CHEMISTRY TZ1

(IB Latin America & IB North America)

Overall grade boundaries

Higher level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 15	16 - 31	32 - 43	44 - 54	55 - 65	66 - 75	76 - 100

Standard level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 17	18 - 32	33 - 45	46 - 55	56 - 65	66 - 75	76 - 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.

Instruction to Moderators May 2009

Dear Moderators,

Thank you for offering your services yet again for vital task of I.A. Moderation. This is the first session under the new criteria and six point scale. Also excitingly I.A. has entered the electronic mark entering age and this should make sample selection more appropriate. So there are many changes to contend with although hopefully the online training will have helped us get up to speed.

Despite the changes our key principles have remained the same:

- **Support the teacher wherever possible:** We are not primary marking and if the teachers grading is a plausible interpretation of the criteria then it should be supported. Remember: we are not imposing our own particular standard of marking, as used in our own classes, on others. Always check to see that the teachers have not made a reasonable interpretation of the Subject Guide before marking up or down.
- **'Complete' does not mean perfect:** You may find yourself supporting 'p' or 'c' for very similar levels of response when different teachers apply the gradual boundary between c and p differently. Try to **give credit for what the candidate has achieved not to simply punish one omission.**
- Mark the report as a whole. Candidates are under no obligation to write up their report according to the criteria headings and evidence for the aspects could be in a very different sequence.
- **Keep marking with the same care and attention throughout your allocation:** Do not ease up once you have dispatched your sample to your team leader. Remember that schools can demand the IMR report after the grades are issued and all school samples could be subject to re-marking by a senior moderator. ***Annotate on the scripts with c, p, n notation and possibly further comment at the point where you decide to award a level. Initial your comments so that they can be distinguished from the teacher's.***

So the broad message is be positive in your marking. Look for what is present in a piece of work and not for minor omissions. Try to avoid pettiness and remember that sometimes you can even mark upwards.

Good luck!

Instruction to Moderators May 2009

The essential reading for moderation are 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). Probably will 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 - 7	8 - 15	16 - 21	22 - 24	25 - 28	29 - 31	32 - 39

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. One question, see below, was excluded from the paper at the grade award meeting, hence the final mark was out of 39. 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 45 G2's that were returned. 65% found that the paper was of a similar standard, compared with last year, 26% felt that it was a little more difficult and 2% thought that it was much more difficult. Only 7% considered the paper easier. 98% thought that the level of difficulty was appropriate and 2% considered the paper too difficult. Syllabus coverage was considered satisfactory by 36% and good by 64%.

In addition, 36% felt that the clarity of wording on the paper was satisfactory and 62% considered that the wording was good. Only 2% stated that the clarity of wording was poor. The presentation of the paper was considered satisfactory by 11% and good by 89%. Overall, this paper appeared to be 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 94.49% to 24.55%, and the discrimination index, an indication of the extent to which questions discriminated between high- and low-scoring candidates, ranged from 0.64 to -0.02 (the higher the value, the better the discrimination). The following comments were made on selected individual questions:

Question 6

One respondent stated that this question was confusing and suggested that two answers were possible (B and D). However, the correct answer is actually B, since the question states explicitly that candidates have to choose the best definition of electronegativity from the four choices given, namely (B) that electronegativity is the attraction of an atom for a bonding pair of electrons, which is based on AS 3.2.1. The question had an associated difficulty index of 24.55% and a discrimination index of 0.23.

Question 7

Two respondents commented that $MgCl_2$ is not the best example of an acidic solution. However, in the question, candidates were asked to consider the reactions of Cl_2, $MgCl_2$ and $SiCl_4$ in H_2O. In this case all three species form acidic solutions and hence the answer is clearly B. It is true that $MgCl_2$ is only weakly acidic here but this should be known from knowledge of AS 18.3.1. The question had an associated difficulty index of 29.02% and a discrimination index of 0.07.

Question 10

Two respondents stated that lattice descriptions such as cubic, face-centred cubic or body-centred cubic are not required. According to AS 4.1.8, it is stated that candidates should be able to describe the lattice structure of ionic compounds and in the corresponding teachers note the example of sodium chloride is cited. Therefore candidates should know that sodium chloride has a cubic type lattice. More complicated lattices such as face-centred cubic etc. are not required and are not mentioned in this question and hence the question as written is perfectly valid.

Question 11

One respondent suggested that this question should be deleted as the question is based on an incorrect interpretation. However, in the teachers note corresponding to AS 4.2.2 examples such as CO, NH_4+ and H_3O^+ are clearly mentioned.

Question 14

One respondent felt that this question was unnecessarily complicated. This was discussed at Grade Award and although there is some validity to this statement, it was considered that the question was fair but was considered one of the harder questions on the paper. With an associated difficulty index of 34.69%, the question was in fact the fifth hardest question overall.

Question 20

It was decided to delete this question from the paper as the question contained the phrase according to the collision theory which resulted in possible ambiguous answers. The question in fact had a negative discrimination index of -0.02 indicating that the question confused even the more able candidates.

Question 28

One respondent stated that this question was fair but tricky. However, this question is based on the syllabus, as stated in AS 18.2.2. In the teachers notes on buffers, selected examples are given. It should be emphasized that buffer solutions should not be confined solely to these examples but these examples should be included in the teaching programme.

Question 40

One G2 comment stated that the question on significant figures should have been asked at the beginning of the paper. In Paper 1, questions are asked in accordance to the order of topics in the guide. As this question is based on Topic 11, it would appear in the later part of the paper and not at the beginning.

