CHEMISTRY TZ2

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

Overall grade boundaries

Higher level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 17	18 - 34	35 - 47	48 - 58	59 - 68	69 - 78	79 - 100

Standard level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 16	17 - 31	32 - 43	44 - 54	55 - 66	67 - 76	77 - 100

Higher and 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

Overall the standard of candidates work appeared similar to previous sessions but with the changes to the assessment criteria adopted by the majority of schools. Certainly the vast majority of schools appreciated that the DCP criterion demanded the collection of quantitative data and far fewer purely qualitative investigations were seen this session. The changes also appeared to result in a more even level of achievement across the criteria whereas in the past Data Collection for example was a much easier criterion to achieve highly against than Planning B or Conclusion and Evaluation.

The change to the new 0-6 points scale seemed to work in many candidates favour with ccp now being 5 out of 6 (83%) as opposed to 2 out of 3 (67%), ppp being worth 3 out of 6 (50%) not 1 out of 3 (33%) and pnn being awarded some credit. These factors appeared to compensate for the increased demand regarding the treatment of uncertainties.

One issue that remained a serious concern was that the work of some candidates was clearly guided by teachers, fellow candidates or unreferenced sources to a level well beyond the instructions evidenced.

It was unfortunately not uncommon for all candidates to choose exactly the same variables, carry out an identical procedure or follow through with identical methods in complex calculations, while the instructions provided had indicated an independent, open-ended task. At best this could be considered poor practise for failing to ensure that candidates carry out the task legitimately for themselves.

Teachers should ensure that assessment is carried out in good faith and that an individual's skills are being assessed.

Candidate performance against each criterion

Design

Aspect 1

This was well addressed with most candidates being able to phrase a research question and identify most variables thereby securing at least Partial and in many cases Complete.

Aspect 2

This was the most challenging of the Design Aspects and many candidates failed to identify any procedural methods to control or at least monitor the control variables that they had earlier identified as needing controlling.

Aspect 3

The clarification in the Subject Guide as to the minimum sufficiency of the data led to a good level of fulfilment of this aspect with most candidates able to design for the collection of data that would include repeats or would be sufficient to analyse graphically.

Data Collection and Processing

Aspect 1

There was generally a good level of fulfilment with more candidates than before including uncertainties and relevant qualitative data.

Aspect 2

The level of fulfilment was mixed but in line with the former DPP Aspect 1. Most candidates made some attempt to process data appropriately although following a calculation successfully through to its conclusion or to plot a graph from which a quantity could be determined remained demanding and Partial was a frequent award.

Aspect 3

Far more candidates than before tried to propagate uncertainties through a calculation although not always successfully. Still a significant number of candidates could not construct a line of best fit on a graph, although thankfully far fewer candidates presented inappropriate bar charts this session.

Conclusion and Evaluation

Aspect 1

Although most candidates could achieve some credit, this proved a demanding criterion and few candidates successfully placed numerical results in the context of a literature value and then identified whether the difference required the invocation of system error. Also relatively few candidates included justification of results in reference to background theory.

More commonly the justification was whether the results were internally consist i.e. more methodological. Since the explained hypothesis has now been removed from the requirements this all means that less background theory is being referred to, even by high achieving candidates which was not the intention of the changes. We had expected the theoretical context to arise in the conclusion.

Aspect 2

This criterion was satisfied to a reasonable extent with most candidates able to identify sensible sources of error. However, few candidates could evaluate whether the source of error accounted for the direction of the deviation from a literature value encountered, although a few schools had clearly stressed that this comparison is a component of the requirements. Assessing this criterion in investigations which did not yield a numerical value to be compared to literature but instead identified a trend was less well defined and variable.

Aspect 3

This criterion was satisfied to a similar extent to previous sessions with many good responses but a similar number of very superficial or simplistic contributions.

Manipulative Skills and Personal Skills

All schools entered marks for these criteria although no evidence needed to be submitted so it is not possible to pass comment on these awards.

Application of ICT

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

Recommendations for the teaching of future candidates

- Candidates should be made aware of the different aspects of the criteria by which they are assessed and evaluation of investigations using a grid of criteria/aspects with n, p and c indicated clearly.
- It is essential to ensure that candidates are solely assessed on their individual contribution to any activity used for assessment of the written criteria.
- Teachers must ensure that candidates have the opportunity to fulfil criteria, and hence should not provide too much information/help for the Design (D), Data Collection & Processing (DCP) and Conclusion & Evaluation (CE) criteria.
- All candidates, both Higher and Standard Level, need to record, propagate and evaluate the significance of errors and uncertainties.

- It is recommended not to use workbooks and worksheets with spaces to be filled in by the candidates for internal assessment as they usually provide too much information and deny the candidates the opportunity to achieve criteria.
- Candidates will need to explicitly identify the dependent variable as well as the independent and controlled variables in the Design criterion.
- Candidates should be encouraged to consider repeat trials, calibration or generation of sufficient data to undertake graphical analysis, when designing procedures for Design.
- All investigations for the assessment of DCP must include the recording and processing of quantitative data.
- Teachers are encouraged to set DCP tasks that will generate a graph that will require further processing of the data such as finding a gradient or intercept through extrapolation.
- Candidates must record associated qualitative as well as quantitative raw data, where appropriate and relevant.
- Candidates must compare their results to literature values where appropriate.
- When assessing the CE criterion, require candidates to evaluate the procedure, list possible sources of random and systematic error, and provide suggestions to improve the investigation following the identification of weaknesses.
- Teachers should not assess for a particular criterion if an investigation does not meet all aspects of the particular criterion.
- If candidates need to be introduced to the skills required for investigative practical work through simple introductory experiments that do not fully meet all aspects of a criterion then it is important that the marks generated are not included on the form 4/PSOW.
- The Group 4 Project is only to be used for assessment of the Personal Skills criterion.
- The Manipulative Skills criterion is to be assessed summatively over the whole practical scheme of work. No evidence for the MS mark need be submitted to the moderator.
- Teachers must refer to, and follow, instructions found in the chemistry subject guide, the Teachers Support Material, and instructions provided in the up to date Handbook of Procedures for the Diploma Programme before submitting work for moderation.

Instructions to Moderators May 2009

The essential reading for moderation is the Criteria and the all important Clarifications to the Criteria in the Subject Guide. Also the TSM exemplars are useful to check through. I do not want to add to many more instructions since we could find ourselves working to contradictory information. However below are some further practical tips and guidelines to follow:

Design

If all candidates are using identical methods then mark as normal and contact Examination Administration Officer (EAO). You will probably be requested to file Problem Report Form (PRF).

Design Aspect 1

- Aspect 1 is really a two part aspect (R.Q. and then Variables). Complete for both parts then gets 2 marks, cp, pp, and p,n would all get 1 mark (a broad band admittedly) and (n,n will get zero).
- If a teacher has supplied the Research Question then this nullifies the first half of the criterion. However if they have satisfied the second half partially (e.g. by correctly identifying a good number of control variables) then maybe Partial can be awarded overall for Aspect 1.
- If the teacher has specified independent and control variables then the second half of the aspect is nullified automatically. It could be felt that it has also completely focussed the research question so the final Aspect1 award could well be Not at all.
- If the teacher has identified just the independent or just a control variable then Partial can still be awarded.
- The teacher is allowed to specify the Dependent Variable when setting the task.

When not to mark down in Design Aspect 1

- The independent and controlled variables have been clearly identified in the procedure but are not given as a separate list (we mark the whole report and there is no obligation to write up according to the aspect headings).

Design Aspect 2

- This Aspect does demand that the candidates clearly describe the procedure to be followed including the materials to be used. The materials could be in list form or embedded in a step-wise description of procedure. If the procedure lacks sufficient detail, so that it could not be followed by the reader in order to reproduce the experiment, the maximum award is Partial.
- Candidates need to make a description of sizes of apparatus (eg. A 250 cm^3 volumetric flask) and concentration of solutions but not the precision because that is assessed in effect in DCP Aspect 1 in the raw data uncertainties.
- If a teacher has given candidates the full procedure then award Not at all.
- If a teacher has given a Partial procedure then see what can be awarded for the candidate's own contribution. Probable award here is Partial.
- If a candidate has used a Partial method from another source then that source should be acknowledged. Once again see what can be awarded for the candidate's own contribution. If a candidate has completely taken a Design from another source then the Award is Not at all even if the source is acknowledged. (In other disciplines you would not be credited for solely quoting someone else's work, acknowledge or not).

When not to mark down in Design Aspect 2

- Similar (not word for word identical) procedures are given for a narrow task. Comment though on poor suitability of task on 4/IAF form.
- Do not only mark the equipment list. Give credit for equipment clearly identified in a stepwise procedure. Remember we mark the whole report.

- Do not insist on the +/- precision of apparatus to be given in an apparatus list. This has never been specified to teachers and the concept of recording uncertainties is dealt with in DCP.
- Do not downgrade a teacher's mark if something as routine as safety glasses or lab coats are not listed. Some teachers consider it vital to list them each time and some teachers consider them such an integral part of all lab work that they go without saying. Support the teacher's stance.

Design Aspect 3

This Aspect assesses how much appropriate data is **designed** for, even if the candidate is then unable to follow it up exactly in the laboratory.

