

May 2013 subject reports

## CHEMISTRY TZ2

(IB Africa, Europe & Middle East & IB Asia-Pacific)

Overall grade boundaries

### Higher level

<b>Grade:</b>	1	2	3	4	5	6	7
<b>Mark range:</b>	0 - 17	18 - 32	33 - 45	46 - 56	57 - 67	68 - 77	78 - 100

### Standard level

<b>Grade:</b>	1	2	3	4	5	6	7
<b>Mark range:</b>	0 - 17	18 - 34	35 - 45	46 - 56	57 - 67	68 - 78	79 - 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

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

## Standard level internal assessment

### Component grade boundaries

<b>Grade:</b>	1	2	3	4	5	6	7
<b>Mark range:</b>	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**

<b>Grade:</b>	1	2	3	4	5	6	7
<b>Mark range:</b>	0 - 10	11 - 16	17 - 23	24 - 27	28 - 31	32 - 35	36 - 40

## General comments

This paper consisted of 40 questions on the Subject Specific Core (SSC) and Additional Higher Level (AHL) and was to be completed without a calculator or Data Booklet. Each question had four possible responses with credit awarded for correct answers and *no* credit deducted for incorrect answers. Some candidates did *not* answer every question.

Respondents, in general, commented that this was a fair and well-written paper with good coverage of the syllabus. One respondent thought there to be too many questions on organic; in this paper, many general concepts were tested by referring to organic chemistry.

The following tables present some data from the G2 survey based on 238 respondents (from 791 schools).

### Comparison with last year's paper:

Much easier	A little easier	Similar standard	A little more difficult	Much more difficult
0.0%	4.8 %	79.4%	12.3%	0.9%

### Level of difficulty:

Too easy	Appropriate	Too difficult
0.4%	97.4%	2.1%

### Suitability of the question paper in terms of:

	Poor	Satisfactory	Good
Clarity of wording	1.3%	45.3%	53.4%
Presentation of paper	0.0%	30.7%	69.3%

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

The difficulty index (the percentage of candidates achieving each correct answer) ranged from 96.47% to 24.58% (May 2012 for comparison, 95.74% and 44.03%). The discrimination index, an indication of the extent to which questions discriminated between high- and low-scoring candidates, ranged from 0.64 to 0.08 (May 2012, 0.58 to 0.08), the higher the value, the better the discrimination.

The following comments were made on selected individual questions:

### Question 13

Although 70% of the candidates gave the expected answer, C, there is *minimal* delocalization in ethanoic acid, so both C and D were accepted (giving an 86% success rate on the question).

**Question 18**

Three respondents asked why “most positive” had been used in place of “greatest”. Lattice enthalpy in the IB Data Booklet is given for the endothermic reaction whereas in many data books they are given, with a negative sign, for the reverse reaction. The intention was to prevent misunderstanding.

**Question 20**

The graph in C showed a constant *half-life* and so represented a 1<sup>st</sup> order relationship.

**Question 28**

We acknowledge the error in asking for the  $pK_a$  of ammonia; it should, of course, have been the  $pK_a$  of the ammonium ion. Nevertheless, over 79% of candidates chose the correct key (C) for answer.

**Question 34**

One respondent suggested that both A and B are answers. There is no evidence of the production of hydrogen molecules in this reaction and only A was accepted.

**Question 39**

This was the second most difficult question on the paper, the most popular answer being D. Candidates have clearly misread the question.

**Question 40**

The answer to this question caused much discussion in the G2s and at the Grade Award. We apologize again here for the lack of accuracy. The two possible correct answers, B and D, were accepted and the question will be modified before final publication.

## Standard level paper one

### Component grade boundaries

<b>Grade:</b>	1	2	3	4	5	6	7
<b>Mark range:</b>	0 - 7	8 - 12	13 - 17	18 - 20	21 - 23	24 - 26	27 - 30

### General comments

It 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. Despite this, some candidates did not answer every question.

The following tables present some data from the G2 survey based on 170 respondents (from 792 schools).

**Comparison with last year's paper:**

Much easier	A little easier	Similar standard	A little more difficult	Much more difficult
0.6%	6.8%	75.3%	13.0%	1.2%

**Level of difficulty:**

Too easy	Appropriate	Too difficult
0.6%	98.2%	1.2%

**Suitability of question paper in terms of:**

	Poor	Satisfactory	Good
Clarity of wording	2.4%	39.1%	58.6%
Presentation of paper	0.0%	23.4%	76.6%

In the general comments, the paper was thought to be fair overall although the examiners were taken to task over one or two of the questions.

One respondent commented that there was little opportunity for strong students to shine; the histogram was certainly skewed to the right.

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

The difficulty index (the percentage of candidates achieving each correct answer) ranged from 89.99% to 20.57% (May 2012 for comparison, 96.25% and 28.09%). The discrimination index, an indication of the extent to which questions discriminated between high- and low-scoring candidates, ranged from 0.65 to 0.22 (May 2012, 0.57 to 0.08), the higher the value, the better the discrimination.

The following comments were made on selected individual questions:

**Question 5**

Many commented that this question, as written, is impossible without more data. Regrettably the state symbol for octane was incorrect and should have been (g). Even so, 84% of the candidates gave the "correct" answer as this was clearly the only "best choice". The question will be corrected in the published version.

**Question 19**

A comment was made that "barely" in answer C may have been difficult for those working in their second language. We acknowledge this, and will avoid its use.

**Question 30**

The answer to this question caused much discussion in the G2s and at the Grade Award. We apologize here for the lack of accuracy! The two possible correct answers, B and D, were accepted and the question will be modified before final publication.