Higher level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 12	13 - 25	26 - 35	36 - 45	46 - 55	56 - 65	66 - 90

General comments

The range of marks awarded was very wide; the best candidates showed a thorough command of the material and a high level of preparation. Overall, the lack of understanding of even core chemical concepts by HL candidates was of concern. The paper overall had a new fresh look to it and this threw many candidates. In fact, some teachers commented to that effect on the G2 forms, but it should be expected that a new course would bring a new examination format and the changes were well represented in the Specimen Papers published on the OCC.

Teachers' impressions of the paper were conveyed by the 49 G2 forms that were returned. In comparison with last year's paper, 84% felt that it was of a similar standard, 5% thought that it was a little easier and 11% were of the view that the paper was a little more difficult.

86% considered the level of difficulty of the question paper appropriate, 2% too easy and 12% too difficult. Syllabus coverage was considered good by 67%, satisfactory by 31% and poor by 2%. Clarity of wording was considered good by 63% and satisfactory by 37% of respondents. The presentation of the paper was thought to be good by 82%, satisfactory by 16% and poor by 2%.

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

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

- Precise definitions in general, such as standard electrode potential, ionization energy and periodicity
- Hypothesis question in Section A
- Performing calculations with the appropriate number of significant digits and units
- Sketching and labelling pH curves
- Knowing when to use $\rightarrow$ and ^{2} in equations
- Knowing why solid ionic compounds do not conduct electricity
- Recalling acid-base trends in the Periodic Table
- Explaining why lattice enthalpies are different for different ionic compounds
- The concept of hybridization and explaining the formation of sigma and pi bonds
- Predicting the products of electrolysis with different electrolytes
- Explanations pertaining to trends in ionization energy: how first IE changes with successive elements indicating the presence of the main and sub energy levels and how successive IE changes when electrons are removed one at a time from an atom
- Electronic configuration of Cu and Cu^{+}
- Writing organic reaction mechanisms

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

Topics generally well answered included:

- Drawing Lewis structures
- VSEPR theory
- Oxidation states
- Identification of monomers from a polymer structure

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

Section A

Question 1

Many candidates could correctly identify the functional groups in vegetable oil and biodiesel in part (a), although a significant number could not. In part (b), a common error in the calculations was the failure to multiply the number of moles of oil by 3. Several candidates used integers for relative molecular masses but still quoted the answer to several decimal places indicating a lack of understanding of the significance of the number of digits used.

The concepts of equilibrium were not clearly understood by many candidates who stated in part (c) that excess methanol was used to cause the reaction to go to completion, although several candidates clearly stated and explained the effect of a catalyst on the position of equilibrium. In part (d), very few candidates discussed vegetable oil and methanol in terms of polarity, referring incorrectly to differences in density. Very few candidates could explain why using biodiesel as a fuel does not significantly contribute to global warming, and this was reflected in the number of comments by teachers on the G2 forms. This question is reasonable and is an example of the changes to the Chemistry course. It is in the spirit of the new Guide, and tests Aim 8.

Question 2

The equation of propanoic acid with water was problematic for many candidates who omitted the equilibrium arrow ($\rightleftharpoons$) in part (a)(i). Although candidates were referred to the Data Booklet, some candidates did not know the formula of propanoic acid. Part (a)(ii) was answered well by about half the candidates. Part (b) also caused difficulties, with many candidates scoring only the mark for showing the pH range of bromophenol blue. Some candidates were thrown by the choice of indicator and selected a more appropriate indicator for these reagents. It is important to answer the question on the paper as the indicator was deliberately chosen to be different to the indicator used in the example. Graphs were generally badly and roughly drawn. Even candidates who had correctly calculated $[H^+]$ in part (a) often did not start the graph at the correct pH. Most graphs finished too low at a pH of 10 or less, and the vertical part of the graph was frequently at a volume less than 25 cm^3. Rarely did a candidate get the half-equivalence value correct.

Question 3

In part (a) candidates commonly did not remember that bond breaking is endothermic and bond formation exothermic, and in part (b) the formula involving enthalpies of formation was often used instead of a correct enthalpy cycle for the combustion. This caused the majority of candidates to score half marks for these questions. A few candidates could suggest a reason why one answer was slightly less accurate than the other in part (c). Most could correctly calculate the percentage difference. Surprisingly, several candidates calculated part (a) correctly and part (b) incorrectly, and then determined a percentage difference of more than 200% without seeming to notice that this does not reflect two slightly different answers. Part (d) was not answered well. A comment on the G2 forms correctly pointed out that cyclic alkanes and alkenes are not required knowledge; however, it was felt that this question was an appropriate extension of bond enthalpies as the equation was given.

Many candidates correctly deduced that the enthalpy of hydrogenation of cyclohexene is the same as the hydrogenation of ethane. Only the very best candidates could correctly answer part (d)(ii), with most candidates discussing ring structures and delocalized electrons.

Question 4

This question was generally well answered. A common mistake with writing half-equations was the failure to realise that only single arrows should be used if oxidation and reduction are specifically asked for. Candidates were only penalized once for this error. Given that the half-equation involving MnO_4^- ions is provided in the Data Booklet, it was surprising that several candidates could not correctly write the equation for their reduction in acidic solution.

Question 5

This question was very poorly answered. Few candidates mentioned ions in part (a) and very few could state the half-equation for the reaction occurring at the positive electrode in part (b). A common mistake made by the relatively few candidates who knew that oxide ions were oxidized was to not balance the number of electrons. Part (c) was poorly answered. A full range of incorrect answers for the acid-base nature of sodium oxide was given, from strongly acidic to slightly acidic to amphoteric to slightly basic. An answer of basic or alkaline was sufficient for the mark. Writing the equation for the reaction of sodium oxide with water proved very challenging. Many incorrect formulas were given for sodium oxide, and a variety of products were given, including hydrogen gas. Even candidates who knew the correct products to be sodium ions and hydroxide ions often failed to balance the equation. Some candidates were penalized for using an equilibrium arrow here.

