One respondent stated that the question should not have been asked, as students are not supposed to know the Cu exception. In the teacher's notes of assessment statement 12.1.6 in the syllabus details it is clearly stated "exceptions to the principle for copper and chromium should be known". 56.49% of the candidates chose the correct answer C, with 30.78% choosing A which means that about one-third of the schools do not teach these two exceptions.

Question 21

One respondent stated that graphs A and B look too similar so students might not be able to clearly see that the answer is B. The initial gradient of curve B is clearly greater so candidates should have recognized the faster decrease in initial concentration for a second order reaction. Curve A clearly shows a constant half-life so candidates should have recognized that it refers to a first order reaction. 60.65% of the candidates chose the correct answer B.

Question 31

Four respondents stated in their G2 forms that they teach that time, current and charge will affect the mass of metal deposited during electrolysis, but nothing about size of the metal ion or the relative atomic mass of the metal. Although charge is important when considering the deposition of Na, Mg and Al when the same amount of current for the same amount of time is used, the relative atomic mass becomes important when considering the deposition of metal with ions of the same charge, Na and K for example.

This proved to be one of the fifth most difficult question in the paper with 37.54% choosing the correct answer A and 36.8% opting for answer B. The discrimination factor in this question was 0.41.

Question 33

Two respondents stated in their G2 forms that the question was tricky and may have confused the candidates as they should apply the difference between Iodine and Iodide. If at Higher level candidates are not able to recognize that the symbol of Iodine is I_2 and that of the Iodide ion is I^- there is a severe problem in the candidates' basic preparation in Chemistry. Indeed, 33.08% of the candidates chose A as the correct answer thinking Iodine is I^-, with only 32.05% choosing the correct answer D. This proved to be the third most difficult question in the paper with a discrimination index of 0.38.

Question 40

One respondent stated in the G2 form that the answer could be A. In the teacher's notes of assessment statement 11.1.3 it is stated that "random uncertainties are reduced by repeating readings". 77.34% of the candidates chose the correct answer D with only 15.79% opting for A. This proved to be the eighth easiest question of the paper with a discrimination index of 0.15.

Standard level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 7	8 - 11	12 - 15	16 - 18	19 - 20	21 - 23	24 - 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. Teachers' impressions of this paper were conveyed by 91 G2 forms that were submitted. 93.3% reported the level of difficulty to be appropriate, 1.1% thought it to be too easy and 5.6% too difficult. In comparison with last year's paper, 57.3% considered it to be of similar standard or a little easier, 30.3% considered it to be a little more difficult and 2.3% much more difficult. Clarity of wording was considered good or satisfactory by 100% of the respondents and the presentation of the paper was considered good or satisfactory by 98.9%. These statistics were mirrored in the general comments, where it was generally felt that the paper was well rounded and good with solid coverage of the syllabus and a good mix of easier and more difficult questions.

One respondent stated that there was a too high percentage of multiple completion questions (6 out of 30). 3 multiple completion questions out of 30 is indeed the norm. 6 does seem a little high but the paper was authored before the change in rules.

One respondent stated that some questions were a little tricky considering SL students in general are not strong. Well, good candidates also take SL Chemistry and there need to be questions that will recognize the 6 and 7 candidates.

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

The numbers in the columns A–D and Blank are the numbers of candidates choosing the labelled option or leaving the answer blank. The correct option is indicated by a grey cell. The *difficulty index* (perhaps better called facility index) is the percentage of candidates that gave the correct response. A high index thus indicates an easy question. The *discrimination index* is a measure of how well the question discriminated between the candidates of different abilities. In general, a higher discrimination index indicates that a greater proportion of the more able candidates correctly identified the key compared with the weaker candidates. This may not, however, be the case where the difficulty index is either high or low.

The difficulty index ranged from 89.86% to 9.95%, and the discrimination index ranged from 0.61 to 0.10.

The following comments were made on selected individual questions:

Question 1

One respondent stated in the G2 form that technically 1 atm is not standard pressure.

In Table 2 of the Data Booklet the conversion “1 atm = 1.01×10^5 Pa” is given, so students should be familiar that 1 atm or 1.01×10^5 Pa can be used for standard pressure.

This question proved to be the most difficult in the paper with only 9.95% of the candidates opting for the correct response D, the vast majority, 75.79%, chose response C thinking that choice I is incorrect. Candidates should know that the sodium ion is Na^+ (assessment statement 4.1.3) so they should be able to deduce the oxidation number of hydrogen to be -1 (assessment statement 9.1.2) and that H^- is the negative ion in sodium hydride, NaH. Although hydrogen is usually assigned the oxidation number of +1, in metallic hydrides the oxidation number of hydrogen is -1.

Question 5

Several responses in the G2 forms stated that there were too many conversions to do which is a fair comment, but options A and B should have immediately been ruled out as the temperature is given in ^{o}C not in Kelvin. It was surprising to see that 38.82% of the candidates opted for answer A.

One respondent stated that the value 8.314 kPa L K^{-1} mol^{-1} should have been used for the ideal gas constant, R. The value for R is given as 8.31 J K^{-1} mol^{-1} in Table 2 of the Data Booklet, so these were the value and units used.

One respondent stated that the value 0.0821 should have been used instead 8.31 for the ideal gas constant, R, with the data provided. 0.0821 could have been used if the pressure was asked to be calculated in atm and not in Pa.

47.58% of the candidates chose the correct answer C. The question had a reasonably good discrimination index of 0.49.

Question 17

Some respondents mentioned in their G2 forms that the question was not appropriate as they could not find in the syllabus details where the specific relationship between temperature in K and average kinetic energy of molecules of gas is mentioned. In assessment statement 6.2.1 in the syllabus details it is clearly stated that "average kinetic energy is proportional to temperature in kelvins". 48.33% of the candidates chose the correct answer D. The discrimination index for this question was 0.42 which is reasonably good.

Question 30

One respondent stated in the G2 form that the answer could be A. In the teacher's notes of assessment statement 11.1.3 it is stated that "random uncertainties are reduced by repeating readings". 75.05% of the candidates chose the correct answer D with only 16.05% opting for A. This proved to be the sixth easiest question of the paper with a discrimination index of 0.20.

Higher level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 12	13 - 25	26 - 38	39 - 48	49 - 59	60 - 69	70 - 90

General comments

The following are some statistical data based on 49 respondents (from 371 schools).

Comparison with last year's paper

Much easier	A little easier	Similar standard	A little more difficult	Much more difficult
1%	10%	27%	9%	0%

Level of Difficulty

Too easy	Appropriate	Too difficult
1%	47%	1%

Suitability of question paper in terms of

	Poor	Satisfactory	Good
Clarity of wording	1%	26%	22%
Presentation of paper	0%	18%	31%

Candidates, in general, coped well with this examination and they seemed well-prepared to answer the standard questions. The paper was still able to challenge the strongest candidates who could interpret results and arrive at logical conclusions. There were, however, too many candidates leaving questions unanswered, the surest way to score zero marks!

The format of the papers is now familiar; candidates used the extra pages when appropriate although most found the space provided in the examination paper sufficient for their answers.