## Higher level paper two

## Component grade boundaries

<b>Grade:</b>	1	2	3	4	5	6	7
<b>Mark range:</b>	0 - 13	14 - 26	27 - 35	36 - 45	46 - 55	56 - 65	66 - 90

## General comments

Generally the paper was found to be accessible. It allowed the weaker candidates to demonstrate some chemical knowledge but was sufficiently challenging to test the strongest candidates who showed a thorough command of the material and high level of preparation. The choice of questions in section B was more balanced than in previous sessions and it was encouraging to see students do particularly well in the organic based question 8.

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

- In Q.1 reading the top of the meniscus in  $\text{KMnO}_4$  titration, in (g) (iii) preventing the formation of a precipitate and in (h) (i) why  $\text{HCl}$  or  $\text{HNO}_3$  should be avoided. These questions were hardly well answered.
- The identification of manganese(IV) oxide.
- The balanced equation for the reaction between calcium carbonate and sulfuric acid.
- The calculation of activation from the slope of  $\ln k$  against  $1/T$ . Many students were either unable to calculate the slope correctly or give incorrect units.
- Identification of the dative covalent bond in carboplatin.
- Determination of equilibrium concentrations. Many struggled to solve the equation and simplified the quadratic formula.
- Explanation of the hydrogen bonding in dimethyl amine.
- Use of IUPAC in naming amines and alkenes.
- Writing a balanced equation for the reaction between  $\text{PCl}_3$  and  $\text{H}_2\text{O}$ .
- Explanation of why some salt solutions are acidic, basic or neutral.
- Description of mode of action of acid-base indicators.
- Description of standard hydrogen electrode and definition of standard electrode potential.
- Explanation of why copper is not used in electrolysis of water and identification of inert metallic electrodes.
- Determination of mass of lead produced in electrolysis of lead bromide.
- Use of a polarimeter and comparison of properties of enantiomers.

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

- Deduction of oxidation number of Mn in  $\text{MnO}_4^-$
- The electronic configuration of  $\text{Ru}^{2+}$  and use of arrows in the box notation for the

electronic configurations.

- Calculation of the entropy, enthalpy and free energy changes. Unlike in the previous years, most used consistent units.
- Drawing Lewis structures and shapes of  $\text{PCl}_3$ ,  $\text{PCl}_5$  and  $\text{POCl}_3$  molecules.
- Explanation of why chromium complex is coloured.
- Calculation of pH of a buffer and acid–alkali solution.
- Diagram of a voltaic cell
- Structures of organic molecules and reaction mechanism.

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

### Section A

#### Question 1

Most candidates were able to state the function of iron in the body but unable to explain why a reading of the top meniscus is taken for the  $\text{KMnO}_4$  titration, which suggests limited practical experience. Some candidates calculated the moles of Fe using the mass of tablets rather than using mole ratio and titre results. Most candidates were able to define ‘reduction’ and determine the oxidation number, although some were penalized for incorrect notation. Many did not know how to prevent the formation of  $\text{MnO}_2$  precipitate or why HCl or  $\text{HNO}_3$  are not used in this titration.

#### Question 2

In (a) the most common mistake was for students to omit minimum in the definition of activation energy. Many described the relation between temperature and rate constant as linear or ‘proportional’. Only a small number of students gained full marks for the determination of activation energy because many either calculated an incorrect gradient or used the wrong units.

#### Question 3

(a) Many candidates identified the functional group but not the type of bond between Pt and N in carboplatin. A surprising number of candidates were unable to draw a  $p_x$  orbital or drew all  $p$  orbitals, or did not label the axis. In (ii) very few gave 16 as the answer.

#### Question 4

Most candidates scored poor marks in this question because they made mistakes in writing the correct equilibrium concentrations for  $\text{H}_2$ ,  $\text{I}_2$  and HI or calculating the value of ‘x’. It was not necessary to solve the quadratic equation to calculate the equilibrium concentrations. Most candidates knew that dimethylamine could form H-bonding with water, but only very few scored the mark for explanation. Reference to electronegativity or the lone pair of electrons on nitrogen was needed for both marks. Few candidates were able to name the amine correctly.

### Section B

#### Question 5

Most candidates were able to calculate the entropy, enthalpy and free energy changes but made mistakes with the correct definition of ‘enthalpy of formation’. Many referred to the gaseous state which suggests some confusion with bond enthalpies. Many were comfortable with writing Lewis structures and shapes of molecules, or some give incomplete explanations, not referring to the

number of electron domains for example. Not many students could write a balanced equation for the reaction between  $\text{PCl}_3$  and  $\text{H}_2\text{O}$  (A.S. 13.1.2 of the guide). In part (d) even though many knew that a ligand has a lone pair of electrons, they missed the second mark for 'bonding to metal ion'.

### Question 6

Most candidates calculated the pH of ammonia solution correctly and also the pH of the buffer solution in part (c) (ii). Most students could explain why a solution of the chromium complex is coloured. The difficult part in this question for many was to state and explain whether the salts in solution were acidic, basic or neutral. (e) again caused difficulties for candidates, similar to previous sessions, though many scored some marks for stating acidic. (ii) was very poorly done and M2 was effectively a dead mark.

### Question 7

Many made mistakes in writing a balanced equation for the reaction between Cu and  $\text{HNO}_3$ , in drawing a diagram for a hydrogen electrode, in writing a definition of 'standard electrode potential'. Most could draw a labeled diagram for an electrochemical cell. Many mistakes were made in writing balanced equations for reactions at the electrodes and overall equation for the electrolysis of water.

### Question 8

A reasonably popular question and often well done. In (a), some weaker candidates did not understand the idea of a stereoisomer. (b) and (c) were well done. In (d), most scored full marks though some gave *cis*. In (ii), many did not gain marks for but-2-ene. (e) (i) also was very well answered compared to some recent sessions.

Perhaps too much was expected in (iii) for one mark and students either omitted polarimeter or did not refer to plane polarised light. In (iv), few scored both marks.