Section B

Question 6

This question was the most popular of the Section B questions. Part (a) was generally well answered with many candidates drawing clear Lewis structures and applying their knowledge of VSEPR theory well. Common errors included the omission of lone electron pairs on outer atoms, and the omission of a bracket and charge on the ion. Incorrect angular values were common. Some candidates described shapes and bond angles in terms of the 'parent shape'. Good candidates explained the answers well and scored full marks. Weaker candidates simply wrote two answers; for example, 'tetrahedral bent' and could not be awarded marks. In part (b) many candidates incorrectly identified the process converting liquid bromine molecules to gaseous bromine atoms as vaporization.

Deducing the enthalpy changes with negative signs proved challenging for many although, with follow through marks credit was earned for the calculation of the enthalpy of formation of potassium bromide. Some teachers commented on the G2 forms that the energy cycle diagram was strange, however, the stages of the Born-Haber cycle were clearly given and candidates should be familiar with those. Very few candidates could explain why calcium bromide has a larger lattice enthalpy than potassium bromide. Many referred to atoms instead of ions, and tried to answer this in terms of the electronegativity of the metals. Part (c) was answered well by some candidates who produced clear and well annotated diagrams as part of their answers. Many candidates however omitted mention of orbitals when trying to describe the formation of sigma and pi bonds or to explain hybridization. There were many diagrams which had no annotations and were difficult to interpret.

Question 7

This question was poorly answered. In part (a), the definition of standard electrode potential was poorly stated, with the standard hydrogen electrode rarely mentioned. Many candidates had difficulty determining the value of the standard electrode potential for the cobalt half-cell. Few gave Co^{2+} as the oxidizing agent. Many candidates gave an equation for the spontaneous reaction as an equilibrium reaction. If a penalty had already been incurred in Question 4, no further penalty was applied; otherwise the use of the equilibrium arrow in this question was penalized once only. In part (b), most candidates correctly determined the oxidation states, although they were frequently written incorrectly as 2+ or 3+. In part (c) many candidates drew a voltaic cell instead of an electrolytic cell. Candidates generally had difficulty identifying products of electrolysis with varying concentrations of NaCl(aq) and with different electrolytes.

Half-equations were frequently the wrong way round, and electrodes were not identified. Candidates who included states of matter in their equations frequently wrote the wrong state and were penalized.

Question 8

Most candidates scored 2 marks out of 5 in part (a) for the description and explanation of the operation of a mass spectrometer. The detector was frequently poorly explained by candidates who otherwise responded well. Most candidates correctly calculated the relative atomic mass of strontium, but lost marks by stating a unit or for not giving the answer to two decimal places as requested. Part (b) was poorly answered with incomplete definitions and a lack of relevant detail. The gaseous state was frequently omitted when describing ionization energies. Many candidates had difficulty correlating the graph of first ionization energy to main energy levels and sub-levels. Few candidates correctly drew a graph representing the successive ionization energies of potassium. Commonly the graph looked very similar to the graph provided of first ionization energy against atomic number. Even the few candidates who seemed to understand the ideas involved with successive ionization energies drew only partial graphs and did not continue for the removal of all 19 electrons. Some teachers commented on the G2 forms that sketching the graph is beyond the scope of the course but it is clearly covered by AS 12.1.2. In part (c), few candidates could correctly write the electron configurations of Cu and Cu+, with many giving a full 4s orbital and only 9 electrons in the 3d orbitals. Candidates who managed to correctly write the electron configuration of Cu often removed a 3d electron when creating Cu+. Many candidates could explain why aqueous solutions of copper(II) compounds are coloured but those of scandium(III) compounds are not, but some candidates responded very weakly.

Question 9

This question was the least popular of the Section B questions. Some candidates were very well prepared and scored well, while many struggled to write correct mechanisms with curly arrows in the right place. For a small number of candidates, all parts of the question other than the identification of a functional group proved very difficult. Additionally, in part (a), few candidates knew the details of the reagents and conditions for a range of reaction types. In part (b), very few candidates could draw three-dimensional structures of optical isomers, although many gained a mark for correctly identifying the structure which could have enantiomers. Few mentioned a polarimeter to distinguish between the two optical isomers, although several described in clear detail a practical method to do so. In part (c) few candidates knew the structure of the organic product and very few got the correct number of water molecules after using n moles of each reactant.

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:

- 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 full explanations for chemical concepts
- Practise writing balanced equations and half equations
- Always label the axes on graphs
- Practise drawing graphs
- Recognize the difference between a graph of first IE against successive elements and a graph of successive IE against the number of electrons removed for the same element.
- Practise predicting products of electrolysis in molten ionic compounds and in solution
- Consider the various steps of the common organic reaction mechanisms, with focus on the positions of curly arrows
- Review the entire syllabus and do not use past examination questions as the sole guide to knowledge requirements
- It is highly recommended that candidates start each section B question on a new sheet of paper

Higher level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 7	8 - 14	15 - 19	20 - 25	26 - 30	31 - 36	37 - 50

General comments

A very wide range of performance was seen, there were some excellent responses but also there were a large number of candidates that were insufficiently prepared for the paper. The major problem continues to be that candidates do not answer with sufficient detail and their answers can tend to be journalistic rather than based on Chemistry. Almost all candidates followed the rubric and answered two options. The most popular options were B, D and E. Few candidates attempted options C and F.