- If the candidate has designed a procedure so poorly that you feel that no relevant data would be collected then award Not at all.
- If the candidate has planned for less than five data points (if a graph is to be produced) or has not planned for any repeats in quantitative determinations (e.g. titrations or calorimetry, etc) then award Partial.

The material/apparatus

There is no longer a specified aspect to assess the equipment/materials list. If the candidates have failed to identify suitable materials to control the variable eg no ammeter in the common "factors affecting electrolysis" investigation where candidates identified current as a control variable then it is going to affect aspect 2. If however the missing material is going to affect the sufficiency of data (eg only identifying two alkanes when looking at affect of alkane chain length on some property) then it would affect Aspect 3 award.

There will be cases where missing materials/aspects will affect both aspects.

Data collection and processing

This criterion should be assessed through investigations that are essentially quantitative, either calculation and/or graph based. If a purely qualitative investigation has been assessed for DCP then the maximum award would probably be p, n, n = 1.

DCP Aspect 1

This aspect refers to the written record of raw data, not the manipulation of the equipment needed to generate it (that is assessed in Manipulative Skills). Do not mark down if the teacher has given a detailed step by step procedural instructions (this may have been marked down in Design Aspect 3 if it is a Design assessment task. Not in DCP though).

- If a photocopied table is provided with heading and units that is filled in by candidates then the maximum the moderator can give is n = 0.
- If the candidate has only recorded quantitative data and relevant qualitative data (e.g. colour changes in titration, observation of soot due to incomplete combustion in calorimetry, residual solid left in a beaker when reaction has excess solid reactant, bubbles being released when a gaseous product is formed) are missing then the moderator gives Partial.
- However, do not be overzealous and penalize Aspect 1 every time a candidate does not find qualitative data to record. Sometimes there is no obviously relevant qualitative data to record.

- If a candidate has not recorded uncertainties in any quantitative data then the maximum award is Partial.
- If the data is *repeatedly* to an inconsistent number of decimal places or in disagreement with the stated precision then Complete cannot be awarded. Be sensible and support teacher if there is just one single slip in a large body of data where all the rest is consistent with each other and the stated uncertainty.
- In tasks such as establishing a reactivity series, too often the candidates put in a reaction equation as opposed to the observation. This cannot be supported and will reduce first aspect to 'p' or 'n' depending on how much other raw data is present.

When not to mark down in DCP Aspect 1

- When the candidate has not included any qualitative observations and you cannot think of any that would have been obviously relevant.
- If in a comprehensive data collection exercise possibly with several tables of data the candidate has been inconsistent with significant digits for just one data point or missed units out of one column heading. If you feel the candidate has demonstrated that they were paying attention to these points and made one careless slip then you can still support the maximum mark under 'Complete not meaning perfect' rule. This is an important principle since often **good candidates responding in full to an extended task unfairly get penalised more often than candidates addressing a simplistic exercise**.
- When there is no table title when it is obvious what the data in the table refers to. I have seen candidates do all the hard work and then lose a mark from the moderator because they did not title the table. Except for extended investigations it is normally self evident what the table refers to and the section heading Raw Data is sufficient. Once again 'c' does not mean perfect.

DCP Aspect 2

If a teacher has given the method of calculation or told the candidates which quantities to plot then award Not at all.

- If a candidate has made an error in a calculation leading to the wrong determined quantity then the award may be Partial or Not at all depending on the severity of the error.
- If a graph with axes already labelled is provided (or candidates have been told which variables to plot) or the candidates have followed structured questions in order to carry out data processing then the moderator should award Not at all.
- If a candidate has simply plotted raw data on axes with no trend line then award Not at all.

DCP Aspect 3

- If you cannot easily determine the candidate's method of processing then award Partial at maximum.
- The candidate must report any final quantitatively determined quantity to a number of significant figures that is consistent with the precision of the input data. Failure to do so will reduce the maximum award to Partial.

- Do not punish inconsistent significant figures reported in the middle of a stepwise calculation if the final answer(s) is (are) reported appropriately.
- If no evidence of errors being propagated through a calculation then award Partial at best. Remember that a best fit line graph is sufficient to meet the requirement for error and uncertainty propagation.
- The error propagation should be correctly followed through to a reasonable extent according to either the Subject Guides protocol or another accepted protocol. Try to support the teacher if the candidate has made a sincere attempt even if there is a small flaw.

When not to mark down DCP Aspect 3

- Do not punish inconsistent significant figures reported in the middle of a stepwise calculation if the final answer(s) is (are) reported appropriately.
- If the candidate has clearly attempted to propagate uncertainties then support a teacher's award even if you may feel that the candidate could have made a more sophisticated effort. Please **do not** punish a teacher or candidate if the protocol is not the one that you teach i.e. top pan balance uncertainties have given as +/- 0.01g when you may feel that if we consider the tare weighing then it should be doubled.

Conclusion & Evaluation:

If structured questions are given to prompt candidates through the discussion, conclusion and criticism then, depending on how focussed the teacher's questions are and on the quality of candidates' responses the maximum award is Partial for each aspect the candidate has been guided through. You have to judge purely on the candidates input.

CE Aspect 1

- This is another multiple aspect. The conclusion can take many forms depending on the nature of the investigation. It could be a clear restatement of the determined numerical quantity (e.g. the molar mass or activation energy) a statement of the relationship found, etc. Such a clear statement earns Partial. To secure Complete the candidate must comment on systematic/random error and where appropriate relate to a literature value. The comment on systematic/random error may well come after the sources of error have been discussed. This is fine.

CE Aspect 2

- Look to see that a candidate has identified the major sources of error. There will always be other possible sources but I do not want to force candidates into writing over-long lists of trivial points just so that they feel they have covered the options. I am concerned at the number of twenty page reports that we are increasingly seeing from diligent candidates that could have been condensed into a quarter of the length.
- There is no written requirement to state the direction of each source error so we are not looking for an explicit statement. However the candidate's comments on significance of sources of error must be CONSISTENT with direction of error. e.g. Heat loss to environment is considered main source of error when experimentally determined enthalpy value is actually greater in magnitude than the literature and therefore implying another more major source of error in the other direction. This inconsistency would reduce the aspect award to Partial.

When not to mark down CE Aspect 2

- Simply apply the principle of Complete not meaning perfect. For example if the candidates have identified most sensible sources of systematic error then you can support a teacher's award even if you think that you can identify one more. Do however be a bit more critical in third aspect that the modifications are actually relating to the cited sources of error.

CE Aspect 3

- It is important that the suggested modifications be realistic and should relate in the main to the weaknesses. Be sensible. If the candidate has cited five weaknesses and come up with good suggestions for modification to address four of them (and the fifth one has no modification readily accessible to a IB candidate) then Complete can be awarded.

Other Issues:

- **Simplicity**

  If you feel a task was too simple to truly meet the spirit of the criteria then comment on the 4IAF as to the unsuitability of the task giving full justifications but do not necessarily downgrade the candidate. Yes, this does mean that candidates could get high DCP marks for some quite brief work on limited data but if they have fulfilled the aspect's requirements within this small range then support the grade.

- **Data logging**

  We are trying to encourage the use of data logging even in assessed work. The key axiom to be followed is that the candidates are to be assessed on their individual contribution to the assessed task. To judge this we have to be guided by the teacher who knows exactly what the candidates had to do. Apply the normal standards regarding expectations of data presentation (units, uncertainties, etc.) and graphs (best fit lines, axes labels, suitable scales, etc).

  If you are concerned as to whether the candidates have had sufficient input feedback to the teacher. I have some recommended phrases below.

Recommended Feedback Comment 1

"The use of ICT in assessed investigations is acceptable and encouraged. The key axiom to be followed is that the candidates are to be assessed on their individual contribution to the assessed task and it should be ensured that they have sufficient input into the task."

Recommended Feedback Comment 2

"In order to ensure that candidates have sufficient opportunity to demonstrate their individual contribution to DCP a recommended strategy is to assess DCP when there is a further component to the data processing phase beyond that carried out using the data logger's graphing software. "

When to Contact IBCA:

- When samples have not arrived by one or two days past the deadline of 20th April.
- When samples do not contain:
    - all flagged work,
    - 4PSOW's that flag two highest grades per criterion,
    - teacher's instructions for flagged investigation,
    - the cover sheet signed by the teacher.

Check through samples for the above as they arrive so that IBCA have time to contact the school and get further evidence sent out.

- When co-authored report has been submit as flagged work for re-marking.
- When you see evidence of complete or partial collusion i.e. word-for-word identical paragraphs in two reports.

These last two are very serious and may require a Problem Report Form (PRF) to be filled in.

Amendment for Nov 2009

Subject guide page 26 Example considerations when assessing sufficiency of data could be the following: If a trend line is to be plotted though a scattergraph then at least five data points are needed, *so* the plan should allow for repeated measurements to calculate a mean (for example, repeat calorimetric determinations when investigating an enthalpy of reaction). The plan should show an appreciation of the need for a trial run and repeats until consistent results are obtained in titrimetric determinations. *So* should be *or* therefore five data points, no repeats, sufficient for c.

Higher level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 8	9 – 17	18 - 25	26 - 29	30 - 32	33 - 35	36 - 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 the 99 G2's that were returned. 71% found that the paper was of a similar standard, compared with last year, 11% felt that it was a little more difficult and 17% thought that it was a little easier. Only 1% considered the paper much easier. 93% thought that the level of difficulty was appropriate, 3% too difficult and 4% too easy.