## Recommendations and guidance for the teaching of future candidates

- More exposure to laboratory work within the programme.
- Writing balanced equations, ionic as well as molecular, including states.
- Calculations of equilibrium constant and equilibrium concentrations
- Hydrolysis of ions in salt solutions.

## Standard level paper two

### Component grade boundaries

<b>Grade:</b>	1	2	3	4	5	6	7
<b>Mark range:</b>	0 - 7	8 - 15	16 - 20	21 - 26	27 - 31	32 - 37	38 - 50

### General comments

The range of marks awarded was very wide; the best candidates showed a thorough command of the material and a high level of preparation.

Teachers' impressions of the paper were conveyed by the 170 G2 forms that were returned. In comparison with last year's paper, 56.8% felt that it was of a similar standard, 6.2% thought that it was a little easier, 1.9% felt it was much easier, 30.9% a little more difficult and 2.5% were of the view that the paper was much more difficult. 86.1% considered the level of difficulty of the question paper appropriate, 1.2% too easy and 12.7% too difficult. Clarity of wording was considered good by 50.0%, satisfactory by 46.4% and poor by 3.6% of respondents. The presentation of the paper was thought to be good by 68.1%, satisfactory by 29.5% and poor by 2.4%. 57.1% of respondents agreed that the questions were accessible to all candidates with special education needs and 39.4% were neutral. 3.5% disagreed. In terms of accessibility of the questions to all candidates irrespective of their religion, gender or ethnicity, 81.8% agreed, 15.9% were neutral and 2.4% disagreed.

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

This examination revealed the following weaknesses in candidates' knowledge and understanding:

- Identification of errors as systematic or random.
- Distinguishing between precision and accuracy.
- Knowing the colour of an aqueous solution of  $\text{KMnO}_4$ ,  $\text{Cl}_2$  or  $\text{Br}_2$ .
- Calculating number of moles of solute in solution from concentration and volume.
- Determining mole ratio of two solutions in a titration.
- Calculating mass of a compound from number of moles and molar mass.
- Calculating percentage yield.
- Writing formulas of ionic compounds such as  $\text{MnO}_2$ ,  $\text{CaCO}_3$  and  $\text{CaSO}_4$ .
- Explaining formation of hydrogen bonds.
- Explaining bond angles and repulsion of bonding and non-bonding electron pairs.
- Explaining why molecules are polar or non-polar.
- Drawing an addition polymer of but-2-ene.
- Writing precise definitions in general, such as activation energy, ionic bonding, isomers, electronegativity.

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

Topics generally well answered included:

- Calculations of enthalpy change using Hess's Law.
- Calculations of enthalpy change using average bond enthalpies.
- Electron configurations.
- Calculation of empirical and molecular formulas.

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

### Section A

#### Question 1

Question 1 presented difficulties to many candidates. It is felt that the extended nature of the response distracted candidates from rather straight-forward quantitative chemistry calculations. Part (a) required candidates to determine whether an error was systematic or random and part (b) asked for the meaning of precision. Both of these questions are relevant to Topic 11. Very few candidates related reading the top of the meniscus in the burette in part (c) to the colour of the  $\text{KMnO}_4$  solution. While it is acknowledged that few candidates would have performed this experiment themselves, it is reasonable that candidates should know the colour of  $\text{KMnO}_4$ . Part d) (i) was answered very well with nearly all candidates correctly defining reduction. In d) (ii) many candidates correctly deduced the oxidation number of Mn in  $\text{MnO}_4^-$ . Several lost marks, however, for not using acceptable notation. 7 by itself is not correct. Part (e) involved the calculations. Candidates were guided through the process of calculating number of moles from concentration and volume, finding mole ratios, and determining mass from moles and molar mass. Better candidates performed these calculations well. Weaker candidates often scored follow-through marks when working was shown. In f) (i) a common error was to write  $\text{Mn}_2\text{O}_4$  as the formula for manganese(IV) oxide. Also common was the use of the symbol Mg for manganese. In f) (ii) very few candidates could suggest a valid reason why  $\text{MnO}_2$  formed instead of  $\text{Mn}^{2+}$ , although many recognized that reduction did not fully proceed. The presence of  $\text{H}^+$  ions as a reactant in the redox equation was intended to provide a clue.

#### Question 2

In contrast, question 2 a), which involved a Hess's Law calculation, was answered correctly by candidates of all capabilities. The definition of activation energy in part b) was reasonably well answered, with some candidates losing marks for omitting the word minimum from their response. However, it is disappointing that even very good candidates sometimes fail to score marks for definitions. Several candidates sketched very clear, correct Maxwell-Boltzmann curves in part c). Most scored at least 1 mark for this question. Some did not know what labels to put on the axes. Some did not realise that the area under the curves represents the total number of particles so as temperature increases the peak of the curve shifts to the right and is lower than the peak at the lower temperature.

#### Question 3

Question 3 a)(i) presented difficulties to some candidates who attempted to calculate the concentration of  $\text{H}^+$  ions even though this is not on the SL course. Simply recognizing that a decrease in pH of 1 unit is equivalent to an increase in  $[\text{H}^+]$  by a factor of 10 was sufficient here (A.S. 8.4.3). In a) (ii) many candidates correctly identified ethanoic acid as the cause of the decrease in pH. Some simply stated carboxylic acid, which is a class of compound and not a name of a compound. Part b) was a challenge to candidates who did not know the formula of limestone. This reaction is mentioned in teachers' notes in 8.3.1. State symbols were also required. Some candidates mistakenly identified sulfuric acid in acid rain as  $\text{H}_2\text{SO}_4(\text{l})$  and did not score the second mark.