From the G2 comments it was felt that options A and G were considerably harder than the other options, however, although it is agreed that it is in the nature of these options that the chemistry involved is challenging, candidates score very well when they are properly prepared.

Also from the 45 G2's received it appeared that most felt the paper was fair and 77% felt the paper was a similar standard to last years although 23% felt it was more difficult. However 89% felt the difficulty was appropriate. It was found that the nature of the questions which often asked for explanations rather than straight statements of fact challenged many of the candidates. Also, questions asked on new material or sections that had not previously been examined caused much difficulty.

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

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

- Description of the operating principles of a double-beam IR spectrometer
- Using information of ^{1}HNMR spectrum to show how they deduced the structure of an organic compound
- Outlining how NMR is used in body scanners
- Explaining why different ligands lead to different colours
- Defining Iodine number
- Comparing HDL and LDL cholesterol
- Comparing the catalytic activity of an enzyme to an inorganic catalyst
- Describing the structure and properties of carbon nanotubes
- Stating the half-equations at the electrodes of the hydrogen-oxygen fuel cell in an alkaline medium
- Describing the composition of the electrodes in the nickel-cadmium battery
- Explaining the meaning of therapeutic window
- Combinational chemistry and parallel synthesis
- Defining BOD
- Writing the expression for K_{sp} and using it in calculations
- Defining the term antioxidant and explaining the differences between the three main types of antioxidant
- Writing equations for the mechanism for the free radical reaction that causes an oily fish to become rancid
- Using curly arrows to describe the mechanisms of organic reactions

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

This was a balanced paper and some of the candidates gave very good answers and were obviously well prepared. Most candidates seemed able to complete the paper in the space given.Some specific areas that wer well answered are:

- Stating the bonding in proteins
- Describing the functioning of the contraceptive pill
- Competitive and non-competitive inhibitors
- Analgesic function
- Action of mind altering drugs
- Effects of global warming
- Description of antioxidants

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

Option A – Modern analytical chemistry

Question A1

Part (a) was quite well answered, but in part (b) candidates did not appear to know how IR radiation interacts with electrons in bonds, and were not specific with bond angle changes or bond stretching. In (c) very few candidates knew the operation of IR spectrometer well enough to gain full marks, and the photomultiplier used for detection was usually missed out. In (d) most candidates correctly identified the spectra, but did not explain clearly how they arrived at their answer, failing to quote frequencies that they had used to identify bonds.

Question A2

From part (a) it is clear that proton NMR is poorly understood in some schools. Whilst many candidates could identify the correct structure, few could write a description of how they had obtained it from the information provided. Very few candidates explicitly mentioned that there were 3 peaks or explained how the structure had been determined, especially neglecting to explain the splitting patterns. In (b) many answers were superficial and did not relate the different proton environments in the body to the generation of a 3 D image, most seemed unaware of the different proton environments in different tissues

Question A3

In (a) (i) many candidates answered this correctly although some only got 1 mark as the splitting was the wrong way around. In (ii) many candidates did not indicate the difference in the size of d orbital splitting caused by a differing oxidation state. In (iii) many candidates correctly stated a colour but few could explain that different ligands caused different splitting of d orbitals.

Option B – Human biochemistry

Question B1

Most candidates correctly identified the bonds in (a) and (b), but in (c) covalent bonding, α-helix or β-pleated sheet were common incorrect answers.

Question B2

In (a) very few candidates scored all 3 marks, a substantial number of candidates had difficulty coming up with a structure for the triglyceride and seldom did they remember to balance the equation. Another common error was the omission of the water molecules. Some could not write a correct structure for glycerol, with OR appearing instead of OH, or C=O bonds being included. Some triglyceride structures contained two C=O groups in each chain, while others showed the ester bonding as –C–O–O–C–. Amino acids also appeared quite often. In (b) many candidates could not define *iodine number*, with many referring to moles instead of grams. This then meant that few were able to calculate the iodine number successfully. In (c) although there were four ways to score 2 marks, few candidates managed this; few referred to the difference in molecular size, some had the properties of LDL and HDL the wrong way round, and there were several references to "good" and "bad" cholesterol which was insufficient for a mark.

Question B3

In (a) most candidates could identify the functional group that progesterone and testosterone had in common, with aldehyde being the most common incorrect answer. In (b) many knew the functioning of oral contraceptives, although descriptions for how oral contraceptives function were not always above a rudimentary/general level of understanding.

Question B4

In (a) the answers of many candidates showed that they had not properly read the question, and the comparative descriptions were not done well, candidates seldom including both the enzyme of the iron catalyst in their answers. Very few scored full marks here; the most common omissions were to mention that enzymes were proteins and that they had a tertiary and quaternary structure. Several referred to the denaturing and specificity of enzymes without comparing these features with iron and so failed to score marks for these correct statements. In (b) candidates showed a good understanding of competitive and non-competitive inhibition and how the inhibitors attach to the enzyme. However many neglected to say that initial rates were reduced by both, and many candidates were confused about how K_m and V_{max} were affected by the two types of inhibition.

Option C – Chemistry in industry and technology

Question C1

In part (a) few candidates could describe the precise structure of nanotubes. Many answers were vague regarding the structure and properties of nanotubes. Some gave weak responses and confused nanotubes and C_{60} fullerenes. In (b) this was usually not answered with enough different points to get all 4 marks. Many candidates achieved 2 out of 3, but answered poorly regarding the developing countries.

Question C2

In (a) some candidates managed to give the correct half-equations but often the cathode and anode were reversed. In (b) this was poorly answered although some candidates managed to write the cell equation without properly describing the cathode and anode. In (c) most candidates could score 1 mark for stating that Pb and H_2SO_4 pollute. In (d) this was not well answered and few understood that the fuel needed to flow.