Syllabus coverage was considered satisfactory by 23% and good by 76%. 1% stated that the syllabus coverage was poor. There were several G2 general comments also in relation to the balance of questions on the paper. However, it should be noted that all Paper 1's are constructed on the basis of a general template which balances the number of questions per topic. This balance of topic questions may vary very slightly for each examination. In addition, 32% felt that the clarity of wording on the paper was satisfactory and 68% considered that the wording was good. The presentation of the paper was considered satisfactory by 19% and good by 81%. Performance on the paper indicated that it was reasonably accessible.

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 96.50% to 4.13%, and the discrimination index, an indication of the extent to which questions discriminated between high- and low-scoring candidates, ranged from 0.56 to -0.08 (the higher the value, the better the discrimination). The following comments were made on selected individual questions:

Questions 1, 2, 3 and 4

Some respondents stated that in many of these introductory questions there was too much mathematical rigour. However, these questions are based on Topic 1: Qualitative Chemistry from the guide and hence often tend to have a problem-solving component by their very nature. For these four questions, performance overall was highly satisfactory and in fact ranged from 79.83 to 56.64 in terms of the difficulty index.

Question 10

Two respondents stated that the reaction of chlorine with water was not on the syllabus. This is incorrect as this is specifically stated explicitly in AS 13.1.2.

Question 11

There were a number of G2 comments on this question and this question was discussed fully during GA. The question was the third most difficult question on the paper, with an associated difficult index of 27.44. However, as the question did ask candidates to choose the **best** description of intramolecular bonding in HCN from the four choices given, it was agreed that answer D was the valid correct answer.

Question 12

One respondent stated that the structure of SF_4 is not specified in the teachers note corresponding to AS 14.1.1. This is a comment that has been made at length in previous subject reports. The AS states that candidates should be able to determine the shape and bond angles of species with five or six negative charge centres using VSEPR Theory. In the teaching programme, examples such as PCl_5, SF_6, XeF_4 and PF_6^- should be definitely included. However, any species with five or six negative charge centres could be asked in a question and hence examples are not restricted to these latter four examples.

Question 14

Two respondents suggested that the terms axial and sideways overlap are confusing. However, these terms are also clearly mentioned in the teachers note corresponding to as 14.2.1 and have also been used previously on examination papers.

Question 19

In this question which referred to the Born-Haber cycle for the formation of LiCl, two respondents stated that the question was confusing especially for ESL candidates. In fact, the 68% of candidates got the correct answer, namely A and it was not felt that the wording of the question would have posed any problem even for ESL candidates.

Question 24

One respondent stated that candidates had to assume that equilibrium has been established since the question does not make this clear. It was felt that this is clearly implied in the question by stating that the container was closed and at constant temperature.

Question 35

There were six G2 comments stating that the correct IUPAC name for the compound was in fact 2-methylbutane and not methylbutane as given in the answer to A. This is correct in fact.

However, 52% of candidates chose A (methylbutane) as the correct answer and hence it was felt that the fact that the 2 was missing did not cause a problem for candidates when they had to make a choice from the four answers given in the question. In the published version of the question paper 2-methylbutane will be used.

Question 37

One respondent commented that the answers were written in an atypical format (and not the more conventional R1CONHR2 format) and hence this may confuse candidates. This was not the case and 82% of candidates got this question correct. If candidates understood the chemistry of the reaction there is no reason why they should not have able to determine the correct answer, A, $CH_3CH_2NHCOCH_2CH_3$ from the choice of answers given.

Question 39

One respondent stated that there were two answers to this question (A and D). The only correct answer is D, namely that, the enantiomers of a chiral compound rotate the plane of polarized light in opposite directions. Enantiomers have the same physical properties. However, diastereomers which are stereoisomers that are not enantiomers can have different physical properties.

Question 40

There were two G2 comments on this question, which stated that some of the alternate answers could also decrease random error. The question clearly asks candidates to choose the best method to decrease the random uncertainty of a measurement in an acid-base titration and 78% got the correct answers which is A i.e. to repeat the titration.

Higher level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 15	16 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 90

General comments

The range of marks awarded varied; the best candidates showed a thorough command of the material and a high level of preparation, although even these candidates struggled often in some of the newer or harder areas of the course, such as the mechanism of elimination reactions, the Arrhenius equation graphical problem, the advanced equilibrium problem etc. Generally the paper was found to be very accessible with a balance between straight-forward questions and some more challenging parts embedded in each of the Section B questions.

The paper overall had a new fresh look to it, particularly in Section A, but this did not appear to greatly throw many candidates in tackling the individual questions. However, some parts of Section B, as stated above did pose some problems for the better candidates.

Teachers' impressions of the paper were conveyed by the 89 G2 forms that were returned. In comparison with last year's paper, 79% felt that it was of a similar standard, 1% thought that it was a little easier and 17% were of the view that the paper was a little more difficult. Only 3% considered the paper much more difficult. 93% considered the level of difficulty of the question paper appropriate and 7% too difficult. Syllabus coverage was considered good by 74%, satisfactory by 25% and poor by 1%. Clarity of wording was considered good by 75% and satisfactory by 25% of respondents. The presentation of the paper was thought to be good by 78%, satisfactory by 21% and poor by 1%.

In general for the first paper of a new curriculum, the paper appears to have been well received and well-balanced, based on G2 comments and overall candidate performance. This was also reflected in the grade distributions and the paper certainly appears to have been very accessible for candidates, with plenty of opportunity for candidates to convey their knowledge of chemistry.

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

- Definition of a ligand
- Groups and periods
- Dispersion forces and hydrogen bonding
- Molecular polarity and drawing dipole moments
- Advanced equilibrium problems
- Electroplating
- Arrhenius equation

- Definition of average bond enthalpy
- Organic reaction conditions
- Two-step organic syntheses
- Mechanism of elimination reactions

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

- Measurement and data-processing
- pH calculations
- Orbital diagrams
- Standard change in free energy calculations
- VSEPR Theory
- Order of a reaction type problems
- Standard enthalpy change calculations
- Geometrical isomerism

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

Section A

Question 1

There were a number of G2 comments in relation to the new style, with most of these commenting on the different wording, style and format. Although the style of this question was new compared to the previous curriculum, candidate performance in general was very good here and this question tested a number of aspects of the new curriculum such as hypothesis, measurement and data processing.

One specific G2 questioned the use of the command term, comment, even though this is a listed Objective 3 command term, as shown on P. 12 of the new guide. For (a) most candidates managed to score at least one mark in this question. The most common error involved candidates stating ketone instead of ester. Many candidates also stated that the functional group was benzene, instead of stating benzene ring. In (b) (i) and (ii) were generally well answered, although a number of candidates gave M_r as 138 for $C_7H_6O_3$ and 180 for $C_9H_8O_4$ respectively which should not be encouraged in the teaching programme. Candidates should use the values given in the Chemistry Data Booklet. Use of scientific notation should also be encouraged where possible. For part (iii) most candidates were able to determine the percentage yield as 61% and in (iv) the majority of candidates were able to state the requisite number of significant figures and a large proportion also scored the second mark for the percentage uncertainty, namely 0.80%. Part (v) was basically testing candidates understanding of the idea of yield and to do so they had to link this back to the equation given in the question in the synthesis of aspirin.

A number of possible answers were allowed here, such as the fact that the sample may be contaminated with ethanoic acid (which can be determined by looking carefully at the reaction), or simply that the sample was impure or that the aspirin was not dry). Specific examples of systematic errors were also allowed. This question proved to be a good discriminator between the strong and weak candidates. Part (vi) was very well answered by most candidates, and many scored both marks. Part (vii) showed Brønsted-Lowry theory was well understood by the vast majority of candidates. A small minority wrote $C_2H_3O_2^-$ for the conjugate base of ethanoic acid, instead of CH_3COO^-. One respondent stated that this was also assessed in Q.25 of Paper 1. In Q.25, the question is based on the difference between the Brønsted-Lowry theory and Lewis theory, whereas the emphasis in (vii) is on the nature of the conjugate base of ethanoic acid. The first part was really asked to assist candidates in writing the conjugate base.

Question 2

Part (a) (i) proved to be a well known topic where only weaker candidates couldn't finish the calculation. For (ii) although a significant number of candidates knew that benzoic acid was a weak acid, only the better candidates explained this based on the fact that K_a is << 1. Part (iii) was very well answered, but even the better candidates often forgot to state one assumption made in the calculation. Surprisingly not many candidates scored all three marks in (b)and for (c) quite a significant number of candidates lost this mark as a result of suggesting CO and CO_2. Several candidates stated acids instead of oxides and therefore lost the mark here. One G2 respondent stated that this question was off-syllabus. This is not correct, as this is a clear Aim 8 type question, which is another feature of the new syllabus, as indicated by AS 3.3.2, and referred to in the corresponding teachers note.