#### Question 4

Question 4 a) asked candidates to identify intermolecular forces in  $\text{HI}(\text{l})$ . A quick check of the Data Booklet should reveal an electronegativity difference of 0.5, so HI is polar and has dipole-dipole forces between molecules. Candidates should also be aware that the large number of electrons on iodine (large mass) would contribute to large van der Waals' forces. Both answers were required for 1 mark. Many candidates only gave one response. In b) (i) nearly all candidates could correctly draw the full structural formula of  $\text{CH}_4$  although some showed Lewis structures with dots and crosses. Fewer candidates could sketch the full structural formula of  $(\text{CH}_3)_2\text{NH}$  and drew the structure of ethylamine

instead. Some candidates did not show all the bonds, leaving  $\text{CH}_3$  groups intact. In b) (ii) candidates were asked which of these two compounds could form hydrogen bonds with water. A few did not realise that the question referred to the compounds already mentioned. This suggests that for some candidates their examination preparation has not included an understanding of question structures. Most successfully identified  $(\text{CH}_3)_2\text{NH}$  but could not explain the hydrogen bond formation for the second mark. Many candidates then managed to draw a diagram of the hydrogen bonds, although some showed their lack of understanding of the nature of a hydrogen bond and drew them as covalent or dative covalent bonds.

## Section B

### Question 5

Many candidates failed to score for the meaning of the term ionic bonding in a) (i). A definition should provide an easily scored mark. Part a) (ii) required a description and a diagram of a sodium chloride lattice. Marks were awarded so that a candidate who attempted a diagram and gave a good description could score full marks. In a) (iii) the chemical formula of ammonium phosphate was sometimes creatively constructed with amm used as the symbol for the ammonium ion and phosphate as  $\text{PO}_3$  or as  $\text{PO}_4^{2-}$ . Lewis structures in b) (i) were generally well done. The most common loss of a mark was due to omitting lone pairs of electrons from atoms. In b) (ii) many candidates stated that S had two lone pairs of electrons but still based the bond angle on a trigonal planar structure. Even candidates who correctly stated the bond angle could not explain it well. In b) (iii) many candidates could identify the molecules as polar or non-polar but could not give a valid reason. Some referred to charges cancelling out rather than dipoles. Part c) required candidates to find differences in electronegativity values to determine if compounds are ionic or covalent. Many candidates answered this well. Some found the electronegativity difference correctly but were confused about how to use this to classify the type of bonding present. A few candidates added the electronegativity values.

### Question 6

This was by far the most popular choice of question in Section B. Again, part a) (i) proved challenging as many candidates failed to refer to atoms in their definition and scored only 1 mark out of 2. In a) (ii) most candidates could state the numbers of protons, neutrons and electrons in the isotopes of chlorine. Those who got this wrong gave answers which indicated a complete lack of understanding of atomic structure. In a) (iii) some candidates remembered the percentage abundance of chlorine isotopes but could not do the calculation. In a) (iv) most could write the electron configuration of a chloride ion. Part b) (i) required another definition. Again, many candidates lost marks for inarticulate responses. The explanation in b) (ii) of trends in electronegativity values was reasonably well done, with most candidates scoring at least one mark out of two. However, writing a balanced equation in b) (iii) was poorly done with many candidates not knowing the formula of  $\text{KCl}$ , and not knowing what products would be formed. This is clearly on the syllabus in 3.3.1. Almost no-one knew the colours of aqueous chlorine and aqueous bromine in b) (iv). c) (i) required one use of PVC. This was a challenge to examiners as there are many correct answers. Better candidates gave more detailed responses, such as heavy duty industrial gloves rather than gloves, which were more likely to gain credit. In part c) (ii) the calculation of  $\Delta H$  using bond enthalpies was done well. Some candidates failed to use the  $\text{C}=\text{C}$  bond enthalpy value and some did not recall that bond breaking is endothermic and bond formation exothermic. Nearly everyone scored a mark in c) (iii) as follow-through marks were awarded. Drawing two repeating units of poly(chloroethene) presented difficulties in c) (iv). Some candidates tried to draw the monomers joined through the chlorine atoms. In c) (v) most candidates scored at least one out of two for explaining why monomers have a much lower melting point than polymers.

### Question 7

Question 7 was answered by relatively few candidates, but those who chose this question were usually well-prepared. In a) (i) and (ii) most candidates correctly identified two functional groups in cortisone, but some incorrectly named the ketone group as an aldehyde. In b) the definition of isomers was reasonably well answered. Most correctly named but-2-ene in c) (i). Some mistakenly

said butene which was insufficient. In c) (ii) most candidates drew the structure of but-1-ene although some drew the original compound. In c) (iii) several candidates identified the product as butan-1-ol rather than butan-2-ol. Nearly all identified butane as the second compound and correctly identified a suitable catalyst for this reaction in c) (iv). The mechanism required in c) (v) was either  $S_N1$  or  $S_N2$ . Several candidates produced very clear, correct mechanisms. A few lost marks for incorrectly having a curly arrow from H instead of O in the nucleophile, or for neglecting to show the curly arrow showing Br leaving, or for omitting the negative charge on the transition state in  $S_N2$ . In c) (vi) some candidates thought that an aldehyde formed from oxidation of an alcohol under reflux. Error carried forward was applied if candidates had given butan-1-ol as the product in c) (iii) and then drew and named butanoic acid here. Drawing two repeating units of the polymer made from but-2-ene caused many problems in c) (viii). Parts d) (i) and (ii) were extremely well answered with most candidates determining the empirical and molecular formulas correctly.

## Recommendations and guidance for the teaching of future candidates

In addition to the usual advice about reading the questions carefully and paying attention to mark allocations and command terms, candidates are advised to bear in mind the following points in this paper:

- Learn the common definitions on the syllabus.
- Practise converting units during calculations, particularly with volumes in  $\text{cm}^3$ .
- Practise writing equations.
- Practise drawing reaction mechanisms.
- Write answers in the boxes provided and if the answer does not fit in the box, indicate that the answer is completed on additional pages.