Question C3

In (a) distinguishing liquid crystals proved difficult for most candidates and incomplete and vague responses were common. In (b) many candidates omitted the location of Hydrogen bonding in Kevlar and frequently vague responses were given for the effect of concentrated H_2SO_4. In (c) candidates showed a poor understanding of the better conduction of Si compared to S and P, very few answered how a p-type semiconductor worked correctly, but most showed a reasonable understanding of the role of light. The movement of electrons from n to p was also poorly understood.

Option D – Medicines and drugs

Question D1

In part (a) many candidates scored full marks, although quite a number wasted time mentioning the disadvantages of aspirin, which the question did not ask for. In (b) this was also well answered generally though some used journalistic and imprecise language (e.g. "numbs the nerves" and "targets the pain"), although the majority realised that they should refer to site and brain in their answers. In (c) (i), a few candidates overlooked the need to draw a ring, while the most common error was to circle the N, CH_3 and CH_2 groups (which then often led to an answer of "secondary" in (ii)). In (ii) quite a number interpreted "type" as meaning which alkyl groups were present, so "methylamine" was seen quite often. In (iii), "ketone" and "carboxylic acid" were sometimes seen instead of the correct answer of ester. In (iv) Very few were able to fully explain the increased potency of heroin – some referred to polarity but did not identify the groups, and some the other way round, a few correctly stated that heroin was more lipid soluble so could cross the blood brain barrier more easily.

Question D2

Part (a) was answered correctly by many candidates. In (b)(i) defining the therapeutic window proved problematic for many candidates. Vague notions abounded. In (ii) tolerance was well understood and reasonably well answered, but many candidates missed the increasing dosage concept for continued effect. Part (c) was the most poorly answered question, only a few candidates mentioned the use of beads, and mix and split, but none stated the covalent bonding to the beads. The concepts of libraries of drugs and the more focused approach of parallel synthesis were not well understood.

Question D3

In (a) many candidates only answered about information on alcohol, and not on depressants. A significant number of candidates gave correct answers but they did not distinguish well between moderate and high doses. As a result of this most candidates scored one mark here. In (b)(i) The colour change was sometimes the wrong way round, or showed only the final colour. In (ii) oxidation appeared as often as reduction as an answer, if reduction was correctly stated it was often without an explanation.

Question D4

Better candidates correctly identified both functional groups, although some incorrect words were used ("hexagon or cyclohexene" instead of "benzene" and "amide" instead of "amine"). Almost all candidates could only describe one effect of mescaline many mentioned hallucinations, but many could not offer a second effect; the effect on appetite was omitted by almost all but the very strongest candidates.

Option E – Environmental chemistry

Question E1

Part (a) was generally well answered but the most common wrong answers were carbon monoxide, oxides of nitrogen and sulfur. In (b) several candidates quoted contributions to global warming using percentages for their examples, but without referring to abundance or effectiveness. There were many answers that were far too vague to gain marks.

In (c) many candidates wrote at length and easily scored both marks, but the most common reason for losing marks from those who wrote less was to state just "climate change" without being more specific. A disappointing number of candidates referred to effects on the ozone layer.

Question E2

In (a) BOD was rarely defined well enough for full marks, with many candidates omitting the time or temperature element for the second mark, some also wrote about oxygen sustaining life rather than decomposing organic matter. In (b)(i) many candidates only repeated the information in the question (decrease in oxygen concentration and increase in temperature), and relatively few mentioned the decrease in solubility; "evaporation" was a common answer. In (ii) many candidates explained the effect of the fertilizer on BOD as resulting from a direct reaction between the fertilizer and the oxygen, some mentioned eutrophication without any explanation of how this occurred. In (c) whilst most candidates understood that oxygen gained electrons in (i) and that the oxidation number of manganese dropped from +4 to +2 in (ii) they had difficulty calculating the moles of dissolved oxygen. The answer of 1×10^{-4} was often given rather than the correct answer of 5×10^{-5}, as many candidates determined that the ratio of O_2: I^- was equal to 1:1.

Question E3

Part (a) was generally done well and the majority of candidates scored 1 or 2 marks here. State symbols were sometimes omitted or incorrect, for example $Cr^{3+}(s)$ and $Cr(OH)_3(aq)$. Some did not know the formula $Cr(OH)_3$ and the coefficient of OH^- (3) was sometimes omitted. In (b) about half the candidates gave the correct expression for K_{sp}. Some included the solid in the K_{sp} expression and quite a few gave the inverted solubility constant expression; there was a lot of confusion with the K_c expression. In (c) only the best candidates did not have major difficulties calculating the solubility product. Most candidates failed to recognize the $[OH^-]$ is three times that of Cr^{3+} when calculating the Cr^{3+} concentration.

Question E4

In part (a) only the more able candidates were able to answer correctly. Few candidates quoted specific wavelengths or mentioned shorter or longer wavelengths. Many scored the mark for stronger bond in the oxygen molecule.

In (b) many candidates scored 1 or 2 points here, but only the more able candidates scored 3 marks by giving the three equations in the markscheme, with a wide range of implausible reactions appearing.

In (c) some candidates did not seem to understand the question and tried to state advantages of CFCs and disadvantages of HCs, or disadvantages and advantages of both. A common error was to state that the disadvantage of hydrocarbons was that they produced the greenhouse gas carbon dioxide on combustion rather than being greenhouse gases in their own right. However, many candidates answered this question correctly.