Question 3

Most candidates were able to draw the dumbbell shaped p_z orbital, although some candidates drew all three p-orbitals, hence failing to read the question carefully. For (ii) the electron configuration of Fe^{3+} was well answered compared to recent sessions. The very weak candidates wrote incorrect answers such [Ar] $4s^23d^2$ and some very weak candidates just gave the electron arrangement 2, 8, 13, which would be a typical SL type answer. The definition of a ligand was poorly answered (iii) by even the strongest candidates. In general candidates showed some understanding but good definitions were rare. Very often candidates did not mention dative covalent bonding and some said that ligands are simply just lone pairs of electrons. In part (iv) most candidates referred to the splitting of d orbitals and related colour to d to d transitions. A very high number of candidates scored at least two points. Often candidates did not mention partially filled d subshells or did not score the point: frequencies of visible light absorbed by electrons moving from lower to higher d levels, colour due to remaining frequencies. The orbital diagram of selenium (v) was very well answered by most candidates. The only minor mistake for the weaker candidates involved lack of understanding of Hund's Rule for $4p^4$.

Question 4

This cohort showed a much better understanding of this topic overall in all parts of Question 4 compared to previous sessions and even weaker candidates often scored nearly full marks here. In (a) the most common mistakes included: failure to consider the correct amount of moles of products/reactants, incorrect identification of values or wrong use of convention. It also should be noted that the correct units of $\Delta H^{\ominus}$ here in the answer will be kJ, since n is used in the equation, as explained in previous subject reports.

Part (b) was another question where the vast majority of candidates scored full marks. Free energy calculations (c) continues to prove problematic for many candidates. Candidates very often lost the first mark due to wrong use of units. ECF allowed them to score the second. In contrast most candidates showed a clear understanding of the relationship between the sign of $\Delta G^{\ominus}$ and spontaneity.

Section B

Question 5

Part (a) was very poorly answered which was surprising at HL. Most candidates described groups correctly but only a small majority stated that for a period the electrons are in the same valence level. Part (ii) was well answered. For (b) VSEPR theory in general was well answered. The most common mistakes involved candidates failing to include square brackets or lone pairs of electrons or charges. Four G2 comments stated that expanded octets are not on the syllabus. However, AS 14.1.1 states explicitly that candidates should be able to predict the shape and bond angles of species of five and six negative charge centres. Four examples are included in the teachers note, including SF_6, but it has to emphasized again, as in previous subject reports that examples should not be confined in teaching programmes to just these four examples. Even SF_6 is a clear example of an expanded octet type structure, as is SiF_6^{2-}, as asked in this question. There were five other G2 comments again stating the fact that NO_2^+ is off-syllabus. Based on AS 4.2.7, this example is clearly on the syllabus as the AS states that candidates should be able to predict the shape and bond angles of species of two, three and four negative charge centres. All the examples in the teachers note should be covered at a minimum in the teaching programme, but these are not the only examples.

This is an objective three based AS and hence the key command term here is predict. Many candidates correctly explained the trend in increasing boiling points in (c) in terms of increasing strength of the London dispersion forces, but some failed to mention the fact that the hydrogen bonding is between the molecules in ammonia. Overall, this question was very poorly answered and understood, which is very surprising at HL. There were seven G2 comments referring to (d); some respondents felt that the candidates had to answer the question by determining the shape of both NO_2 and CO_2 using VSEPR Theory. This is a classic example of candidates reading the question carefully and not making unnecessary assumptions in relation to what is being asked. Only three marks are allocated to this question and hence this should be another clue as to suggest that the answer can be given in a concise manner. All candidates had to do was determine the fact that both species are XY_2 species (not XYZ even) and hence can only be one of two geometries, either linear or bent. CO_2 must be non-polar since it is a linear geometry and hence the two dipole moments cancel each other out, yielding a net dipole moment of zero. In the case of NO_2, the geometry must be bent, and therefore there is a net dipole moment meaning it is a polar molecule. A simple diagram of the two species with the two bond dipole moments in each case and the resultant net dipole moment (in the case of NO_2) would have scored both marks. There was no need to show lone pairs of electrons or isolated electrons etc. to answer this question, as candidates were not asked to write Lewis structures etc. Some candidates wasted time here trying to work these out and even some candidates thought that there might even be a mistake in the question and tried to answer the question with NO_2^-, because this is an example given in the teachers note in AS 14.3.1, based on delocalization.

The very best candidates did draw dipole moments, as the question did ask for diagrams, when explaining polarity, as opposed to simply a description in words. For (e) many candidates did not score the first mark for the macromolecular structure of silicon dioxide, but did score the second mark which referred to covalent bonding. The number of candidates that stated that silicon dioxide was a linear molecule was alarming. In (f) (i) although the second mark was scored by a large number of candidates, a significant majority gave the name of the compound as methanamine, instead of methanamide. Hybridization was usually well answered in part (ii), but sometimes candidates did not score the mark due to lack of specific subject vocabulary. Although candidates often had some understanding of sigma and pi bonding, very few mentioned electron density in (iii). For (iv) one G2 comment stated that the hybridization of N in $HCONH_2$ will in fact be sp^2 due to the planar nature of the NH_2 group here in this example, which is in fact correct, although it is unlikely that candidates at this level would know this. Nearly all candidates gave sp^3 hybridization for N, which they based on a perceived pyramidal type geometry, like in ammonia. For this reason, during GA, we decided to allow both hybridizations, even though the correct answer is actually sp^2 in this example.

Question 6

Many candidates had little difficulty in writing the equilibrium constant expression for (a) (i). One respondent stated that K_p is more appropriate for gaseous equilibria, which is correct, but Kp's are not required in the syllabus (AS 7.2.1 and corresponding teachers note). In (ii) an overwhelming number of candidates were able to score the first mark but did not refer to the gaseous state and hence lost the second mark. For part (iii) most candidates obtained the first mark but often failed to score the second due to incomplete explanations. Part (iv) was another question where candidates easily scored the second and third mark. Although this has been asked a number of times in recent sessions, some candidates still do not state that the rates of both the forward and reverse reactions increase **equally**.

(b) was considered a very challenging question for candidates, and usually only the better candidates scored all four marks. In (c) (i) most candidates scored two marks and for (ii) the better candidates obtained both marks but weaker candidates tried to answer this question in terms of delocalized electrons. Very few candidates scored all five marks in (iii), the most common mistake involved not writing the liquid state for Na. Other mistakes involved candidates mixing up the redox processes at each electrode. Although a significant majority scored the mark in (iv), only the better candidates stated that Al does not rust or is less dense. Stating that Al was lighter was however accepted. Electroplating was a topic only partially understood by candidates, and so only a few candidates obtained all three marks in (v). Often the nature of the electrode was mixed up or in many cases incorrect electrolytes were given.

Question 7

Surprisingly, the rate of reaction was only correctly defined by approximately 50% of candidates in (a) (i). The equation for the reaction of magnesium carbonate with dilute hydrochloric acid was not well answered (part (ii)), and often candidates did not write correct formula or forgot to include water as a product. Parts (iii) and (iv) were well answered by most candidates, although the weaker candidates often only scored two or three marks. Part (b) (i) was well answered and many candidates scored all four marks. Some candidates used a simple mathematical approach and those that followed this method typically were able to deduce the order correctly.

For (ii) most candidates were able to write the rate expression for the reaction. In (iii), determining the value of the rate constant and its corresponding units was difficult for many candidates and only the better candidates scored both marks. Many mistakes were seen in the units. Part (c) (i) was usually well answered, but a common mistake for (ii) involved candidates writing O_2 instead of O. The definition of activation energy was well answered in (d) (i). Part (ii) was a question where most candidates scored at least one/two marks although perfect answers were less common. Reasons leading to the loss of marks included: absence of axes, incomplete libelling of axes and the incorrect identification of the position of the transition state. Parts (iii) and (iv) were very poorly answered for such a fundamental topic. All sorts of errors were evident, including incorrect gradients, inability to rearrange the Arrhenius Equation etc. Even the better candidates struggled greatly with this question, even though this comes straight from AS 16.3.2.

Question 8

The definition of average bond enthalpy, (a) (i), has been asked a number of times in previous sessions, but still candidates rarely are able to define this precisely. Very few mentioned the gaseous state and the fact that the average values are obtained from a number of similar bonds/compounds. Most candidates were able to score some marks on both parts of (ii) and (iii). Part (iv) was well answered by the majority. Weaker candidates usually failed to score the third and fourth mark. Most candidates were able to identify the catalyst in (v) and had no problem stating a use of the ethanol formed. One respondent stated that there are no references to the uses of ethanol on the syllabus other than as a fuel, however this certainly did not appear to be a problem for most candidates and clearly many teachers discussed the uses of ethanol in general as a typical Aim 8 type extension to the teaching material. In addition, one of the possible answers was esterification, which candidates should know, as this is explicitly stated in AS 20.4.1. In (b) (i) and (ii) only a few candidates answered both questions correctly. Fewer candidates scored one mark in one or both by correctly presenting the structural formulas. Conditions and reagents were in general poorly known.

One G2 comment stated that there is no need for a two-step reaction here and that the product could have been made in one step by reacting the alcohol with the carboxylic acid. Although this is true, this was not the purpose of the question and a common feature of organic synthesis in general is that products can be made via either single or multiple-steps, often because of availability of reagents, different yields etc. Hence, it is important that candidates appreciate this aspect of organic chemistry synthesis. Almost nobody answered (c) correctly. Candidates identified this as an SN1 mechanism. There were a number of G2 comments on this, and one respondent expressed surprise that sodium ethoxide was used as a reagent. However, the candidates were clearly told in the question that the reaction was an elimination reaction and hence should have been able to write the mechanism, as outlined in AS 20.3.2. Part (d) (i), (ii) and (iii) were all well answered questions but some candidates lost a mark in (iii) because the structures were not represented as clear mirror images of each other.