One respondent commented that students missed the beginning of section B. This might account for the number of candidates who seemed to attempt three questions in section B. Although the examiners have some sympathy with this comment, candidates are given reading time at the beginning of the examination and one of their tasks at this time should be to identify the break in the paper.

Another respondent commented on the number of "1 mark" questions; there were 14 in section A (40 marks). There is a difficult balance to strike between making the examination more accessible and examining in depth.

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:

- Uncertainties.
- Calculations (which were poorly set out).
- Definitions (which generally showed the right idea but missed crucial pieces of information).
- Hypothesis questions (which require logical thought and careful explanation).
- Electrolytic cells (often confused with voltaic cells) and the products of electrolysis.
- Finding E_a by a graphical method.
- Clear, logical explanations.
- Explanation of delocalization.
- Description of metallic bonding.

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

The areas which seemed well understood were:

- Equilibrium expression and the effect of external constraints on the position of equilibrium.
- Oxidation numbers (generally using correct conventions).
- Calculating empirical formulas.
- Atomic structure.
- Organic chemistry.

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

Question 1

Marks were frequently lost in (a) because neither uncertainty was given and many did not realize that the absolute value was obtained by adding the two individual errors. If (b) was attempted, the most frequent error was to omit the factor of 4 and arrive at a molar mass of 556 g mol^{-1}. In (c), many candidates found the molecular formula from the % composition and the answer to (b). Errors were carried forward in the marking of (d). Candidates were generally able to answer (e), the definition of strong/weak acids. The common error in defining a buffer solution in (f) (i) was to omit “small” in the addition of acid or alkali whilst in (ii) candidates needed to be more specific about the volume of acid added for full credit.

Question 2

The trend in atomic radius was generally correctly identified (although some seemed to use ionic radius data) but many tried to explain in terms of electronegativity. Part (b) was felt to be challenging and it required calm and logical thought with a clear explanation; many realized that the hypothesis was wrong but very few could explain why.

Question 3

The idea of activation energy being a *minimum* was seldom communicated. Few were able to follow through all the mathematics to find E_a by a graphical method and those that did had often omitted 10^{-2} in their calculations. The answers were often poorly set out so it was difficult to assess the award of part marks; indeed, many candidates seemed to hope that a correct answer would somehow emerge from a mass of incomprehensible figures. The gradient of the graph for (c) was generously marked; all candidates had to do was to realize that the catalyst would lower the activation energy and thus the gradient would be less negative. As long as a line with less negative gradient was drawn, the mark was awarded.

Question 4

Part (a) was usually correct. The notational convention in (b) was generally correct, if a little patchy and this was an improvement on previous sessions. Many identified the oxidizing and reducing agents as Mn and C – or reversed the correct answers. Even when candidates appeared to be getting (d) correct, electrons were omitted or the equation was unbalanced (usually electrons).

The standard electrode potential in (e) was given in standard form and 1.51 V was usually found in the Data Booklet but a significant minority gave the wrong manganese potential and many gave the answer as +1.02 V. Candidates should note that the sign of E° should be given in any answer. The spontaneity and signs in parts (e)(ii) and (f) caused little difficulty.

Question 5

Most were able to answer (a) correctly although there were some careless variations. There was a tendency in (b) to redraw butan-2-ol in different layouts – or the bonds were connected carelessly. In (c) (i) the name was rarely correct and in (ii) a number of otherwise correct equations didn’t balance the H_2 molecules. In (iii), about 50% of candidates gave the correct answer, “condensation”, although few understood the need for each molecule to have two (reactive) functional groups. Most were able to give a use of a condensation polymer such as nylon although there were some other interesting examples given: fertilizers, perfumes and food flavouring for instance! One respondent questioned the relevance of asking about economic importance in (v); this was an examination of assessment statement 20.4.5.

Section B

Question 6

In (a), the general idea of an isotope was known, but so many omitted the word atoms from otherwise correct answers. The calculation of the relative abundance of ^{10}B and ^{11}B was usually successful although candidates should note that the command term “calculate” requires them to “show the relevant stages in the working”.

The Mass Spectrometer was, in general, well understood but some confused R with ionization, B^+ was often produced and only about half knew about ^{12}C as the scale.

The electron configuration of phosphorus was successfully answered (even by apparently weaker candidates) and there were many good answers for the Lewis structures. Candidates would do well to draw the “dots” clearly remembering that their answer will be scanned. They should group the electron dots neatly in pairs (much easier for the examiner to count, for one thing) or use a line to represent an electron pair. The usual errors occurred namely missing lone pairs on P and/or Cl atoms. The shapes and angles in (iii) were patchy but there were also some impressive answers. About half knew that sp^3 was the answer to (iv) and in (v) about half based their explanation on the dipole moment in PCl_3. (One mark was allowed for those who recognized that PCl_3 would be polar whilst PCl_5 would not – thus suggesting that PCl_3 had the higher melting point.) Candidates were expected to know the order of melting points as this had been studied in 13.1.1. Very few were able to write a balanced equation for the reaction of PCl_5 with water.

Many failed to note that a Lewis acid is an electron *pair* acceptor and the definition was often muddled with that of Brønsted-Lowry. Some, in (d) (ii), treated the P and Cl atoms separately.

In (e) there was little discussion of overlap of *p* orbitals, some of resonance but hardly any evidence in terms of equal bond length and equal bond strength. The bonding in an ozone molecule was not well-understood.

Question 7

This was the least popular of the Section B questions. In (a) (i) the trend was generally correctly identified but the reasons were not clear, many confusing *electronegativity* with *electron affinity*. Most knew about the reactions (or lack thereof) of bromine but the equations were sometimes unbalanced or included halogen atoms rather than molecules.

There was a tendency to describe the bonding of metals in terms of nuclei rather than cations and malleability was not well understood. The properties in (b) (ii) were surprisingly poor. Many suggested that the metals themselves are coloured rather than the compounds, for instance. The bonding in (iii) was not well known but the oxidation number was generally answered correctly. In (v), some candidates gave the *full* orbital diagram, some omitted [Ar] – and some just got it wrong!

The diagrams in (c) were poorly presented and often inaccurate (much confusion with a voltaic cell) and there was little understanding of how current was transmitted. In (iii), few candidates correctly predicted the products of electrolysis of dilute iron bromide, with many seeming to ignore the presence of hydrogen ions/hydroxide ions/water; correct explanations in terms of electrode potentials or preferential discharge were rare. Despite this, bromine was often correctly identified in (iv). In (v), few understood the impact of concentrating the electrolyte.

Question 8

(a) There were some good answers to (i) although some did not realize that they were expected to use the experimental data even though this was signalled in the first line of the stem. Few candidates properly compared the experimental result to the data booklet value (less heat liberated than theoretically) and there were many vague answers about “insulation”. (What, precisely, is going to be insulated?)

In (b) (i), the most common error was +129 kJ mol^{-1} but in (ii) the answer was often correct. Units tended to get muddled in (iii) and many marks were awarded as “error carried forward”. Few were able to explain the ΔH and $T\Delta S$ relationship in detail in (iv).