Option F – Food chemistry

Question F1

In part (a) reflecting and/or absorbing of light was given by many but different wavelengths of visible light was often not mentioned. In (b) most answered anthocyanins correctly. Part (c)(i) carotenoids was answered by many, but carotene was a common incorrect answer.

In (c)(ii) Many of the candidates did not make specific reference to double bonds being between carbon atoms and half of them did not score the second mark because “change in colour” " or "turns brown" was more common than colour lost.

Question F2

In (a) explanation of antioxidant was well done. In (b) many candidates did not give examples of the different types of antioxidants and the answers were a little confused. The candidates were often unable to separate the parts of their answer, despite the help to do so being given in the question. The better candidates were able to come up with the three examples of types of antioxidants and how each worked though. In (c) most identified one functional group correctly, only the better candidates gave a second group correctly. In (d) many candidates gave the names of the steps correctly so they scored the 3 marks, possibly because of the core organic chemistry reaction of alkanes with halogens. However little was understood about what they meant, and they made a substantial numbers of mistakes in writing equations for each step.

Question F3

The definition of a GM food was difficult for many candidates, as there is much confusion. Instead of stating that GM foods were derived from plants whose genetic makeup had been altered, many wrote that the foods themselves had been genetically modified, while others thought that they had been injected with steroids or hormones. Most could mention some benefits and concerns, but very journalistic language without specific detail made it hard for them to score marks at times.

Option G – Further organic chemistry

Question G1

In (a)(i) although most knew that the electrophile produced was NO_2^+, very few showed the correct equation(s) for its formation; the most common errors were failure to balance and omission of charges. In (a) (ii) in the reaction between CH_3COCl and $AlCl_3$, candidates often omitted $AlCl_4^-$ or showed it without a charge. The non-aromatic intermediate often appeared without the + charge, and curly arrows often started or finished in the wrong places.

In (a) (iii) many candidates had problems suggesting a two step synthesis and common wrong answers for the first step included ethane, ethene and Grignard reagents, although those for the second step were better known.

In (b) (i) most candidates managed at least one of the reagents and conditions, and in (b) (ii) many drew a correct formula for the product, with most common error being to show the replacement of both bromines. The more able could explain that substitution occurred on the alkyl group.

Question G2

In (a) (i) many candidates could correctly provide the formula of the Grignard reagent with ethylmagnesium bromide the most common error. In (a) (ii) candidates could generally come up with 1 of the 2 correct structural formulas. In (b) only the best candidates got all 4 structures correct, with the last two being most prone to error. In part (c) relatively few drew mirror images, or showed 3-D arrangements; few stated or explained the existence of the chiral carbon.

There was also some misinterpretation by candidates, who took the phrase "B can exist in two forms" to mean the two structural isomers formed via the primary and tertiary carbocations, rather than the two optical isomers formed via the tertiary carbocation.

Question G3

Most candidates correctly identified the organic product as methylpropene, but very few scored full marks for the mechanism. The usual errors of curly arrows starting and finishing in the wrong places were seen and also some did not show lone pairs on O so could not correctly place curly arrows. A substantial number of candidates did not even attempt the question.

Recommendations and guidance for the teaching of future candidates

- Candidates need to study each option in depth and ensure they know the equations relating to the processes they study.
- Candidates must study all of the option in depth- any part of it can be assessed and pure recall of knowledge without understanding is insufficient for many questions.
- Candidates should practise writing balanced equations.
- Candidates need to read questions carefully to ensure they answer appropriately and precisely.
- Candidates should take note of the command terms used and also the mark allocation for each question.
- Candidates should prepare for the examination by practicing past paper questions and carefully studying the markschemes provided, alongside careful reading of the syllabus.

Standard level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 7	8 - 12	13 - 17	18 - 20	21 - 22	23 - 25	26 - 29

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. One question, see below, was excluded from the paper at the grade award meeting, hence the final mark was out of 29. 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 60 G2s returned, 67% commented that this year's paper was of a similar standard to last year's paper, 21% felt that it was a little easier and 10% thought that it was a little more difficult. 97% felt that the level of difficulty was appropriate and 3% thought that the question paper was too easy. Syllabus coverage was considered satisfactory by 32%, good by 66% and poor by 2%.

The clarity of wording was thought to be satisfactory by 26%, good by 72% and poor by 2%. The presentation of the paper was considered satisfactory by 17%, good by 81% and poor by 2%. Various comments were made about several questions, some of which are addressed in the next section. There was a general comment welcoming a reduction in the amount of mental arithmetic required, which reflects a conscious trend to move away from questions of that nature. There was also a general comment that the paper contained too much organic chemistry. There were 4 questions on this area of chemistry which is in proportion to the amount of time suggested in the Teachers' Guide for the delivery of Topic 10

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 97% to 5%, and the discrimination index, which compares the high-scoring candidates with the low-scoring candidates, ranged from 0.60 to 0.04. A higher value indicates better discrimination with more high-scoring candidates more likely to answering correctly than low-scoring candidates.

Questions 4 and 5

These questions both required candidates to carry out a calculation of the yield of a reaction, one in terms of mass the other in terms of volume. A significant number of candidates left these questions blank, perhaps indicating they were uncertain of the answer and then failed to return to them before the end of the examination. Only about half of the candidates answered these questions correctly and for both the discrimination index was high. This would indicate that many candidates taking the examination were unfamiliar with routine calculations.

Question 10

With a difficulty index of 24%, this proved to be one of the most challenging questions on the paper and seems to reinforce an impression, also noted elsewhere, that whilst candidates have some general awareness of a concept, they are unable to define it in appropriate detail.