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
- Always use relative atomic masses quoted in the Data Booklet when calculations are required
- Consider the units and the appropriate number of significant figures for the final answer in calculations
- Practise writing balanced equations and half equations
- Always label the axes on graphs
- Practise drawing graphs
- Practise writing dipole moments
- Solve the Arrhenius Equation using a graphical method
- Consider the various steps of the common organic reaction mechanisms, with focus on the positions of curly arrows and reaction conditions. Some attention should be given to elimination reactions here in this context.

Higher level paper three

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 paper discriminated well with the range of marks awarded being very wide. Most candidates attempted answers to all parts of their chosen options. All of the options had questions where all but the very weak candidates were able to demonstrate their factual knowledge but also contained questions which tested understanding. However, it is difficult to understand candidates who scored so poorly after having attended Chemistry lessons for two years. It seems many candidates and probably some teachers did not dedicate the necessary amount of time and effort to learn the options, not fully realising that apart from understanding the processes as is required for Paper 2, many topics require the acquisition of additional concepts and vocabulary. Thus, it is not enough just to read the Options – these have to be studied in depth in order to do well in paper 3.

In some schools, a range of Options were selected by candidates and it was clear that not all of the Options selected had been covered. It is best for candidates to only attempt the Options covered in class. However, it was evident that in several cases candidates did not study as much as they should, or had studied the option idependently. Some others relied mainly on rote learning. The most popular options were B, D and E, followed by A, C and G. The new Option F (Food Chemistry) was only rarely answered.

Teachers' impressions of this paper were conveyed by the 92 G2 forms that were returned. In comparison with last year's paper, a majority (56%) thought this year's paper to be of a similar standard, 25% felt that it was a bit difficult and 19% found it much more difficult. Yet this contradicts the overall performance which was very similar to last year’s.

76% of the respondents thought the level of difficulty was appropriate with almost all the rest stating that it was too difficult. Syllabus coverage was considered satisfactory by 38%, poor by 21% and good by 41%. Clarity of wording and presentation of the paper was considered satisfactory or good by 97% of the respondents. The presentation of the paper was found to be either satisfactory (29%) or good (71%).

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

This examination revealed weaknesses in candidates' knowledge and understanding in all options. Levels of knowledge and understanding were sometimes poor in the topics that were new to the programme. Though this is a HL subject, candidates had trouble writing chemical equations correctly. Specific weaknesses per Options included:

Option A

Difference between absorption and emission spectra, understanding of UV spectroscopy, identifying the correct splitting pattern in NMR and relating conjugation of double bonds to wavelength/absorbed energy.

Option B

Chirality of C1 in glucose, polymeric forms of starch, HDL and LDL and the chemical difference between the two, explanations of the relationship between enzyme activity and substrate concentration.

Option C

Description of an alloy and the reasons for modifications in the structure and properties of its components, workings of the lithium-ion battery, similarity and difference between fuel cells and rechargeable batteries, principles of liquid-crystal display devices, free radical mechanism in the manufacture of low density poly(ethene) and structural features of condensation polymers that affect its properties

Option D

How aspirin can be made water soluble and an equation for the reaction, writing redox equations correctly for the oxidation of ethanol to ethanoic acid by dichromate(VI).

Option E

CFCs and the ozone layer, the role of ammonia in acid deposition, SOM; sources of organic soil pollutants PAHs and organotin compounds.

Option F

Explanation of why raw meat changes colour on standing, antioxidants, explanation of colour change in terms of changes in bonding in lycopene when bromine is added to tomato juice and differences between BHT and B-carotene with reference to their structures.

Option G

Explanation of the term delocalized electrons, the relative rates of reactions of hydroxide ions with chlorobenzene and (chloromethyl)benzene, accurate drawing of curly arrows in organic mechanisms.

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

During this session excellent scripts were seen, invariably from those who had been taught two options, rather than from those who seemed to have been allocated little teaching time or who had made their choice of options on the day of the examination. It was pleasing to see the use of precise scientific language in many cases although some of the weaker candidates are still relying on jargon particularly in options B, C, D and E. Although often Options A and G are considered the more difficult, candidate performance was good yielding high marks compared to some of the perceived easier options such as Option D (Medicines and Drugs) and Option E (Environmental Chemistry). Good levels of knowledge, understanding and skill were demonstrated in the following areas:

Option A

Principles of TLC and IR spectroscopy, deduction of the correct structure and proton NMR peaks for ethanoic acid.

Option B

Structural features of cholesterol, negative effect of high LDL concentration in the blood, relationship between the structures of vitamin A and C and their solubility in water, effect of competitive inhibition on V_{max} and K_m.

Option C

The effect of the tempering process on steel and the environmental impact of iron and aluminium production.

Option D

Deduction of the structure of fluoxetine, determination of the amount of ethanol from the infrared spectrum, the relationship between the general structure of penicillin and its antibacterial activity and difficulties associated with solving the AIDS problem.

Option E

Formation of pollutants from the internal combustion engine and impact of increasing the fuel/air ratio and soil degradation.

Option F

Main nutrients in a can of meat, how canning increases the shelf life of the meat and function of sodium ascorbate.

Option G

Physical and chemical evidence for the presence of delocalised electrons in the structure of benzene, structural formulas of the elimination products of butan-2-ol, reaction between sodium hydroxide and ethanoyl chloride.

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

Option A – Modern analytical chemistry

Question A1

Candidates had difficulty distinguishing between an absorption and an emission spectrum and some did not refer to electron movements between ground state to higher state for the former and excited state to ground state for the latter. Some candidates did try to distinguish between the two by stating missing lines corresponding to energies absorbed for an absorption spectrum but failed to score the mark by omitting the fact that this spectrum is in fact continuous.

Many candidates incorrectly identified mass spectroscopy instead of proton NMR as the technique to distinguish between butn-1-ol and butan-2-ol. Although part (c) asks to outline the principle of thin-layer chromatography, few referred to paper chromatography. Some others described the method for carrying out TLC rather than outline the principle involved – it is essential that candidates spend time reading the question carefully before answering the question.

Many candidates calculated the correct Rf value in the range of 0.86 to 0.88, though a significant number did not measure the distance from the centre of the spot, leading to the wrong answer.

Question A2

Nearly every candidate got the formula $C_2H_4O_2$ correct and most stated the fact that the compound was ethanoic acid. The main mistake involved candidates omitting the + charge on the fragments, even though they usually were able to deduce CH_3 and COOH as the fragments.

Question A3

Many candidates had little trouble scoring full marks on the IR spectrometer question and some candidates even gave a carefully annotated diagram although the beam being split into two was sometimes left out. In deducing the structural formula of X, the most common mistake involved a carboxylic acid functional group instead of the aldehyde functional group. Generally, once candidates had the structure correct, many had little trouble predicting the splitting pattern.

Question A4

Most candidates simply stated double bonds and very few mentioned limited or isolated conjugation in identifying the feature that allows organic molecules to absorb UV light. Some incorrectly thought that the key feature is extensive conjugation. Others did not read the question carefully and listed partially filled d orbitals as the feature. The most common mistake in part (b) was that many candidates suggested that 1,4-pentadiene has conjugation (which it does not have). Very few discussed the compounds in terms of energy. Explanations tended to be unclear or vague, not referring to each compound in turn. The important points were: increasing wavelength means lesser energy; 1,3-pentadiene has two conjugated C=C double bonds whereas 1,3,5-hexatriene has three, thus the former requires more energy; the two C=C double bonds in 1,4-pentadiene are not conjugated (or separated by a sp3 C atom) and thus require the highest energy.

Option B – Human biochemistry

Question B1

Several candidates could not write the formula of glucose correctly due to lack of care and precision such as OH- or too many H's. Some drew ring structures in spite of the question asking for the straight chain structure of glucose.

Most candidates did not mention the presence of the chiral carbon though they could explain the difference between α and β–glucose. A number of candidates had no idea that amylose and amylopectin are the two polymeric forms of starch.

Question B2

Many were able to identify phospholipids but not triglycerides as two types of lipids (other than cholesterol) found in the human body. A very common but incorrect answer to the meaning of the terms HDL and LDL were high and low density lipids instead of lipoproteins. The chemical difference in terms of the proportion of proteins between them was answered correctly by very few candidates. The most common answers were in terms of saturation and the sizes of the molecules.

Question B3

The part on the comparison of solubilities of vitamins A and C was answered well as was the description of the effect of deficiency of either vitamin A or C and suggestions of two possible solutions to the deficiency.

Question B4

Instead of explaining the relationship between enzyme activity and concentration of the substrate, many candidates just described the relationship indicated by the graph. Many candidates were correctly able to describe why competitive inhibition may take place. On the other hand, others misinterpreted the question and wrote about the need for the inhibition. Where they had to explain, in several cases it was not well answered and when drawing the graph several candidates did not take into account that Km should be the same.

Option C – Chemistry in industry and technology

Answers to questions in Option C suffered from generalities rather than including chemical concepts and examples. Questions tended to be answered incompletely or incorrectly showing that candidates had some notion but were unclear about the principles involved.