Equilibrium was well understood in general with many candidates gaining one of the two available marks. “Equal rates” was more often given than the constancy of macroscopic properties for the second mark. The K_c expression was given correctly by the vast majority of candidates (including the correct brackets and indices) but many had difficulty with the equilibrium concentrations in (iii).

The changes in equilibrium position were well understood for the most part although if a mark were to be lost it was for not mentioning the number of moles of gas.

Question 9

Features of an homologous series need to be learnt; this was answered relatively poorly. The most common reagent was bromine (some indeed used liquid bromine!) and the common errors were using HBr and describing “colourless” as “clear”. In (iii), some gave the equation backwards, a consequence, perhaps, of misreading the question. In (iv) many referred to “same molecular formula” rather than “same structural formula” and the lack of rotation about the double bond in (v) was not well described.

Answers to (b) (i) and (ii) were generally sound although candidates should note that the question asks about pH so that answers saying “it becomes less basic” do not score.

In (c) (i) the explanations were a little vague, some candidates perhaps being fooled by the data of *time* rather than *rate*. Many expected to be given marks for a series of numbers and calculations without explanations. Answers to (ii) and (iii) were usually consistent with (i). Part (iv) however, had poor correlation with (ii), the reason usually being omitted. Part (v) was marked as a follow through to part (iv).

Mechanisms such as that requested in (d) (i) must be learnt and curly arrows need to be accurate in origin and destination. (d) (ii) was rarely answered correctly while the answer to (iii) was patchy.

Recommendations and guidance for the teaching of future candidates

Students should:

- ensure they know where Section B begins and choose the best questions for which they have been prepared; only do two questions in Section B and declare what they are on the front cover sheet. If they attempt others, they must be crossed out before submitting the paper.
- use the number of lines and the marks as a guide to the expected length of the answer. Longer answers do not necessarily mean more marks – and may allow a candidate to contradict an earlier answer hence losing marks already gained.
- learn what is expected of them from each command term.
- learn definitions carefully and accurately.
- set out calculations carefully and neatly in order to gain part marks. Examiners are not mind-readers! Even though struggling with a calculation, candidates should keep going as ECF marks are awarded.
- learn (and understand!) curly arrow diagrams, paying particular attention to the origin and destination of curly arrows and the charge in any intermediate.
- not write sideways – examiners cannot turn their computers on their side to mark your work.
- draw diagrams neatly and carefully, labelling them clearly and in appropriate detail.
- be encouraged to explain chemical phenomena using proper scientific terminology. It is one thing to understand a concept in general and quite another to be able to explain or describe the concept scientifically.
- 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.

- be provided copies of past examination papers and discuss strategies to approach questions successfully. Help them to “see through” the context, identify the relevant information and identify what the question is asking.
- and finally… study this report and previous reports as part of their examination preparation.

Standard level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 7	8 - 14	15 - 19	20 - 24	25 - 30	31 - 35	36 - 50

General comments

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

The topics that presented most difficulties:

- Calculation and evaluation of experimental results: students had difficulties with the calculation of the molar mass and enthalpy of combustion, calculating percent error of measurements, and comparing and explaining discrepancies between experimental and theoretical values.
- Explanations: students have a tendency to state facts quite well, like periodic trends, but do poorly when explanations are required.
- Conductivity of Na and NaCl produced surprisingly weak answers.
- Electrolysis, there was very weak understanding of the concept of electrolysis, diagrams were very poorly drawn and in many cases voltaic cells were drawn instead of electrolytic cells.
- The oxidation of a secondary alcohol.
- VSEPR explanations of molecular shape.
- Polarity of bonds and molecules.
- Application of Lewis acid/base definitions to real examples.
- Link between rate and the deduction of S_N1 and S_N2 mechanisms.
- Reaction mechanisms.

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

Students seemed well prepared for:

- Atomic structure.
- Lewis structure.
- Periodic trends.
- Definition of redox.

- Energy cycle calculations.
- Equilibrium and Kc.
- Drawing isomers and in writing equations for substitution reactions.

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

Question 1

(a) Many students lost easy marks as they forgot to propagate uncertainties.

(b) Many candidates struggled with the concept of mole and the dilution factor added to the difficulty.

(c) Most students determined the empirical formula correctly.

(d) Weak and strong acids were generally correctly defined, though sometimes they were defined in terms of pH.

(e) The conductivity test appeared frequently and was well described. Many candidates used a strong based, but then went on to describe a titration method.

Question 2

(a) The trend of atomic radii was described well, but many candidates explained the increased attraction between nucleus and electrons with increasing amount of electrons instead of protons. Very few mentioned that electrons are being added to the same level.

(b) Many thought that the ionic radius in the data booklet was for P^{3+}. Others suggested that the P^{3+} radius would be smaller, but did not specify what it would be smaller than. Many thought that fewer outer electrons in the outer shell mean weaker attraction from the nucleus.

Question 3

(a) Very poorly answered. The state of matter received most marks, conducting particles seldom correct and reaction occurring generally misunderstood by candidates.

(b) Diagrams were very poorly drawn, many without power supplies and the wires within the electrolyte. The electrodes were often mis-signed as Na and/or Cl. Many candidates seem to confuse voltaic cells with electrolytic cells.

(c) Generally clear answers, related to extraction and purification of metals.

Question 4

(a) Oxidation was generally correctly defined.

(b) Many candidates calculated correctly the change in oxidation numbers, though often 2+ instead of +2 (or II) was given for the oxidation state of Mn^{2+}.

(c) Marks were lost because candidates did not name the species but the elements or gave incorrect formula of $(COOH)_2$ or forgot the sign on MnO_4^-.

Question 5

(a) Most candidates gave the correct name, though often but-2-anol was given.

(b) The question was fairly well answered, though a common error was drawing butan-2-ol in different layouts.

(c) Almost universally unsuccessful. Most students did not follow the instructions and did not use [O] for the oxidizing agent, and the few who did, did not give water as the other product.

Question 6

(a) (i) Few candidates defined isotopes in terms of atoms; (ii) The percentage abundance was generally done well.

(b) (i) The stages of the mass spectrometer were generally correctly identified; (ii) Protons and neutrons were well answered but the electron arrangement often was given for the atom; (iii) Candidates generally did know that 1/12th of ^{12}C is the scale for masses.

(c) (i) The Lewis structure of NH_3 was well answered, though many forgot the non-bonding electron pairs of fluorine; (ii) The covalent bond was often just described as electron sharing between non-metals; (iii) Shapes of molecules and angles were often well known, but the explanation using the VSEPR theory was very weak, with many students not being able to describe the bonding and lone pairs in terms of negative charge centres; (iv) Polarity was very poorly understood, with almost no candidates actually talking about polarity of bonds or showing an understanding of the impact of symmetry on the overall dipole moment.

(d) (i) There was some confusion between the Bronsted-Lowry and the Lewis theories of acids. Many missed out than an electron pair is involved; (ii) A significant number of candidates answered that NH3 is a base and BF3 and acid, but could not explain it.