## Higher level paper three

### Component grade boundaries

<b>Grade:</b>	1	2	3	4	5	6	7
<b>Mark range:</b>	0 - 7	8 - 15	16 - 21	22 - 27	28 - 32	33 - 37	38 - 50

## General comments

Overall teachers' impressions of this paper were indicated by the 238 G2 forms that were submitted. 95.3% of the teachers who responded felt the paper was appropriate in terms of level of difficulty. 74.2% felt that the paper was of similar standard to last year's paper with 15.4% feeling that the paper was a little more difficult than last year. In terms of clarity of wording, 59.6% felt it was good and 39.5% felt that it was satisfactory. For the presentation of the paper, 67.7% indicated that it was good and 32.3% rated it as satisfactory.

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

There were a number of areas in which there were clear weaknesses in the candidate's knowledge and understanding of specific concepts. On many occasions, these arose due to lack of clarity and use of specific and appropriate terminology.

- Explanation of retention factors in chromatography.
- Calculation of iodine numbers.
- Drawing the structural formula of a triglyceride.
- Purification of aluminium oxide.
- Phenol-methanal plastics.
- Analysis of alcohol levels in blood.
- Identification of chiral centres.
- Secondary pollutants in smog.
- Browning and the Maillard reactions.
- *d/l* and *R/S* terminology.
- Addition-elimination reactions.

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

- IR and NMR spectroscopy.
- Structures of dipeptides.
- Electrophoresis.
- Catalysis.
- Drug action.
- Acid deposition.
- Calculation of  $K_{sp}$ .
- Benefits and concerns of use of GM foods.
- Electrophilic addition mechanism.

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

### OPTION A – Modern Analytical Chemistry

#### Question 1

In (b), most candidates scored at least one mark by establishing that components have different solubilities in different solvents. However, many failed to discuss how intermolecular forces were affected for the second mark.

Part (c) was answered well by most candidates with the use of UV light, ninhydrin and a dye being the most popular choices.



**Question 2**

Part a) (i) was well answered overall. Candidates that lost the mark usually failed to realize that this component ensures that light of only one frequency is allowed to pass the sample.

Many candidates correctly answered (ii) and (iii) often giving a good description with correct vocabulary.

In bi) most candidates scored the first mark although many candidates did not refer to the vibrations involving a change in dipole moment/polarity for the second mark.

**Question 3**

Many candidates scored at least one mark in a). There was evidence that candidates related greater conjugation/delocalization to absorption within the visible region of the spectrum but often arguments were poorly worded for second and third mark. There were also frequent references to electronic transitions occurring within a *d*-subshell.

In part (b), most candidates recognised that there was a change in the extent of conjugation but did not elaborate on whether conjugation had increased or decreased.

**Question 4**

Overall, there was a mixed response to part a) of this question with some students scoring full marks and others only achieving 1 or 2 marks.

Parts (b) (i) and (ii) showed many correct answers although in part (iii) ,candidates often referred to number of carbonyl groups in each of the two painkillers but established no connection with how this would affect the IR spectrum of each compound.

**OPTION B – Human Biochemistry****Question 1**

In a) (i), few candidates achieved the maximum 3 marks although most obtained at least one mark. Very often candidates drew incorrect structures for the triglyceride and glycerol and also did not balance the equation if written correctly.

The calculation of the iodine number for oleic acid was not well done overall although a fair number of candidates obtained at least one point by providing alternative answers such as values of iodine numbers corresponding to 1g of oleic acid.

This question b) i) was quite well answered overall. Those who did not fully score two marks usually failed to establish a link between C=C and the difficulty in molecules packing effectively with each other and/or made reference to covalent bonds rather than Van der Waals forces evidencing a poor understanding of intermolecular attractions.

**Question 2**

In a) some candidates' lost one mark by incorrect use of representation of the peptide bond but generally the dipeptides were drawn well.

In b) (i) many candidates scored 2 or 3 marks as there were so many possible marking points for describing electrophoresis.

**Question 3**

Part a) was done well overall although there were a fair number of candidates who thought that anaerobic respiration in the human body produces  $\text{CO}_2$  and ethanol.

The determination of  $V_{max}$  and  $K_m$  from the graph was done very well overall.

In b) ii), answers were often poorly presented but many candidates scored the second mark. The high affinity of the enzyme for the substrate was rarely mentioned for the first marking point.

For part (iii), many candidates obtained the first mark for  $K_m$  increasing and a good number of candidates managed to achieve the last two marking points.

**OPTION C – Chemistry in industry and technology****Question 1**

Overall, part a) (i) was a poorly answered question on the extraction of bauxite. The mark most commonly scored in a)i) was for adding NaOH. Many candidates presented answers addressing the process of obtaining aluminium by electrolysis rather than the purification of the oxide from the ore.

Part (ii) was well answered by most. Those who lost the mark either showed very little grasp of the topic or suggested only vaguely that the reason for using cryolite was to lower the operating temperature.

(iii) A fair number of candidates answered this correctly although some lost the mark by stating the equations at the wrong electrode.

(b) Most candidates failed to suggest displacement with a more reactive metal. The blast furnace was mentioned quite frequently as a response.

**Question 2**

This question was generally very well-answered by most candidates.

**Question 3**

There were very few correct answers for this question with many blank answer boxes. In a) i), only a small number of candidates gave correct answers here. Many incorrectly gave the group  $-\text{CHO}$  instead of  $-\text{CH}_2\text{OH}$  as a substituent on the ring.

Part (ii) also proved elusive to many and although part (iii) was also poorly answered, a few candidates did correctly identify that covalent bonds would form between the chains.

There were more correct answers in b) i) here with the amide link often being correctly identified.

Quite a few candidates scored one mark by identifying hydrogen bonding in b) ii), but few achieved the first mark.

**OPTION D - Medicines and drugs****Question 1**

Many answered a) correctly. Those who didn't often suggested an aldehyde or carboxylic acid group as the answer instead.

In (b), most candidates scored at least one mark. The other mark was sometimes lost with vague or general statements.