Question C1

Very few realized that an alloy is an homogeneous mixture of metals or a metal and a non-metal. Only few candidates discussed the lattice and the atomic sizes and its effect on properties of metals – answers tended to show a lack of understanding of the chemistry involved. The effect of the tempering process on steel was generally answered well although some described the tempering process rather than its effect on steel. Discussion of the environmental impact of iron and aluminium production was also generally answered well although a surprising number of candidates had little idea.

Question C2

Answers showed a lack of understanding of the lithium-ion battery with many irrelevant answers. Candidates were unable to describe that the lithium-ion battery does not contain lithium metal. Rather, it uses a lithium salt in an organic solvent as electrolyte and involves the movement of Li+ ions between the two electrodes. Very few candidates scored partial marks in describing the migration of ions that take place at the two electrodes in the lithium-ion battery when it produces electricity. Very few were able to describe the migration of ions using half-equation at each electrode. Namely at the (–) anode, Li+ ions dissociate from the anode and migrate to the cathode, for example: $LiC_6 \rightarrow Li+ + 6C + e^-$. At the (+) cathode, the Li+ ions are inserted into the metal oxide (or phosphate) structure, for example: $Li+ + e^- + MnO_2 \rightarrow LiMnO_2$. Although many candidates were able to discuss one similarity and one difference between fuel cells and rechargeable batteries, others had no idea and wrote answers showing a lack of understanding of the principles involved in the functioning of fuel cells and rechargeable batteries, and thus were unable to discuss a similarity and a difference between the two.

Question C3

Although some candidates were correctly able to compare the positional and directional order in a crystalline solid, nematic phase liquid crystal and a pure liquid, many had no idea and made incorrect guesses. Only about a quarter of the candidates understood how LCDs worked.

Question C4

Many were able to state free radical addition as type of mechanism, but some stated only addition or had no idea although they should have been able to deduce from the information given in part (b) of the question. Often, the radical sign was incorrectly placed on the hydrogen atom or the R group in the product and candidates were unable to write an equation between the radical $RO\cdot$ and $CH_2=CH_2$. Very few attempted to describe correctly the motion of the electrons in sufficient detail. The answers given were too general in most cases. Distinguishing between addition and condensation polymerization solicited partial answers: candidates need to appreciate that in addition polymerization, unsaturated molecules (containing C=C bonds) add together without the elimination or removal of any atoms. Condensation polymerization, on the other hand involves bifunctional monomers (monomers with two reactive sites) that produce a larger molecule with the elimination of a smaller molecule (such as water). How the properties of condensation polymers depend on structural features turned out to be a challenging question in which few candidates scored partial marks.

Option D – Medicines and drugs

Question D1

The meaning of therapeutic window was answered correctly by many candidates, but there were also answers that showed a complete lack of knowledge of the term.

Question D2

Few candidates knew how to make aspirin more water-soluble – most answers showed a lack of understanding of the chemistry involved, namely reaction with NaOH to produce the ionic salt of aspirin. Many were able to deduce the structure of fluoxetine.

Question D3

The half reactions were answered correctly by very few candidates and this part seemed to present a challenge to candidates. The answer to part (i) required an oxidation half-equation, balanced with respect to both mass and charge, of ethanol with water to form ethanoic acid. Part (ii) involves the reduction of dichromate(VI) to Cr^{3+}. The colour change from orange to green in part (iii) had better responses. Few candidates appreciated that the infrared intoximeter detects the C-H bonds of ethanol. In other cases, candidates described the working of an intoximeter rather than explaining how the amount of ethanol is determined from the infrared spectrum.

Question D4

This question was generally done well. However, many candidates were unable to explain the importance of the beta-lactam ring in penicillin. The bonds in the opened structure blocks the action of the enzyme, transpeptidase, a non-reversible reaction that prevents cross linkage of peptides in the bacteria, which inhibits the synthesis and growth of bacterial cell walls.

Question D5

This part was generally done well. However, many candidates neglected to mention the similar metabolism of HIV virus to human cells. A small number did not describe the high price of the antiviral drugs or the socioeconomic or cultural issue related to solving the AIDs problem.

Option E – Environmental chemistry

Question E1

Many were able to answer part (a) correctly; however, the question refers to the internal combustion engine, but many candidates wrote the equation for the partial combustion of carbon rather than a hydrocarbon found in car petrol. The discussion on the impact of increasing the fuel/air ratio was not done well and many did not discuss VOCs at all. Also, many candidates did not give correct reasoning for the decrease in NO (in fact many said it increased). It seemed that candidates were making an effort to remember instead of trying to reason what would happen. Some gave answers for the increasing air/fuel ratio rather than fuel/air ratio.

Question E2

The equations for the depletion of ozone were correctly answered by few candidates. Instead of the catalysis being heterogeneous, some incorrectly identified heterolytic or homogeneous or surface catalysis. Why in spring the depletion was greatest was not very well answered either.

Question E3

This question was one of the poorest of this option; many candidates gave confused accounts and most did not discuss nitrification. Few explanations were correct and most candidates were unable to write correct equations either for the formation of ammonium salt with acid deposition or the conversion of ammonium ion to nitrate ion.

Question E4

This part on SOM was quite unsuccessfully attempted by most candidates. In many cases it gave the impression that they were trying to invent an answer, as if they had never discussed the topic before. Humus was a common answer for a main constituent of SOM, and very few noted that the animal and plant tissue needs to be decayed/non-living.

Most except the very best were incapable of relating nutrients providing capacity of the SOM constituent with presence of N or the ion exchange capacity of H of COOH. Additionally the irrigation associated problems were usually not identified and very few had any idea about the source of PAHs and organotin compounds.

Option F – Food chemistry

Question F1

Some candidates were not correctly able to describe the chemical composition of a triglyceride as an ester of propan- 1,2,3 - triol and three fatty acids, the word *ester* being often ommited.

Question F2

Although candidates were able to list protein as one of two main constituents in meat, some were not able to list fat/lipid as the other one. Many had some idea of how canning can increase the shelf life of meat but others presented confused answers and the function of sodium nitrite was often not listed correctly.

Question F3

The responses to the question were very poor with incomplete or unclear explanations. Very few candidates highlighted the role of the oxidation state of iron in determining the colour of the meat. Most candidates were unable to relate the addition of bromine to bond saturation, the shift of energy absorbance to violet/higher energy in the visible region and the transmittance of the complementary yellow light.

Question F4

Few candidates could state an example of a chelating agent such as salt of EDTA or explain the difference in action of BHT and β-carotene as antioxidants. Typically the structural characteristic of the presence of conjugated/alternate single and double bonds in β-carotene were not identified by many candidates. Neither was the radical scavenger activity of BHT and its association to the bulky tertiary alkyl radical substituted phenol identified.

Option G – Further organic chemistry

Question G1

Many candidates did not refer to the fact that the bonding electron pair is spread over three or more nuclei when discussing delocalization but often explained too vaguely in terms of free electrons and had great difficulty in explaining delocalised electrons. Candidates were generally able to state and explain one piece each of physical and chemical evidence for the presence of delocalised electrons in benzene. In the part on the chlorination of nitrobenzene, very few expressed the relative charge distribution of the different positions most candidates did not refer to the fact that the greater charge distribution is associated with the 3-position.

Question G2

Candidates generally knew what a Grignard reagent is and how to produce it

Question G3

This was typically answered well and, overall, Grignard reactions were well understood by candidates.

Question G4

Not many candidates were able to write the mechanism correctly. The sequence and identity of bonds broken and formed was often incorrect and many had trouble with drawing curly arrows correctly either in terms of where the arrows start to where the head of the arrow should point to. Others incorrectly identified the type of reaction as nucleophilic substitution.

Recommendations and guidance for the teaching of future candidates

- Impress upon candidates the importance of taking the time to read and understand the questions properly.
- Thoroughly review the command terms used in questions at the beginning of the course and explain the difference between these. Too many candidates lose marks as they do not address the question asked.
- Train candidates in answering questions giving full answers within the spaces provided – it should be stressed that candidates should not have to write on additional sheets for P3.
- Practice exam technique such as looking at the number of marks available and making sure that enough points are made to tally with the number of marks being awarded.
- Stress the importance of correctly writing balanced equations, formulas, significant figures, units and providing thorough explanations. These seem little details to the candidates but they need to understand that this is where they lose marks very often.
- Ensure answers are given from the chemistry and not a generalist point of view. This often happens in Options B, C, D and E questions and candidates do not gain marks because of lack of specific details containing chemical principles and concepts.
- Practice past papers as soon as possible. Not just answering the questions but doing group work exercises such as getting the candidates to highlight the salient points in the questions or putting them in their own words, making bullet points, learning to express precisely and concisely and in context.

Standard level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 7	8 - 12	13 - 18	19 - 21	22 - 24	25 - 26	27 - 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. A periodic table was provided. Each question had four possible responses with credit awarded for correct answers and no credit deducted for incorrect answers. The G2 forms provided teachers with an opportunity to compare this year's paper with last year's. Of the 87 G2s returned, 74% commented that this year's paper was of a similar standard to last year's paper, 3% thought that it was much easier, 8% that it was a little easier and 15% that it was a little more difficult. 93% felt that the level of difficulty was appropriate, 5% considered the question paper was too easy and 2% considered it too difficult.