Question 7

(a) (i) Many candidates used the mass of methanol in their calculation and most did not convert the mass of methanol to moles; (ii) Students did not make a comparison between their calculated value and the theoretical value, often just stating the numbers. Most candidates were aware that heat was lost but improvements were generally simplistic.

(b) The energy cycle was fairly well done, though working out could be shown better.

(c) (i) Many students had no problem with the characteristics of a chemical equilibrium; (ii) The expression for Kc was done quite well; (iii) Most candidates referred to the Haber process.

(d) The effect of changes on the equilibrium position was answered quite well, though candidates had difficulty in explaining the rationale, omitting often gas molecules (ii) and increasing equally in (iii).

Question 8

Very few candidates chose this option, but those who did, did well in part (a) and very poorly in part (b)

(a) (i) Students had surprisingly difficulties to name the features of a homologous series. Common mistakes were to say SAME chemical or physical properties or same empirical/molecular/structural formula; (ii) Most candidates did well describing the test to distinguish alkanes and alkenes; (iii) The formation of dibromobutane was a common error.

(b) (i) The equation for the reaction of the C_4H_9Br with NaOH presented no problem; (ii) Some did not realize that pH decreases as NaOH is reacting, often referring as the pH would become more neutral.

(c) (i) Candidates could deduce that the concentration of NaOH does not affect the rate, but could not accurately explain and quantify the relationship between the concentration of C_4H_9Br and the rate of reaction. Time and rate were often confused; (ii) This was well answered; (iii) Very few candidates could relate rate information to deduce that C_4H_9Br was tertiary; (iv) The structural formula was generally gained by ECF; (v) Students did not have problems with the equation.

(d) Mechanism with curly arrows was done very poorly, students confused S_N1 and S_N2 mechanisms, drew arrows that did not show clearly origin and end or did not draw any arrow at all.

Recommendations and guidance for the teaching of future Candidates

- Students should have more care with language, especially in definitions where they should be aware of key words.
- The importance of clear well-laid out work should be stressed, especially in calculations to be able to obtain ECF. Also attention should be paid to clear, realistic diagrams.
- The importance of reading questions should be stressed.
- Students should have more guidance on how to evaluate experimental information.
- Students should study electrochemistry at greater depth. They should know the difference between electrolytic and electrochemical cells. They should be able to predict the products of the electrolysis of solutions and understand why they are produced.
- Organic chemistry should be given with greater depth and a link between rate and reaction mechanism should be made.
- Students should become more acquainted with reaction mechanisms.

Higher level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 6	7 - 13	14 - 16	17 - 22	23 - 28	29 - 34	35 - 50

General comments

The following are some statistical data based on 49 respondents:

Comparison with last year's paper

Much easier	A little easier	Of a similar standard	A little more difficult	Much more difficult
0.0%	6.5%	65.2%	23.9%	2.2%

Level of difficulty

Too easy	Appropriate	Too difficult
0.0%	91.7%	8.3%

Suitability of question paper in terms of

	Poor	Satisfactory	Good
Clarity of wording	0.0%	52.1%	47.9%
Presentation of paper	0.0%	43.7%	56.3%

Based on the G2 comments teachers in general found this to be a fair paper. One teacher did state that all topics should be assessed in each option. This is not the intention of the design of the paper and candidates may be assessed on any of the topics contained in the options themselves. Sometimes questions based on the options may assess a number of sub-topics or alternatively perhaps one or two sub-topics might be focused on entirely. Candidates should be prepared for all sub-topics.

The general consensus amongst examiners this year was that candidate performance certainly appeared weaker than in previous years. Several examiners noted the fact that they got a strong impression that some students appeared as if they had studied for the options perhaps in isolation and hence as a result often gave poorly constructed answers, which strayed from what was asked. A sizeable number of very poor scripts were observed. The paper appeared balanced overall and the options looked of equal difficulty, with a good smattering of easy marks in each option. However there were a number of equally challenging sub-questions in each option, and the paper certainly tried to bring out more of the chemical principles in Options B, D and F rather than biological concepts as has been the case oftentimes in the past. This may have been a challenge for the weaker students.

Some teachers also stated in the G2's that they particularly liked the fact that in Options D and E on the paper there was more of an emphasis on the chemistry compared to previous sessions for these two particular options and less of an emphasis on rote-learning and memory work.

On the plus side, Option G was done quite well and there was a marked improvement on organic reactions and reaction mechanisms in general this session. There also was a noticeable shift towards Option F, the option on Food Chemistry which was the third most popular option on the paper with several candidates choosing to answer this. Lesser students attempted Option E on Environmental Chemistry in May 2013 than in the past.

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

- Mass spectrometry.
- Column chromatography and GLC.
- Structures of alpha and beta glucose.
- Environmental concerns associated with the production of aluminium.
- Mode of action of a heterogeneous catalyst.
- Intermolecular forces in general.
- Core chemical principles underpinning many applied topics.
- IR and fuel cell for the detection of ethanol in an intoximeter.
- Basic representation of a dipole moment and difference between bond polarity and molecular polarity.
- Explanation why cisplatin is more effective than transplatin in the treatment of cancer.
- Molecular polarity of a drug and examples of how it can control efficiency.
- Comprehensive answers relating to environmental concerns pertaining to global warming and ozone depletion.
- Mechanism of the formation of nitric(V) acid from nitrogen monoxide.
- Writing K_{sp} expressions.
- Function of t-butyl group in antioxidants.
- Explanation why the properties of pigments in live lobster shells result in colour variation and why the colour of astaxanthin changes when cooked.

- Deducing whether an enantiomer is R or S.
- Auto-oxidation and rancidity.
- Explanation why the relative rate of hydrolysis of (bromomethyl) benzene is faster than bromobenzene.

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

- Electromagnetic spectrum.
- Visible spectroscopy.
- Inhibitors.
- Structures of monomers.
- Explanation why diamorphine (heroin) is more potent compared to morphine.
- Description of the dependence of ozone and oxygen dissociation on the wavelength of radiation absorbed and explanation of how this relates to bonding.
- Recycled solid waste.
- Difference in solubility between a dye and a pigment.
- Chemical structure of benzene.
- Organic chemistry reactions in general.
- Organic reaction mechanisms in general.
- Organic reaction pathways.

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

Option A – Modern analytical chemistry

This was the third least popular option on the paper, but in general attracted some of the stronger candidates. Performance however on this option was quite mixed and it was surprising that mass spectrometry was done so poorly in Option A, even by the better candidates. One respondent in a G2 welcomed the return of greater emphasis on spectroscopic analysis in Option A.

Question 1

Most candidates were able to draw the two structures in part (a). In part (b), the majority of candidates stated that both the aldehyde and the ketone contained the carbonyl group. The most common mistake was stating that both have the same functional group, which scored no marks. In part (c), candidates were asked to explain how the mass spectra of the two respective structures could be used to distinguish between them. However, this was by far one of the poorest answered questions on the entire paper, and virtually no candidate other than a few top-tier students managed to score both marks. The lack of understanding of mass spectrometry this session was particularly disappointing. In (d), the most common mistake was candidates omitting the + sign.