Parts c) and d) were usually well-answered.

### Question 2

Part a) and b) i) were very well answered overall. In b) (ii), although there were many correct replies, it was disappointing that a fair number of candidates suggested water or other inorganic compounds when the question clearly addressed the production of an organic compound.

In part c), few well-constructed answers were seen. The suggestions for determining the ethanol present in a blood sample were often the weakest and only very few candidates suggested GLC. Poor understanding of the basics of this technique was also evident. Many candidates showed a poor understanding of the intoximeter and O-H was often identified as the bond whose absorption was measured. Few candidates suggested the fuel cell (probably because it is not a specific request in the guide) and scored only by mentioning it with a poor understanding of it overall.

Many answered part d) correctly.

### Question 3

Part a) (i) was very well answered overall. In a) (ii) while many candidates showed familiarity with the  $\beta$ -lactam ring, not as many were able to convey arguments that allowed them to score.

Good candidates achieved at least one mark in a) (iii) for the increase in polarity although often answers for this question were vague and just referenced 'an increase in solubility' without specifying 'in water'. The reason for converting the drug into a sodium salt was often incorrectly linked to digestion as opposed to making the molecule more polar.

In b) (i), a fair number of candidates incorrectly circled the  $\text{NH}_2$  group of the amide group and classified this as a primary amine.

Many had difficulty explaining how to make the drug more polar in b) (ii).

(iii) Most candidates obtained second mark in this question and very few identified the correct number of chiral carbons.

## OPTION E- Environmental chemistry

### Question 1

Part a) i) was often correctly answered but there were a surprising number of wrong answers or replies that were incomplete.

Many provided correct examples and equations for a) (ii). Very often those who failed to score the second mark presented wrong equations for  $\text{NO}_2$ . Quite a few candidates incorrectly suggested carbon dioxide here.

The idea of neutralising the lake water in a) (iii) was generally well understood hence many candidates achieved this mark.

In (b), a substantial amount of candidates scored full marks here. In general, arguments used for decreasing emissions for the oxides of sulfur seemed better understood than those affecting nitrogen dioxide emissions.

### Question 2

Many students did not write two equations each for ozone formation and depletion in a) and some included other pollutants such as  $\text{ClO}$ . The problem of CFC longevity was done reasonably well

although there was some confusion in a fair number of explanations. Part (ii) was generally well answered.

### Question 3

A substantial number of candidates knew the conditions for photochemical smog in a) although temperature inversion seemed to be not as well understood as in previous sessions.

This is a topic that keeps on challenging students and this was also reflected in b) (ii). Only a small number could name any secondary pollutants apart from  $O_3$  and  $NO_2$  and even fewer could write the correct equations.

### Question 4

The question on the solubility of cadmium was done reasonably well but many erroneously produced hydrogen gas instead of hydrogen ions in their equation and hence lost both marks.

$K_{sp}$  was often calculated correctly in b) i) although the arguments around the common ion effect in b) ii) showed a poor understanding.

## OPTION F – Food chemistry

### Question 1

This was a generally well-answered question although a fair number of candidates could not identify the phenol group in 2-BHA correctly in part b).

The modes of action of each type of anti-oxidant was generally well-explained although in a fair number of answers, 'reducing agents' were often not attempted or showed very shallow arguments.

Only a few could name a natural chelating agent in d) ii).

### Question 2

Part a) was answered very well overall.

In part b) (i), some candidates scored one mark here but it was fairly evident this topic was not well understood.

Parts b) (ii) and b) (iii) had very few correct answers. Very few could explain how bicarbonate maintains the green colour and very few knew the pheophytin complex.

In c), the chemistry of non-enzymatic browning was not well explained overall.

### Question 3

This was answered very well. Most candidates scored at least 2 marks and many scored 3 or 4 by providing suitable arguments on the benefits and concerns around GM food.

### Question 4

Most could identify the chiral carbon in a). In part b), most candidates showed familiarity with topic but correct use of vocabulary was not seen very often. There were still too many references to the rotation of the molecule rather than the rotation of plane-polarised light.

Many candidates scored the first mark in c) but provided incomplete or wrong answers losing the second mark. Many incorrectly tried to apply the CORN rule and also atomic masses to identify the S isomer.

**OPTION G - Further organic chemistry****Question 1**

The mechanism for electrophilic addition was well known but few candidates could successfully explain why the major organic product was a tertiary halogenoalkane. Many simply quoted Markovnikov's rule in a) iii) with no further explanation of the greater stability of a tertiary carbocation over a primary one and reasons for this.

Most students did not score a mark for b) as often no reference was made to the need for NaOH to be in the aqueous state.

**Question 2**

In (a) many candidates obtained at least two marks usually by correct arguments referring to same length/strength of C-C bonds in the benzene ring and the fact that benzene undergoes substitution rather than addition reactions. References to the existence of only one 1,2-disubstituted isomers and enthalpy changes were less common and often poorly described.

The explanations of the reactivities of iodobenzene and iodomethylbenzene were poor. Most students tried to discuss the effects of substituents on the benzene ring rather than the effect of the benzene ring on the substituents. Many students were also confused about the differences between electrophilic and nucleophilic substitution.

**Question 3**

Many candidates found the addition-elimination mechanism in (b) very challenging and hence there were very few correct answers. The intermediate was rarely correctly presented and charges on O and N even rarer.

There was more success though with the final electrophilic substitution in (d) and many candidates scored full marks here.

**Recommendations and guidance for the teaching of future candidates**

- The importance of ensuring that students write legibly and clearly when answering exam questions.
- Ensuring greater familiarity with command terms, particularly those from Objective 3, and more practise in writing clear explanations using the correct scientific terminology.
- Continuous practise of answering past exam questions on each options including development of strategies for planning and writing coherent responses.
- Greater familiarity and practise of mechanisms including positioning of curly arrows and drawing of organic structures.
- Ensure that the appropriate time is dedicated for the teaching of each of the two options some of which could be done through integrating them with the core topics.