Question 14

This was the question that caused candidates the most trouble, with a difficulty index of 5%. It would appear from the responses that about 80% of the candidates believe that the structure of silicon dioxide is identical to that of carbon dioxide. The discrimination index, at 0.04, was very low and this would seem to indicate that many candidates are not being made aware of these important structural differences.

Question 16

The difficulty index for this question was 35% with both answers A and D providing very attractive discriminators. Though the bond enthalpy can be determined in terms of the change in response A, candidates should have realised that the magnitude of the associated enthalpy change would be approximately four times greater than that required to break a single C-Cl bond.

Question 17

There was some ambiguity in the wording of the question as to whether the enthalpy change required was that associated with the burning of the particular sample of magnesium, or the molar enthalpy change. For that reason it was decided to accept both response C and response D as correct.

Question 19

The fact that the state of the reactants is inevitably linked to the frequency of collisions between particles appeared to cause a degree of confusion as to whether they were separate factors and as a result the question also proved a poor discriminator, with a discrimination index of 0.04. A decision was therefore taken to omit it from the total mark.

Question 20

Opinion expressed through the G2 forms was divided with some commenting that this was a good question, whilst others felt it was too time consuming. Though a significant number of blank responses would seem to indicate that some candidates found the format of the question confusing, those that answered it performed quite well as indicated by a difficulty index of 44%. The question also proved to be quite a good discriminator, with a discrimination index of 0.33.

Question 22

With a difficulty index of 24%, this was the second most challenging question on the paper and the responses seem to indicate that the vast majority of candidates think that a strong acid requires more moles of alkali for neutralization than a weak acid. Surprisingly the question proved quite a weak discriminator, with a discrimination index of only 0.15.

Question 28

Though it produced a significant number of blank responses, with a difficulty index of 57%, the majority of the candidates answered this question correctly and with a discrimination index of 0.59 it was one of the best discriminators on the paper.

Question 29

One teacher commented on the G2 form that this question required more specific knowledge than was indicated by the syllabus and indeed many candidates found this question challenging, as indicated by the very high number of blank responses and the difficulty index of 33%. The discrimination index of 0.23 showed that it was accessible to many of the better candidates.

Question 30

In spite of the fact that there was a G2 form comment that the question was too easy, 26% of the candidates managed to give an incorrect response and the discrimination index of 0.27 showed it to be a reasonable discriminator.

Standard level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 7	8 - 14	15 - 19	20 - 25	26 - 30	31 - 36	37 - 50

General comments

Judging by the performance of the candidates this proved to be quite a demanding paper. It may be that the slightly unusual layout of the first two questions had unsettled many candidates for the remainder of the paper. Some recovered from this which may account for the fact that the marks for Section B were better than those for Section A.

Teachers' impressions of this paper conveyed by the 57 G2 forms returned indicated that half thought the paper to be of a similar standard to last year's and a quarter thought it to be a little more difficult, though some four fifths felt that the level of difficulty was appropriate. Syllabus coverage, clarity of wording and presentation of the paper was considered to be satisfactory (one third) or good (two thirds). Clarity of wording was found to be satisfactory or good by 93% and the prexsentation of the paper was found to be satisfactory or good by 95%.

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

The following weaknesses in the candidates' knowledge and understanding were apparent:

- inorganic chemistry in general. On this paper the nature of the bonding and reactions of Sodium Oxide proved difficult.
- setting out calculations in a logical way.

- using significant digits and units correctly.
- accurate drawing of organic reaction mechanisms
- confusion between Lowry – Bronsted and Lewis acid-base theories.

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

There was only a limited number of very high scoring scripts. However, there were some topics that were generally well answered. These included;

- knowledge of oxidation and reduction.
- Lewis diagrams and the Valence Shell Electron Repulsion Theory
- calculation of a relative atomic mass given the percentage abundance of the different isotopes

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

Section A

Question 1

Part (a) was reasonably well answered with most candidates opting for an ester. Ketone (frequently spelt keytone) and carbonyl were the most common incorrect responses. In Part (b) most candidates scored 1 or 2 marks, showing that they knew the correct method but the third mark proved to be more difficult to obtain, usually because the factor of 3 was omitted. In general, equilibrium (Part (c)) seems to be quite well understood. The most common error in (i) was to describe the reaction as constant rather than having opposing reactions with equal rates. The expression in (ii) was an easy mark for the better candidates. The weaker ones often missed one or both of the powers of three and a small number had + signs in both the numerator and denominator. In (iii) the most common incorrect answer was 'to use up all the vegetable oil'. In (iv) most candidates were aware that a catalyst has no effect on the equilibrium constant but failed to gain the second mark for saying that the catalyst affected both reactions equally, either by increasing the rates equally or lowering the activation energy by the same amount. Very few candidates scored both marks for Part (d) of the question. The better candidates realised that there was a difference in polarity, though not always identifying which reactant was polar and which was non-polar. The most common answers either simply stated that the two were immiscible or that they had different densities. For the second mark an increase in collisions was often mentioned but not always an increase in the frequency of collisions. Candidates found Part (e) to be very difficult. This was not helped by the small amount of space available to them on the paper. Many answers expressed the data in terms which would have calculated (100 - %) as though they had been drilled to calculate % impurities. Part (f) was surprisingly poorly answered. Most candidates had no idea of the role of carbon dioxide in global warming with many saying that burning biodiesel produced only carbon dioxide and not carbon monoxide and so this was less harmful. The few candidates who did mention photosynthesis using up carbon dioxide seldom related this to happening to the plants that had been used to make the biodiesel. The cyclic nature of the whole process was very rarely appreciated.