Question 2

In part (a) on column chromatography few candidates scored all three marks, but most managed to score at least one mark. Very few stated that components are actually adsorbed on the stationary phase. In part (b), which related to GLC, again few scored full marks. Many knew that the mobile phase involves an inert gas but it was disappointing that more comprehensive descriptions of the stationary phase were not described e.g. long-chain alkane adsorbed on silica. In contrast part (c) was well answered with most candidates stating that GLC cannot be used to separate a mixture of sugars since they decompose at high temperatures.

Question 3

This question on ^{1}H NMR was well done with many candidates picking up all three marks.

Question 4

Part (a) posed no problem for candidates, with the majority getting both marks. In (b), answers were varied but usually at least one mark was obtained.

Question 5

All three parts of this question were generally well answered, though a few candidates gave an answer of 0.62 ppm in part (c) which did not score as it was outside the allowed range of acceptable answers, namely 0.63 to 0.65 ppm with the majority giving the answer of 0.64 ppm.

Option B – Human biochemistry

This was one of the most popular questions on the paper and generally performance was strong on this option. This option was well-received by teachers based on the G2 comments.

Question 1

In (a) (i) candidates were asked to deduce the structural formulas of two dipeptides. This question proved to be a good discriminator in terms of candidate performance. The question posed no difficulty for the stronger cohort. However, many of the average candidates and especially the weaker candidates made several mistakes here in their representations of structures. Typical mistakes included incorrect peptide links, missing hydrogens and incorrect bonding arrangements e.g. NH_2C. There was a large number of the latter type of mistake seen on papers this session and this is an area that should be highlighted perhaps to a greater extent by teachers in preparing candidates for examinations as a simple mark can be dropped for this type of error in a structure. In contrast nearly all candidates knew that the other product of the reaction was water. In part (b), candidates were asked to explain how amino acids can be analyzed using electrophoresis, which is a question that has been asked a myriad of times in the past in this option. Surprisingly, marks were still dropped and few scored all four marks, though usually candidates scored at least one, with two out of four being the typical score. In (c), although accepted, general answers such as structural were common. It would have been better if more precise answers were given e.g. specific functions. Some candidates also wrote simply storage instead of storage of molecules / *O*WTTE. Storage alone was not deemed sufficient.

Question 2

The structural features of monosaccharides were very poorly understood and all sorts of vague answers were frequently given. In (b) (i), incorrect bonding arrangements were widespread e.g. hydrogen bonded to carbon in the CH_2OH to C link. In (ii), usually if candidates got the alpha and beta structures correct in (i), then they generally got the correct structure for maltose subsequently.

Question 3

The fat-soluble nature of both vitamin A and vitamin D caught out a large number of candidates. In addition even when candidates stated correctly that both vitamins were fat-soluble many went on to discuss the solubility in terms of alluding to the one OH group and failed to comment on the main reason i.e. the fact that both contain mainly hydrocarbon parts. Rickets however was well known.

Question 4

In part (a), many candidates managed to score both marks, and most stated that enzymes are proteins, which scored at least one mark. In (ii), the better candidates scored two marks. However, many candidates gave quite general answers which lacked depth. One respondent in a G2 comment expressed the desire to see an expanded mark scheme incorporating several answers for part (a). This was certainly taking into account in the mark scheme and the subsequent applied marking during the session itself. In (b), (i) and (ii) were well answered though for the non-competitive inhibitors some did not state explicitly that they change the shape of the active site so the substrate no longer fits, in addition to stating that they bind to the enzyme but not at the active site. In (iii), the better candidates scored full marks, though many scored at least one mark, usually for getting the two V_{max} correct.

Option C – Chemistry in industry and technology

This was the least popular option on the paper and very few candidates attempted it. However of those that did attempt this option they appeared to have a solid grasp of the subject matter tested.

Question 1

(a) was well done. In (b), few scored both marks.

Question 2

In (a), most candidates were able to identify chlorine, hydrogen and sodium hydroxide and many gave correct uses for all three substances also. In contrast the correct equation for the reaction occurring at the mercury electrode was only seen on a few papers.

Question 3

Parts (a) and (b) were answered correctly by most candidates. (c) was the most problematic and (d) was usually answered correctly.

Question 4

(a) and (b) posed no problems. In (c) very few gave complete answers for the distinction between thermotropic and lyotropic liquid crystals though many had some idea of differences relating to temperature and concentration ranges.

Question 5

In (a) (i), few mentioned methyl groups. In (ii), although the idea of closer packing of isotactic chains was often stated, the associated idea of isotactic having stronger dispersion forces was not seen in general. In (b), the structures of the monomers that form PET were usually correctly represented, even by the weaker students. However, intermolecular forces again were the downfall of most candidates in the answers that they provided in part (iii). Many of course did not even get PET correct, thereby also missing out on M2 and M3.

Option D – Medicines and drugs

This was the second most popular option after Option B. Performance did vary quite a bit. The stronger candidates did very well on this option but it was very disappointing at the lack of chemistry conveyed by the weaker candidates. The emphasis here must be on applying core chemical concepts to the associated applied topics on medicines and drugs embedded within this option and candidates should not simply depend on biological principles and general information related to medicines and drugs in order to perform at an acceptable academic level on this option in a chemistry paper.

Question 1

In part (a) candidates were asked to state one effect of a depressant at moderate dosage and one effect of a depressant at high dosage, which was a very easy one mark at the beginning of the option. Most managed to score this. In part (b), the emphasis was on the breathalyzer. However, the weak understanding conveyed by many candidates of core chemical concepts here was very telling. Few could write the correct chemical formula for potassium dichromate(VI) in (i). Although many knew the colour change from orange to green, some stated the reverse, some wrote just green and others gave different colours such as colourless to purple. In part (iii), few could state the correct oxidation number of chromium in the product. Answers such as II, +2 were often incorrectly cited. Another common mistake involved giving the answer as 3+, which is charge. In (iv), the top students managed to deduce the full balanced chemical equation for the redox reaction of ethanol with acidified potassium dichromate(VI). However most struggled with the products and all sorts of incorrect compounds were mentioned in several scripts, such as alkanes, organometallic compounds and haloalkanes! The better students were able to state ethanoic acid in part (v). (c) proved to be one of the questions most poorly answered in the entire paper. Reference to the fuel cell was rarely seen and only some candidates managed to give IR. Even when IR was identified as an appropriate technique, again few referred to the CH characteristic band for ethanol. In general it was highly disappointing that candidate's knowledge of the breathalyzer from a chemical perspective was so weak this session.

Question 2

In part (a) candidates were asked to list two physiological effects of stimulants, again what in essence should be an easy entry-level mark. However, many students instead gave the effects of depressants and some could name only one effect. In (b) (i), candidates struggled with the structure of the phenyl group. In (ii) however, amphetamine was usually correctly stated.