## Standard level paper three

### Component grade boundaries

<b>Grade:</b>	1	2	3	4	5	6	7
<b>Mark range:</b>	0 - 7	8 - 14	15 - 17	18 - 21	22 - 26	27 - 30	31 - 40

### General comments

The paper was fairly straightforward and the mean mark obtained by students was significantly higher than on the May 2012 paper. Though a handful of students performed very well on it, as usual, there were a significant number who seem to have been inadequately prepared and performed badly on even the most straightforward sections.

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

As has been the case for a number of years, one of the major areas in which candidates experienced difficulty across all options, was in writing balanced chemical equations. Candidates also frequently failed to give enough specific detail and employ correct vocabulary in explanations. Other Option specific weaknesses were:

- Explanation of paper chromatography and developing chromatograms.
- Meaning of iodine number and calculating values for it.
- Purification of bauxite.
- Analysis of blood and breath samples for alcohol content.
- Soil degradation.
- Colour reactions in foods.
- Explanation of the Markovnikov rule.

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

In general students seemed to perform best in tasks involved simple recall of factual data. Option specific examples are:

- Components of a double beam IR spectrometer.
- Relationship between wavelength, frequency and energy.
- Characteristics of vitamins and their deficiency diseases.
- Heterogeneous and homogeneous catalysts.
- Actions of analgesics.
- Acid deposition and combating its effects.
- Sources and characteristics of natural antioxidants.
- Effect of the benzene ring on nucleophilic substitution of halogeno compounds.

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

### Option A – Modern analytical chemistry

Option A was reasonably popular and seemed to attract quite a few of the stronger candidates, hence it was in general quite well answered.

#### Question 1

Many students could correctly define “retention factor” though they frequently used the term “solute” rather than “component” and “solvent” rather than “eluent front”. Very few candidates were capable of describing, in sufficient detail to gain the second mark, how the properties of the eluent, such as its polarity or ability to engage in particular types of intermolecular bonding, affected the relative attraction of a particular component for the stationary and mobile phases, and hence the distance it would travel relative to the eluent front; indeed many said that as the distance travelled by the eluent might vary so the  $R_f$  value would vary. About half the candidates were aware of some technique to identify colourless components.

#### Question 2

The components of the double beam spectrometer seemed to be well known, though in the first part many said a monochromator “emitted” light of a single wavelength, incorrectly implying it was the light source. Many candidates knew that IR absorption depended on vibrations and polarity, though only a few gained the second mark by specifying a change in polarity. The final section appeared to well understood by candidates, with even the weakest students usually scoring full marks.

#### Question 3

Many students could use the spectroscopic data provided to correctly identify the compounds, with the first part of the question, dealing with mass spectrometer data, probably proving the most challenging.

### Option B – Human biochemistry

Option B was, as usual, very popular and many candidates performed well on it.

#### Question 1

This proved surprisingly challenging. Even using R for the hydrocarbon chain, many candidates found drawing the structure of a triglyceride a challenge and only a handful correctly balanced the equation by adding an appropriate number of water molecules. From the way in which the calculation was tackled, very few knew the definition of iodine number and there were even less correct answers. Few students gained marks for the early steps of the calculation because their working was rarely clear. The effect of the double bond on packing was better known, as was the importance of essential fatty acids.

#### Question 2

Whilst some candidates were unaware of how amino acids might join (or even what they were!) many could correctly write the structures of the two possible dipeptides. Many candidates knew the basics of electrophoresis, but the high scores they achieved were also a reflection of a generous markscheme and this lack of a sound understanding was often reflected in their inability to correctly identify the acid that would move to the anode. Whilst many candidates knew interactions responsible for the tertiary structure of proteins, their descriptions of what this was often failed to differentiate it from secondary structure.

**Question 3**

Probably the best answered question on the whole paper with even the weakest of candidates often scoring full marks.

**Option C – Chemistry in industry and technology**

Once again this was probably the least popular option and was often poorly answered.

**Question 1**

This question was probably the worst answered question on the whole paper. In the first section many candidates confused the purification process with the electrolytic extraction and answers that scored any marks were rare. Many candidates knew the reasons for the addition of cryolite, but it was unusual to find both electrode equations correct and balanced. Hardly any had the lateral thinking skills to suggest displacement by a more reactive metal as a possible way of obtaining aluminium, but most students knew of at least one way in which aluminium production resulted in the emission of carbon dioxide.

**Question 2**

This question was relatively well tackled. Almost all knew the difference between the two types of catalysts, though many referred to “state” rather than the more correct “phase” and could identify an advantage and a disadvantage and knew of at least some of the factors that need to be considered in decisions relating to the choice of a catalyst.

**Question 3**

The answers to this often betrayed a confusion between isotactic and atactic polypropene. That being said the link between packing and the strength of the dispersion forces was relatively well understood at least to the extent of gaining one of the marks. Most candidates were aware of the role of pentane and even the weakest were scoring the mark for a use of expanded polystyrene.

**Option D – Medicines and drugs**

As usual this was the most popular option and candidates seemed to score well on it.

**Question 1**

This was well answered. Most students could correctly identify the group common to both analgesics and could explain the differences in their modes of action, though the terms used often lacked precision. The reasons for regularly taking low doses of aspirin and the advantages and disadvantages of morphine and heroin, were also well known.

**Question 2**

This question produced significantly lower marks. In the first part candidates often confused moderate and high dose symptoms and the latter were often confused with chronic effects. The colour change and product were widely known though, as in the past, some students forgot that a colour change involves stating both the initial and final colour and some gave the class of compound (aldehyde/carboxylic acid) rather than the specific product from ethanol. Only a handful of students gained any of the marks for specific techniques used to assess blood alcohol levels, with IR methods being the best known. Many knew what a “synergistic effect” was, but many struggled to convey this in appropriate language rather than just quoting an example of this type of activity.