Syllabus coverage was considered satisfactory by 25% and good by 75%. The clarity of wording was thought to be satisfactory by 29% and good by 71%. The presentation of the paper was considered satisfactory by 14%, good by 85% and poor by 1%.

Various comments were made about individual questions, some of which are addressed in the next section. There was a general comment welcoming a reduction in the number of questions requiring candidates to consider the validity of three statements. There was also a comment that the questions tested only on factual recall. This is however the nature of Paper 1, which is intended to emphasise objectives 1 and 2.

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

The difficulty index, which is the percentage of candidates achieving a correct answer, ranged from 92% to 24%, and the discrimination index, which compares the high-scoring candidates with the low-scoring candidates, ranged from 0.64 to 0.18. A higher value indicates better discrimination with the high-scoring candidates more likely to answer correctly and the low-scoring candidates more likely to answer incorrectly.

Questions 1, 2, 3 and 4

There were a number of comments that these questions had a high degree of commonality and that maybe other aspects of stoichiometry could have been tested. There were also a number of comments that these questions were testing mathematical ability rather than chemistry. Almost all of the calculations involved only required order of magnitude estimates to determine the correct response and hence did not require detailed mental arithmetic. In general the questions were tackled well with the mean difficulty index being about 56% and they also proved good discriminators with a mean discrimination index of >0.5.

Question 5

Though this did not affect the correct answer, this question wrongly gave the number of neutrons, rather than the mass number, as 91. The lack of blank responses, the high difficulty index of 75% (remember the higher the number the more accessible the question) and the discrimination index of 0.40 all indicate that this error did not affect the validity of the question.

Question 6

There were G2 comments about the mathematical ability required for this question and the format of the graph. The high difficulty index of 80% and satisfactory discrimination index of 0.42 would however indicate that it was accessible to candidates.

Question 10

This was by far the most challenging question on the paper, with a difficulty index of 24%, and many teachers commented about it on the G2 form. It appears that at SL many candidates were not familiar with the term “intramolecular” and in addition failed to assume that the pure liquid compound was being referred to, both of which seemed to create a degree of confusion. It did however appear more accessible to the better candidates, with a discrimination index of 0.18.

Question 12

The question proved surprisingly challenging, as indicated by a high number of blank responses and a difficulty index of 55%. This would seem to indicate that a disturbing number of candidates are not aware of the charges on the common ions. It was however a good discriminator with a discrimination index of 0.55.

Question 19

The difficulty index for this question was 58%, with incorrect responses distributed quite evenly over the distracters. It did however prove to be the best discriminator on the paper with a discrimination index of 0.64.

Question 26

This proved to be one of the most challenging questions on the paper with a difficulty index of 42%, with more candidates selecting oxidation products from a primary alcohol (B and C) than the correct response. It did however prove to be a very good discriminator with a discrimination index of 0.56.

Question 28

This question provoked a large number of comments on G2 forms, mainly stating that 2-methylbutane should have been given rather than just methylbutane. There is some merit to this although in this case the word methylbutane alone is not ambiguous. Though many were attracted by the incorrect response of 3-methylbutane, a greater number of candidates answered the question correctly and it proved quite a good discriminator, with a discrimination index of 0.41.

Standard level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 8	9 - 16	17 - 20	21 - 26	27 - 32	33 - 38	39 - 50

General comments

This paper indicated a very broad range of capabilities of candidates. Some candidates struggled with even the most basic concepts while others demonstrated an excellent depth of understanding of the standard-level course. It produced a range of responses from almost full marks to zero. In general, answers lacked precision in terms of wording used and explanation were often vague and repetitive. There were some schools where candidates seemed unfamiliar with most of the subject material and left many areas of the question paper blank.

Candidates must pay particular attention to the number of marks allocated to the question and write their answers accordingly. Calculations must be shown clearly and should be checked for accuracy, significant figures and units where appropriate.

The 85 G2 forms that were returned from this region, conveyed teachers' impressions of this paper. In comparison with last year's paper, three-quarters felt that it was of a similar standard, while the remainder of respondents opted for a little more difficult. The vast majority (94%) of the respondents thought the level of difficulty was appropriate. Syllabus coverage was considered good by half and satisfactory by the remainder of respondents. Clarity of wording was considered good by three-quarters and satisfactory by the remainder of respondents. The presentation of the paper was considered good by three-quarters and satisfactory by the remainder.

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

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

- recognising different functional groups
- acid-base character of the oxides of period 3 elements
- enthalpy level diagram
- definition of the term average bond enthalpy
- S_N2 mechanism
- State symbols
- Structure of silicon dioxide

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

Topics generally well answered included:

- Mole calculations and theoretical yield
- empirical formula and A_r calculations
- calculation of enthalpy changes from average bond enthalpy values
- equilibrium

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

Section A

Question 1

In (a) Some candidates gave the correct three names of the functional groups; however some candidates gave answers such as alkene, ketone, aldehyde, ether, and carbonyl. Candidates did not have problems determining the number of moles of salicylic acid used in (b) (i), although a few gave the answer with one significant digit only. For (ii) the majority of candidates correctly used the value obtained in (i) to calculate the theoretical yield of aspirin.

In (iii) the percentage yield was calculated correctly in most cases and the calculation of the percentage uncertainty (part (iv) proved to be a little more difficult, but many candidates gave the correct answer of 0.80%. Part (v) was correctly answered by only a few candidates who stated that aspirin was contaminated or that the aspirin was not dry. Nearly all the candidates correctly stated that the suggested hypothesis was not valid in (vi), giving the right reasons. In (vii) most candidates gave the correct definition of an acid according to Brønsted-Lowry theory, although a few defined the acid according to Lewis theory. The conjugate base of the ethanoic acid was not always correct.

Question 2

The majority of candidates gave the correct answers to (a), but a few were confused about the acid-base character of the oxides of aluminium and silicon. Part (b) proved to be a difficult question. Not many candidates gave the name or formula of an acidic gas produced by an industrial process. Some wrong answers were: CO, SO, H_2SO_4, CFCs, Methane, NH_3. There were a few good answers to (c); measuring the conductivity or the reaction with magnesium or calcium carbonate was a possible method for distinguishing between a strong and a weak acid of the same concentration.

Question 3

It was pleasing to see the majority of candidates determine the correct empirical formula of PAN. Also, candidates showed the proper working with all the appropriate steps.

Question 4

Most candidates gave the correct definition of activation energy in (a) and for (b) the two conditions needed for a reaction to take place were given by the majority of candidates. In (c) some of the enthalpy level diagrams had many labels missing. Axes weren't always labelled, one of them was wrongly labelled as delta H, and the curves of Ea with and without catalyst were not properly indicated. A few answers showed an endothermic reaction instead.

Section B

Question 5

Nearly all candidates deduced the equilibrium constant expression for the reaction given in (a) (i) and there were many good and complete answers here for (a) (ii). Some candidates did not state that the forward reaction was exothermic or the reverse reaction was endothermic, when trying to decide the effect of an increase in temperature on the yield of SO_3. In (a) (iii) most candidates correctly stated that the catalyst would not have any effect on the value of Kc. In part (iv) many candidates correctly stated that the catalyst would not have any effect on the position of equilibrium, but some did not explain why. In (b) (i) some candidates defined oxidation as the loss of electrons but not in terms of oxidation numbers, as required by the question. Some candidates described a voltaic cell instead of an electrolytic cell in (b) (ii). In some cases the electrodes were wrongly labelled or wrongly connected to the battery and the electrolyte was missing. A large number of candidates stated that solid sodium chloride did not conduct electricity because it did not contain electrons in (iii). However some gave the correct answer indicating the free/moving ions as the particles responsible for the conductivity. Part (b) (iv) was generally well answered. Most candidates lost a mark because they did not give the correct state symbols in the overall reaction.

Most candidates gave a correct answer as to why aluminium is preferred to iron in many uses in (b) (v) and there were very good answers indicating the main differences between an electrolytic cell and a voltaic cell in (vi).

Question 6

The definition of average bond enthalpy given by most candidates was not complete in (a) (i). The word gaseous was missing and the fact that it is an average of values from bonds in similar compounds was very rarely mentioned. In (ii) the calculation of the standard enthalpy change for the combustion of ethanol was done correctly by most candidates. In (a) (iii) the amount of energy produced by 1g of ethanol and by 1g of octane was correctly calculated by some of the candidates. Candidates gave correct formulas for the aldehyde and the carboxylic acid in (iv), but the conditions required to obtain a high yield were not correctly stated or were absent. In (a) (v) most candidates correctly stated that ethanol would have a higher boiling point than ethanal because of the presence of hydrogen bonding in ethanol and in (vi) the catalyst for the conversion of ethane into ethanol was not always identified. In (b)(i) most candidates stated correctly that methylbutane would be a structural isomer of pentane. Part (ii) was not answered very well, some of the mistakes were: the curly arrow was coming from the H and not from the lone pair of electrons; dashed lines were not used in the transition state; there was no charge on the transition state and Br^-, one of the products, did not have the charge.