Question 3

In (a) (i), most candidates knew that both isomers involved a square planar geometry, though the weaker students stated incorrectly that the stereochemistry was tetrahedral. In (ii), most candidates knew the correct structures of both cisplatin and transplatin, but the number of candidates that drew incorrect NH3Pt bonds (with H bonded to Pt instead of N) was surprising, which is an aspect previously mentioned in this report. The two angles of 90 and 180 degrees were usually correctly identified in (iii). In (iv), the top students stated that cisplatin is polar and often gave a vectorial type representation of the resultant dipole moment which was possibly the best way to answer the question diagrammatically. This type of representation can be very useful and could be encouraged in the teaching programme. Most students mixed up bond and molecular polarity. (v) proved to be a highly discriminatory question in this Option. The top students stated that the reason why cisplatin is more effective in the treatment of cancer than transplatin relates to the fact that in its binding to DNA/guanine, the chlorines need to be on the same side of the complex. The lead-in questions on shape should have helped students grasp this idea. In contrast (b) was very well answered by nearly all students and several got all three marks. However (c) was poorly answered though most managed to score at least one of the four assigned marks.

Option E – Environmental chemistry

Fewer students attempted this option this session compared to previous sessions, and it appeared that a much greater number opted for Option F over Option E. As has often been the case in the past, many weaker students tend to opt for this option, but often do poorly giving more journalistic type answers and similar to Option D, often ignoring core chemical principles underpinning the applied topics.

Question 1

In (a), few candidates gave a specific CFC compound as an example of a gas that is both a greenhouse gas and a cause of ozone pollution. The most common incorrect answer given was carbon dioxide. In (b), vague answers were common e.g. stating that using the car less should be one way to reduce the impact of global warming, did not score and candidates typically did not give comprehensive answers. (c) was well answered however.

Question 2

In (a), few candidates scored full marks. Again precise answers stating that incineration produces HCl/dioxins while landfills do not for example was required. Some candidates did not adhere to the command term used in the question i.e. compare. In (b), nearly all candidates scored full marks.

Question 3

Part (a) was usually well done. In (b), although some managed to give the correct equation, some forgot to balance it and many were not able to state that the equation involved a redox process. The most common error involved stating that the process was a combustion reaction. (c) was very poorly answered.

Question 4

It was very surprising in (a) at the number of candidates who simply could not write a correct K_{sp} expression for lead sulfate. Only the stronger candidates got (b) and subsequently (c) correct.

Option F – Food chemistry

It was particularly encouraging this session to see the large take-up for Option F, which is an option that has developed considerably in the cycle of the programme amongst teachers. This is to be welcomed. The option was particularly popular and in fact was the third most popular option on the paper after Options B and Option D. The performance of candidates did vary however.

A number of G2 comments did feel however that some of the questions were quite challenging. Although some parts were quite challenging all questions were deemed to be firmly based on the defined syllabus for this option and the difficulty may lie in the fact that a number of the questions may not have been asked previously in this option.

Question 1

Most candidates were able to define an antioxidant as a substance that delays the onset of oxidation though some incorrectly stated that antioxidants prevent oxidation. In (b) surprisingly few could identify selenium as an example of a common naturally occurring antioxidant and usually if they could, went on to cite shellfish as one food type in which the antioxidant can occur in. In (c), only the better candidates deduced that all four antioxidants contain the phenol group though most claimed that THBP does not contain the t-butyl group. Again very surprisingly virtually no student could suggest the function of the t-butyl group, namely quoting its free radical scavenging property in (c) (iii). As stated before it is critical in the programme that chemical aspects pertaining to applied topics are carefully understood i.e. candidates should not just be able to identify such a group but surely should question its function in the context of antioxidants.

Question 2

In (a), most understood the difference in solubility between a dye and a pigment but some forgot to mention water solubility. Others simply did not read the question and ignored solubility. In (b), although the majority could identify the class of pigment to which astaxanthin belongs, adequate explanations of the colour variations associated with a lobster were not given in parts (ii) and (iii).

Question 3

RCH=NR’ was usually given in part (a)(i), though in many cases a C-N bond was given, instead of C=N, and often R was stated for R’. Water was usually cited as the other product of the reaction in part (ii). Although there are a number of different types of reactions involved in the other two steps of the Maillard reaction, many candidates struggled in naming one correct type.

Question 4

This was a question which often showed lack of core chemistry conveyed in answers and correct use of chemical terminology amongst candidates. In part (a), some gave the correct chiral centre but many incorrectly gave the C in C=C as the chiral carbon. In (b), absolute configuration was rarely seen and plane of polarized light often was incorrectly expressed. One respondent in a G2 suggested that it would have been better if in part (c), candidates were asked to explain the method of how priorities are assigned instead of having to explain the answer, which is a valid comment and will certainly be considered in future examination paper-setting for this type of question. (c) typically tended to be a case of hit or miss with many failing to mention priority groups, even if they got R correct. Only a tiny minority of the better candidates got (d) correct. (e) also proved problematic with sweet and sour the most frequent incorrect answer seen.

Question 5

In (a), many scored M1 for the RH going to the R• and H• radicals, but the other equations often were either incorrectly given or not given at all. In (b) few stated that the O-O bond breaks easily and incorrect functional groups were often given.

Option G – Further organic chemistry

This was the second least popular option on the paper. However, performance here was often very strong and the standard of organic chemistry was much higher than in previous sessions for this time zone which is a welcome development. Very few weak scripts were seen on this option and even though many candidates tend to find this a difficult option, if well prepared, candidates can do quite well here. Certainly this session, organic mechanisms were done very well overall.

Question 1

In (a), most scored at least two out of three marks. In (b), the majority of candidates stated that (bromomethyl) benzene reacts faster with hydroxide, but only the better candidates could then progress with adequate explanations.

Question 2

All three parts were very well answered.

Question 3

In (a), the mechanism usually was well done by the better candidates. Some of the weaker students had curly arrows going from H^+ to oxygen, and the + charge on the oxygen intermediate often was omitted. The weaker candidates also struggled in stating that side-products occur using sulfuric acid over phosphoric acid in (b).

Question 4

In (a), again the mechanism was very well answered. Nearly all got (b) (i) correct, but very few got full marks in part (iii). Few stated that if the electrophile attaches at the 3-position then positive charge cannot be localized on the carbon bonded directly to the methyl group / OWTTE. (c) was very well answered.

Recommendations and guidance for the teaching of future candidates

- Options should be taught in class and are an integral part of the teaching programme. It is critical that the recommended time is devoted to cover the two options thoroughly and in depth. Certainly this session there was clear evidence that some subject areas were not covered by some schools. Students who are left to learn material independently can struggle with the options.
- It is critical that core chemical principles are brought to the fore in the Options, especially those which have often a twin biological focus e.g. Options B, D and F. In addition core chemistry should always underpin applied topics.
- Candidates should not use extra continuation sheets.
- Candidates need to fully understand the various command terms and should always look at the associated marks allocations in questions.
- Candidates should prepare for the examination by practising past examination questions and carefully studying the markschemes provided.
- Candidates should be fully au-fait with formal definitions and organic reaction mechanisms.
- Greater care needs to be made in drawing chemical structures. This session there was a very large number of candidates who either omitted hydrogens or gave incorrect bonding arrangements.
- Candidates should practise writing balanced chemical equations.