**Question 3**

Many students knew that penicillins affected the walls of bacteria, though many wrongly stated that it destroyed the cell wall, rather than hindering its formation. The effects of changing the side chain were generally appreciated, but once again, in the final part of the question, students often failed to express the reasons for using multiple antibacterials clearly enough to gain full credit. In the last two parts candidates often, incorrectly, referred to bacteria being “immune” or “tolerant” rather than “resistant” - another example of a failure to use precise vocabulary correctly.

**Option E – Environmental chemistry**

This option seems to be becoming less popular and almost all of the candidates attempting it struggled with certain sections.

**Question 1**

Though the precise definition of “acid deposition” was rarely encountered, most candidates managed a reply that gained them the mark. Even the simple equations required for the reaction of the oxide with water proved difficult for many candidates and, even though most knew how to counteract lake acidity, a disappointing number of students failed to link their method of reducing emissions to the oxide selected, for example mentioning catalytic converters in reference to oxides of sulfur.

**Question 2**

The equations required in the first part of this question were amongst the best known in the examination; the result of memorisation? A number of candidates incorrectly gave the reaction between two oxygen atoms as a significant process in ozone depletion and some discussed the way CFCs accelerate the depletion, rather than giving the natural processes asked for. Relatively few could give correct reasons for the persistence of CFCs in the atmosphere, but advantages and disadvantages of were relatively widely known.

**Question 3**

Soil degradation seemed to be only vaguely understood, with most responses bordering on the journalistic, and though these occasionally managed to provide sufficient detail to score some credit, high scoring answers were rare.

**Question 4**

Part a), relating to the reaction precipitating mercury sulfide, was very challenging and arguably marginal to the syllabus and as a result hardly any students gained any marks; unbalanced equations, especially yielding hydrogen as a product, proliferated. The process of eutrophication was better known, but many students incorrectly attributed the depletion of oxygen to the excessive growth of plants and algae rather than their subsequent death and decay.

**Option F – Food chemistry**

Whilst this option continues to increase in popularity responses to some questions showed that certain topics are very poorly understood.

**Question 1**

The role of antioxidants was well understood, though many students consider that these prevent oxidative degradation rather than slowing or delaying its onset. Almost all candidates could correctly name sources of the specified antioxidants. Many candidates correctly identified the required groups on the structure of 2-BHA, though a significant number obviously confuse “phenyl” and “phenol”, failing to realise that the -OH group was part of it. In spite of the somewhat confusing wording of the

question, most students gained some credit for the advantages and disadvantages of these compounds, with many gaining full marks.

### Question 2

This question was very poorly answered. Whilst many candidates correctly identified factors affecting the stability of pigments, hardly any displayed the detailed knowledge required regarding the degradation of chlorophyll and the way that sodium hydrogencarbonate and vinegar affect the process. The Maillard reaction was even less well understood with only a handful of candidates gaining any marks.

### Question 3

The benefits and concerns regarding genetically modified foods seemed to be well known with almost all candidates scoring well, though a common failing was again the use of journalistic descriptions that lacked the precision one hopes would result from an in depth study of the subject.

## Option G – Further organic chemistry

Quite a few candidates attempted this option, with many of them scoring quite well.

### Question 1

Almost all candidates correctly identified the mechanism and more than in some previous sessions gained full credit for describing the mechanism, though some lost marks through a lack of precision regarding the start and end of the curly arrows. Explanations regarding the preferred product were disappointing, often not explicitly referring to the stability of the possible carbocation intermediates. Some still just quoted the Markovnikov rule without discussing the reasons underlying this. Many stated that the bromo compound could be converted to the corresponding alcohol by nucleophilic substitution, but failed to mention the nucleophile and often, even when sodium hydroxide was correctly identified, the need for aqueous solution was not. By contrast the reagents and conditions for the formation of a Grignard reagent were better appreciated than in recent years.

### Question 2

Most students could identify one (usually concerning the length/strength of the bonding), or two pieces (substitution-v-addition) of evidence regarding the bonding in benzene, but few gained all three marks. Some candidates obviously realised there was some thermochemical evidence, but were confused as to exactly which enthalpy change they were referring to and could not unambiguously express how this related to appropriate compounds containing just normal carbon-carbon double bonds. Whilst the relative reactivity of the iodo compounds was frequently known, candidates often struggled to express the reasons for this clearly and it was unusual to award full marks.

### Question 3

The inductive effects causing the variations in strengths of the acids mentioned seemed to be quite well understood, though again the explanations often lacked precision and clarity. Some students seemed to have confused methanoic acid with ethanoic acid and ethanoic with propanoic; fortunately the underlying reasons in both cases are the same!

## Recommendations and guidance for the teaching of future candidates

The poor level of performance may be a result of insufficient teaching time being devoted to the Options. As they comprise 24% of the final mark then a conscientious teacher would devote the required teaching time of 30 hours (15 per Option in SL), to ensure that they are covered thoroughly.

It is important that the Options are actively taught, rather than being assigned for self-study, so as to try to avoid student misconceptions.

It is important that candidates display the precise knowledge they should have acquired, both through the study of the Option and the rest of the Chemistry course, so that they answer questions as a chemist rather than a broad, vague journalistic style.

Chemistry involves writing balanced equations and candidates should ensure that they are capable of writing balanced equations for the reactions involved in the Options covered.

Candidates need to read questions carefully to ensure they answer exactly what has been asked, taking into account the number of marks that the question is worth.

Candidates should hone the above skills, by practicing past paper questions and carefully studying the mark schemes.

Students need coaching in the art of writing clear explanations based on underlying chemical concepts. In this they must develop precise language skills (less exothermic" rather than "lower") and learn to use appropriate vocabulary ("resistant" rather than "immune").