Question 7

In general the definition of isotopes was correct in (a) (i), but there are still some candidates who stated “isotopes are elements” and not “atoms of the same element”. Nearly everybody gave the correct answer of 28.1 for the relative atomic mass of silicon in (ii). Part (a) (iii) proved to be very difficult for the candidates. There was a lot of confusion about the two molecules; some candidates stated that they had the same double bond. Not many candidates mentioned the giant covalent structure for the silicon dioxide or the simple molecular structure for the carbon dioxide. In (b) (i) the majority of candidates drew the Lewis structure of the ammonia molecule correctly showing the lone pair of electrons and the correct shape and angle and (ii) was well answered by most candidates. They realised that NH_3 had a higher boiling point than PH_3 because of the intermolecular hydrogen bonding present in NH_3. For (c) most answers given here showed diagrams of the three molecules, including distribution of charges, bonding and shapes. Some candidates gave very good answers showing a good understanding of the polarity of molecules.

Recommendations and guidance for the teaching of future candidates

Candidates and teachers are advised to bear in mind the following points.

- Teachers are strongly advised to refer to past examination papers and their mark schemes to assist candidates with examination preparation.
- Candidates must know the meaning of the different action verbs that appear in the assessment statements and in the examination papers.
- Candidates must read the question carefully and correctly address all points. Working must be shown for all calculations so that the chance of obtaining ECF marks is maximised.
- Candidates must ensure that they cover a sufficient number of different points to score the full range of marks assigned to each question.

Standard level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 4	5 - 8	9 - 12	13 - 16	17 - 21	22 - 25	26 - 40

General comments

The levels of achievement were as usual very variable. Some candidates showed good command of the material and were clearly well prepared, meanwhile others did very poorly. In general however, it seems that the introduction of the new syllabus was felt most with paper 3 and for many candidates the questions of the new topics were quite challenging.

Of 84 G2 forms with teachers´ comments on the paper, 52% felt that it was of similar standard as last year, meanwhile 45% found it more difficult. The level of difficulty was perceived by 73% as appropriate, meanwhile 26% found it too difficult. Responses also varied in syllabus coverage: 81% answered that it was satisfactory and good, meanwhile 19% found it poor. The clarity of wording and presentation of the paper were found to be good.

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

Within each option, the following repeated weaknesses were:

Option A

- The distinction between absorption and emission spectrum
- The calculation of Rf

Option B

- The straight-chain structure of glucose and an explanation of the difference between α and β glucose
- The chemical difference between LDL and HDL

Option C

- Equations of catalyzed reactions
- The lithium-ion battery

Option D

- Redox equations of a breath analyzer when ethanol is present in the breath
- The aids problem

Option E

- The effect of fuel/air ratio on pollutants
- SOM
- Sources of soil pollutants: polyaromatic hydrocarbons and organotin compounds

Option F

- An explanation of colour changes in meat upon standing
- An explanation of colour of food pigments

Option G

- An explanation of the term delocalized electrons
- Reaction mechanisms

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

The areas that seemed well understood were:

Option A

- Atomic absorption spectroscopy
- Identification of structures with the help of spectroscopy

Option B

- The characteristic four ring structure of cholesterol
- The relative solubility of vitamins A and C
- The effects of vitamin deficiency and possible solutions

Option C

- The tempering process on steel

Option D

- The action of antacids
- The colour change that occurs to the acidified dichromate(VI) if ethanol is present in breath

Option E

- The source and properties of CFCs

Option F

- The identification of the cis-fatty acid as the isomer with the highest melting point
- The advantages and disadvantages of hydrogenating fats

Option G

- The description of the relative rates of the reactions of hydroxide ions with chlorobenzene and chloromethylbenzene
- The elimination products of heating butan-2-ol with phosphoric acid.

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

Option A – Modern analytical chemistry

Question A1

Many candidates lost marks as they made no reference to lower and higher/exited energy levels (a) but most identified correctly the separating techniques (b).

The principle of thin-layer chromatography seemed understood as well as its advantage of paper chromatography (c). There were difficulties in the calculation of R_f, some candidates did not seem to know what it means, others what to measure.

Question A2

Most candidates gave the correct molecular formula (a) and many candidates identified the fragments correctly, though many candidates did not give the charge of the ion (b).

Many candidates identified acetic acid (c).

Question A3

Most candidates did not understand clearly what occurs in atoms when infrared light is absorbed (a). Those candidates that answered (a) correctly, generally answered (b) correctly.

Many candidates only gave at least one reason why X cannot be the given formula (c) and many gave the correct formula for X, but some could not identify the relative areas under the peaks.

Option B – Human biochemistry

Question B1

The better candidates gave the correct structure (a).

Many candidates named the two isomers correctly, few could explain clearly why they are formed. Many candidates think α- and β-glucose are optical isomers (b).

Many candidates identified amylose and amylopectin (c) but few candidates could compare structure and linkage (d).

Question B2

Most candidates identified the steroid backbone (a) but many named only one other type of lipid (b).

Some candidates stated correctly the terms of HDL and LDL but only the very few named the proportion of proteins as their chemical difference (b)

Most candidates compared at least two features of the structures of linoleic and linolenic acid (c).

Question B3

Most candidates answered that vitamin C is water soluble and vitamin A not, although some were vague in their explanations why (a) and many identified correctly the deficiency symptoms and named at least one solution.

Option C – Chemistry in industry and technology

Question C1

Many candidates did not gain the mark as they omitted the required word *homogeneous* (a), but they could explain how alloying can modify the structure (b). The effect of tempering was often described correctly (c), though some candidates think it makes steel harder. Most candidates described the environmental impact of the production (d).

Question C2

Many candidates described homogeneous and heterogenous catalysts, but not their mode of action. Poor chemical equations were given and correct state symbols were rare.

Question C3

Only the better candidates described how the lithium-ion battery overcomes the reactivity of lithium (a) and the description of the migration of ions was poor (b).

The similarity and difference of fuel cells and rechargeable cells had better resposes (c).

Question C4

The positional and directional order were generally compared correctly (a) but candidates struggled with the principles of a liquid-crystal device (b).

Option D – Medicines and drugs

Question D1

Most candidates gave the description of a therapeutic window, but it was clear that many candidates did not really understand what it means and some confused wide and narrow therapeutic window with wide and narrow spectrum antibiotics.

Question D2

Most candidates gave correct equations (a) and identified $CaCO_3$ as the antiacid that neutralizes more acid.

Question D3

Very few candidates gave correct equations for oxidation and reduction in a breath analyzer (a), but most described correctly the color change.

The way how a breath analyzer works seemed clear for most candidates (b).

Question D4

Most candidates knew that R is a side chain, although some identified it as a functional group (a). Some candidates got confused with over-prescription of antibiotics and answered that the body becomes resistant or dependent (b).

Question D5

The question was answered surprisingly poorly. Many candidates gave a description of the mechanism of action of anti-viral drugs, but made no reference to socio-economic issues, other gave a detailed description of socio-economic issues, and only obtained one mark.

Option E – Environmental chemistry

This was the most popular option.

Question E1

Many candidates identified correctly how the three gases are formed, though some candidates named the reaction of N_2 and O_2 as the source of NO_2 and for incomplete combustion equations with methane and carbon were given (a).

Only well prepared candidates understood the effect of increasing fuel to air ratio on the pollutants (b)

Question E2

This question was generally responded to well, though some candidates mentioned as the disadvantage of tetrafluoromethane that it produces methane.

Question E3

Many candidates struggled with this question. Few could name the main constituent of SOM, many named humus (a) and many gave correct reasons why SOM increases soil quality without referring to the structure given (b).

Many candidates identified salinization as a soil depleting effect of over-irrigation (c), but only few candidates named correct sources for PAH´s and organotin compounds.

Option F – Food chemistry

Only few candidates responded this question.

Question F1

Many candidates knew the structure of triglycerides (a). Most candidates identified structure II as the one with the highest melting point and many gave the correct reason (b). Advantages and disadvantages of hydrogenating oils were generally known to the candidates (c).

Question F2

Many candidates named the ingredients of the can instead of the nutrients of meat (a).

The principle of canning seemed clear to most candidates (b) but fewer recalled the function of sodium nitrite and sodium ascorbate (c).

Question F3

Many candidates had difficulties explaining the brown colouring of meat upon standing (a) and the system of conjugated double bonds was rarely mentioned in the explanation of why food pigments are coloured (b).

Option G – Further organic chemistry

Question G1

Candidates had some problems in explaining precisely delocalized electrons (a). Generally they gave correct evidence of the presence of delocalized electrons in benzene but again could not explain it precisely (b).

Most candidates identified correctly chloromethylbenzene as the species with the highest rate, but explanations were often weak (c).

Question G2

Most candidates predicted correctly the major and minor product, but only well prepared candidates explained it completely. Some candidates only named Markonikoff´s rule

Question G3

The question was generally answered well.

Question G4

Some candidates were not precise in outlining the formation of a Grignard reagent (a), but many identified correctly the three substances (b)

Recommendations and guidance for the teaching of future candidates

- Candidates should be provided with sufficient resources to complement the teaching of the options. The options must be studied with sufficient depth. Even though candidates were often familiar with the general concepts, few remembered details.
- Every part of the syllabus must be covered, there was evidence that some areas had not be covered by some schools.
- Candidates must work with the data booklet during their preparation and be familiar with it. The half-equation of the reduction of dichromate (VI) is given in the date booklet as were the structures of linoleic and linolenic acid, but many candidates were not aware of it.
- Candidates should give scientific answers, whereas many give journalistic responses. Working with past papers and their mark schemes is a good reference for candidates to understand what is expected of them.