Standard level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 5	6 - 10	11 - 15	16 - 18	19 - 22	23 - 25	26 - 40

General comments

Many candidates demonstrated a good understanding of concepts and provided detailed answers with correct use of terminology. However, there was also a large proportion of papers of very poor quality indicating that these candidates were not properly prepared for the paper. The options are meant to be covered in detail during instruction time (15 teaching hours for each option besides the time spent on related lab activities as part of the internal assessment component). The options provide an opportunity to apply the concepts covered in the Core programme in a variety of situations. A good level of depth and a focus on chemical aspects are expected in the teaching of the options.

Option D was the most popular option among SL candidates this session, followed by options B, E and F. The least popular option was C. There were several straight-forward marks to be gained in each option and a handful of marks that discriminated at the top end. Candidates generally scored better on Options B and D. Option F was perhaps the most challenging followed by Option E. The questions focused on the chemical applications in these options, and answers of a general nature were not able to satisfy the requirements of the markscheme.

In terms of skills, a high proportion of candidates could name functional groups correctly and were careful to connect bonds to the correct atoms when drawing structures. The answers were focused on answering the question asked, and candidates did attempt to provide explanations when requested.

However, it was disappointing to see unbalanced chemical equations appearing in the scripts. It was pleasing to see a good knowledge of organic reactions and a marked improvement on previous sessions in explaining organic mechanisms from candidates who answered Option G.

Feedback from teachers through G2 forms showed that 90% of teachers found the level of difficulty appropriate and 9% found it too difficult. 62% judged the paper as of similar standard to the May 2012 paper, with the rest divided equally between judging it easier and more difficult than last year's paper. Feedback on the clarity of the wording and the presentation of the paper was generally positive. The number of G2 forms received this session was 91. Teachers are encouraged to continue to provide feedback that is carefully considered during the Grade Awarding.

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

- Mass Spectrometry
- Column chromatography
- Structures of alpha and beta glucose
- Structure of a disaccharide
- Environmental concerns associated with the production of aluminium
- Cracking
- Mode of action of a heterogeneous catalyst
- Redox equations
- IR and fuel cell for the detection of ethanol in an intoximeter
- Sources of water pollutants
- The catalytic converter
- Pigments in food
- The Maillard reaction
- Rate of hydrolysis of halogenated arenes
- Mechanism for the elimination of water from alcohols

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

- Infrared spectroscopy
- NMR spectroscopy
- The Electromagnetic spectrum
- Functions of proteins
- Factors involved in choosing a catalyst
- Action of analgesics
- Identification of functional groups
- Effects of drugs
- Impact of global warming
- Effects of acid deposition
- Waste disposal

- Shelf life
- Structure of benzene
- Identifying products of organic reactions

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

Option A – Modern analytical chemistry

Question A1

The majority of candidates was able to identify the two structures in (a) and recognized that IR spectroscopy could not distinguish them easily because they contained the same types of bonds in (b). Answers to part (c) were often general and did not meet the requirements. Only few candidates predicted the peaks in the mass spectrum that could be used to distinguish the two compounds. Part (d)(i) and (ii) were answered well by about half the candidates. However, some candidates are still forgetting to include a positive charge for fragments detected in the mass spectrometer.

Question A2

The explanations offered by candidates of how components of a mixture are separated in column chromatography in part (a) were mostly disappointing. Most candidates only managed to score one mark for stating that components took different amounts of time to emerge from the column. There was a lack of understanding of the roles of the stationary and mobile phases. Part (b) was answered well by many candidates stating that column chromatography could separate larger quantities than thin-layer chromatography, or that it allowed for easier collection of the components for later use.

Question A3

This was a well-answered question generally. In part (a) most candidates recognized the area under the peak as the indicator of the number of hydrogen atoms in NMR spectroscopy, although few candidates thought it was the chemical shift, and few candidates incorrectly stated that it was the height of the peak (rather than the area underneath it). The majority of candidates chose the correct molecule (pentan-2-one) in part (b) and gave the correct ranges of IR absorptions in part (c).

Question A4

Part (a) was well answered by the majority of candidates displaying good knowledge of the electromagnetic spectrum and the effects of different types of radiation on molecules. Part (b) was successful at discriminating among candidates. Half the candidates read it carefully and attempted to compare the appearance of absorption and emission spectra, some of them gaining full marks. The other half did not focus on what the question required and failed to gain any marks.

Option B – Human biochemistry

Question B1

Part (a) was generally well answered. There were instances of careless mistakes where the side-chain of the amino acid was incorrectly copied or connected, and some instances where peptide links were incorrectly represented as COHN resulting in the loss of one mark. However, there were many cases where candidates had totally incorrect links between the amino acids in the dipeptide, and some scripts did not even attempt to connect the two amino acids.

In part (b), all candidates were reasonably familiar with describing electrophoresis and some of them tried to explain how electrophoresis separated amino acids, but most candidates did not show a thorough understanding of the technique and only scored partial marks out of the 4 marks allocated. Most candidates did not clarify that amino acids moved at different rates through the gel depending on their charge (at the buffer's pH), or the relation between isoelectric point, buffer pH and charge on amino acid.

The majority of candidates stated two correct functions of proteins in part (c). Energy storage was not accepted, and transport needed mention of molecules.

Question B2

Only some of the candidates described a monosaccharide correctly in part (a) although its features are given in the programme guide. Drawing alpha and beta glucose was also a discriminating question. About a third of candidates were able to score full marks on part (b)(i). Similarly, drawing maltose in part (d)(ii) was a challenge for the majority of candidates. Many had missing hydrogen atoms or an incorrect orientation of bonds around the linkage. In part (c) the majority of candidates correctly described dietary fibre, and many candidates were able to state three correct reasons for its importance in the diet (also given in the programme guide).

Question B3

The majority of candidates identified the solubility of both vitamins correctly in part (a). The explanation was correctly scored by only half of the candidates, while the rest talked about the OH group and did not discuss the main part of the molecule. The majority of candidates answered part (b) correctly that vitamin D prevented rickets.

Option C - Chemistry in industry and technology

Question C1

The answers given for the environmental concerns about aluminium production focused on mining and CO_2 as a greenhouse gas. Most candidates only scored one mark on part (a). Most candidates did not gain the mark for alloys in part (b) because they did not state that the mixture was homogeneous which was needed for the mark. The majority of candidates knew that alloying aluminium increased its strength in part (c), while only about half of the candidates chose two properties of aluminium that were relevant for its use in food containers in part (d).

Question C2

Less than half of the candidates knew the uses of the products of cracking in (a) and very few candidates knew the product of steam cracking in (b). The mode of action of heterogeneous catalysts was also not well answered. The majority of candidates wrote about catalysts in general gaining no marks on part (c). Parts (d) and (e) about the advantage of heterogeneous catalysts over homogeneous catalysts, and factors to be considered when selecting a catalyst were well answered by the majority of candidates.

Question C3

The majority of candidates recognized polarity as the property of liquid crystals in part (a) and were able to give two substances that could act as liquid crystals in part (b). Many candidates knew that thermotropic liquid crystals worked within a temperature range and lyotropic liquid crystals work within a concentration range in part (c), but only few candidates distinguished between the two types fully.

Question C4

The orientations of methyl groups in isotactic and atactic poly(propene) were known by more than half of the candidates, but the explanations of the properties did not involve intermolecular forces for the majority of candidates.

Option D – Medicines and drugs

Question D1

The mode of action of mild and strong analgesics in part (a) was well known by most candidates; however, the terminology used was sometimes inaccurate and reflected confusion. For example, some candidates talked about intercepting pain receptors on site of injury for mild analgesics. The majority of candidates stated correct advantages and disadvantages of paracetamol over aspirin in part (b). Some answers did not highlight that it was an *overdose* of paracetamol that caused kidney/liver/brain damage. Part (c) was well answered by the majority of candidates (increased risk of stomach bleeding when alcohol is consumed with aspirin), and two-thirds of the candidates identified the functional groups correctly in part (d). A common mistake was using the term *esther* which was not clear whether it was meant to indicate *ether* or *ester*.

Question D2

The effects of depressants were answered well in part (a), however, few candidates used everyday language instead of chemical terms in this part.

Only about half the candidates gave the correct formula for potassium dichromate(VI) in part (b)(i), but most candidates knew the colour change in (b)(ii). The oxidation number was often given using incorrect notation (3+ or 3) failing to score the mark in (b)(iii). The redox equation was challenge except for the strongest candidates. About half the candidates gave the correct product for the oxidation of ethanol in (b)(v).

Part (c) was poorly answered. About half of the candidates scored one mark for recognizing that the intoximeter used IR radiation. Few candidates gained a second mark for recognizing that the absorption by C-H bonds is used to determine ethanol concentration. It was rare to see an answer mentioning the area under the peak or using the fuel cell in the intoximeter.

Question D3

The effect of stimulants were generally well answered in part (a), although some candidates focused on effects caused by specific stimulants rather than general ones. In part (b) many candidates gave benzene for the structure of the phenyl group and others had no idea. Only the strongest candidates gained this mark. The majority of candidates gave amphetamine as containing a primary amine.

Option E – Environmental chemistry

Question E1

Few candidates gave a CFC compound in part (a). Candidates were more familiar with the impact of global warming than they were with the impact of ozone depletion. Answers were often too general on part (b) and most candidates only scored one or two marks on this part. Some candidates gave wrong suggestions such as using a lean burn engine to reduce CO_2 emissions.

Question E2

Strong candidates gave correct sources for the water pollutants in part (a), but the majority of candidates only scored one mark for the source of nitrates. Only few candidates knew how nitrates were removed from waste water in part (b). Also many of these incorrectly stated that it was nitrogen-fixing bacteria, or that it occurred under aerobic conditions. The advantage of the biological process was mostly incorrectly given as no harmful products.

Question E3

Most candidates gave specific detail in their answer to the effects of acid deposition gaining partial marks, and about a third of the candidates gained full marks on part (a). The equation for the catalytic converter was only known by a third of the candidates and a surprising minority recognized it as a redox reaction. Many candidates gave an unbalanced equation in this part.

Question E4

Many candidates gained two or three marks on comparing landfills and incineration as methods of waste disposal. Comments about cost did not gain any marks. Some candidates focused on greenhouse gas emissions as a disadvantage of incineration, which was incorrect, as landfills also release greenhouse gases (CO_2 and CH_4). Only few candidates mentioned that methane from landfills and heat produced by incineration could be used for energy production. An important issue that was highlighted by this question was that many candidates did not deal correctly with the command term *compare*.

Option F – Food Chemistry

Question F1

Shelf life (part (a)) and factors affecting it (part (b)) were generally well understood. Many candidates missed the command term used in part (c) and failed to *describe* the rancid food. In part (d) only some candidates gave selenium as the antioxidant. Many did not notice that the question asked for an element. The sources of selenium were well known. Some candidates lost the mark in (d) (i) for stating that antioxidants *prevented* rather than *slowed down* oxidation. In part (e) (i) only some candidates noticed that all four compounds contained phenol. Many candidates correctly stated that THBP did not contain a t-butyl group in (e) (ii), but very few knew the function of the t-butyl group in (e) (iii).

Question F2

The solubility of dyes and pigments was only known by half the candidates in part (a). Most candidates knew that astaxanthin was a carotenoid, but it was rare that a candidate recognized the role of the complex with the protein in altering the colour in part (b) (although it is explained in the programme guide). This was one of the most discriminating questions in the paper.

Question F3

Many candidates deduced the structure of the product and that water was the by-product of the condensation reaction. However, very few candidates could identify the type of reaction in part (b).

Option G – Further organic chemistry

Question G1

Part (a) on the structure of benzene was well answered by the majority of candidates. A few candidates did not pay attention to the mark allocation and were too brief in their answers. Part (b) was also very well answered except for candidates who provided physical rather than chemical evidence for the structure of benzene. Part (c) on the relative rates of nucleophilic substitution of bromobenzene and (bromomethyl) benzene was a discriminating question that was only well answered by the strong candidates.

Question G2

This question was very well answered in all of its parts, reflecting a strong background of students who did option G this session.

Question G3

In part (a) the mechanism was well answered by stronger candidates. The curly arrows were often drawn accurately and lone pairs shown. The weaker candidates collected partial marks for the mechanism as they missed part of the required details. About half the candidates recognized that sulphuric acid would cause side-products to be formed in part (b). The most common incorrect answer for part (b) was that phosphoric acid had one more proton than sulphuric acid.

Question G4

The majority of the candidates recognized that chloroethanoic acid was more acidic than ethanoic acid, but only some gave a detailed enough reason to gain the second mark.

Recommendations and guidance for the teaching of future candidates

Pay attention to command terms. In particular, the command term compare requires mention of both items being compared for each point.

Correct notation must be used for oxidation numbers. For example, the oxidation number of chromium in Cr^{3+} should be stated as +3 or III. It is not acceptable to state it as 3+ or 3.

Candidates should give specific details and avoid general answers. For example, specify the relevant type of intermolecular forces. Another example, it is not enough to suggest that use of CFCs should be reduced as a way to reduce the impact of ozone depletion. The students should mention that alternatives to CFCs should be used for refrigerants and aerosols, preferably providing an example of these alternatives. Similarly it is not enough to state that monosaccharides contain –OH groups. It is better to state that they contain at least two –OH groups.

Advise candidates to use the correct terminology as far as possible. For example a `hydrocarbon chain' rather than 'carbon chain' in Vitamins A and D.

Candidates studying option B should have many opportunities to practice drawing the structures and joining monomers to form the polymers correctly.

Insist on thorough explanations throughout the course. This serves to deepen students' understanding and give them a better chance of meeting all the required points in the markschemes.

Some candidates write 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 have opportunities to consult past examination papers and markschemes in preparation for the examination.