Question 2

Candidates struggled with Part (a). The most common errors were those of calculation, incorrect identification of the bonds involved and a final answer with the opposite sign and missing units. In (b) many candidates found it difficult to use Hess' Law with the cycle presented in this form, a good proportion not recognising that this was, indeed, a Hess' Law calculation. In Part (c) many of the candidates simply repeated the question, giving no reason or explanation for the likely difference in accuracy. Many candidates repeated the calculation from (a) in (d)(i) instead of realising that the question asked for a deduction rather than another calculation. Credit was given if the same (even if incorrect) answer was obtained as in part (a). In (d)(ii) very few candidates seemed to notice that this process involved substances in the liquid state hence the need for enthalpies of vaporization/condensation. It was commonly thought that the position of the double bond in the cyclohexene ring would make a significant difference.

Question 3

This was expected to be a high-scoring question but this was not found in practice. In Part (a) there were many references to delocalised/mobile electrons and also molecules and atoms. It did not appear that the structural properties of ionic substances are well understood. There were many attempts in (b) which involved the sodium ion rather than the oxide and those who chose oxide often had difficulty in producing a balanced equation. The best answered part of this question was Part (c) though a significant percentage described it as a weak base. Part (d) was also poorly attempted, with candidates often knowing the correct product but producing equations that did not balance or giving hydrogen as a product also.

Question 4

This question was probably the best answered on the paper. Most candidates were able to score the mark for the definition of oxidation. In Part (b)(i) many candidates scored both marks, though a significant number received a single mark penalty for not including the + sign. In (b)(ii) most candidates were able to identify chlorine as the substance oxidised but many suggested rather odd values for its oxidation states.

Section B

Question 5

In Part (a)(i), most of the candidates who opted for this question did little more than list the steps in the operation of a mass spectrometer, not always a complete list at that. An accurate description of the ionization process was rarely given and there was much confusion over the roles of the electric and magnetic fields. Detection by producing a current was often missed. Most candidates scored some marks in (a)(ii). Mass and charge were both seen more frequently than speed or the strength of the magnetic field. The type of calculation in (a)(ii)is well understood. In the cases where both marks were not awarded, this was due to arithmetic error, not reading the question properly and providing an answer to other than two decimal places, or giving some unit such as grams. Part (b)(i) resulted in very few marks being awarded; the requirements to refer to a gaseous atom and the idea of repetition in periodicity were sufficient to prevent otherwise reasonable answers from scoring. The electron configuration was usually known in (b)(ii), as was the fact that there is a full outer electron shell. The third mark was less frequently awarded, with candidates often using the simplistic "it is full so it doesn't want to lose electrons" argument.

(b)(iii) was commonly correct but (b)(iv) was less well answered as many candidates failed to realise that these ions are isoelectronic and gave an answer relating to sulphide having more electrons with a consequent increase in repulsions. Part (b)(v) was poorly answered. Very few scored the first mark, many answers referring to some sort of ionization process. A handful of candidates scored the second mark for a reference to van der Waals forces but explanations for an increase were very weak. A number of candidates lost marks by referring to the breaking of covalent bonds rather than overcoming intermolecular forces.

Question 6

This was, by far, the most popular choice of question in Section B.

Part (a)(i) was well answered, though the weaker candidates often drew a double bond in carbon monoxide or missed out lone pairs. These errors then gave rise to problems in attempting to answer (a)(ii). The better candidates scored all six marks for Part (b), the weaker candidates commonly giving the correct names more often than the correct angles.

In Part (c) the definition was generally well answered and the acids and bases were usually correctly identified though not always paired as asked for in the question. However, (iii) was very poorly answered. Even those who realised that this was a Lewis acid-base reaction failed to mention the donation of a “pair” of electrons. Most candidates were able to define a weak acid though there were many answers expressed in terms of the range of pH of a dilute solution. The equation was often written without the reversible arrow. In the final equation it was rare to see a correct formula for calcium ethanoate, and even when present, the equation was not usually balanced.

Question 7

For (a) (i) of those who attempted this question about half got the order correct. Those with it correct usually gave creditable explanations. With the weaker candidates the most common error was an explanation making reference to the breaking of covalent bonds rather than intermolecular forces. In (a)(ii) most candidates identified butane as the compound but there were very few sound explanations The oxidation products of propan-1-ol were generally given correctly by both name and structure. The structure in (a)(iv) was usually drawn correctly. Candidates were generally able to identify the class of alcohol and the name of the oxidation product in (a)(v), although this was sometimes referred to as propan-2-one. In Parts (b)(i) and (ii) many marks were lost by candidates who gave the correct reagents but failed to answer the question which asked for their ‘names’. In (b)(iii) there were very few answers giving text-book explanations of the mechanism. The errors included curly arrows starting and finishing in the wrong places, a lack of partial bonds and/or charge in the reaction intermediate. In the final part candidates rarely mentioned that ethene undergoes reaction with steam though most could identify the commercial use of ethanol as a fuel.

Recommendations and guidance for the teaching of future candidates

It is important to make full use of past examination questions and papers as a teaching aid. In particular candidates must learn to answer the question that has been set. Thus on this paper, it was required for the relative atomic mass to be calculated to two decimal places so to give an answer to any other number of places is certain to lose a mark. Also if the name of a reagent is asked for, giving the formula will clearly incur a penalty.

The numbers of marks allocated to the various sections can be used as a clue as to how much detail is likely to be expected for the marks. If there are two marks available, a one-word answer is unlikely to score both. Also:

- practice giving explanations for chemical phenomena rather than statements of them.
- concentrate on the meaning and use of significant digits in calculations and stress the need for setting out calculations clearly, showing all the steps involved in the working.
- ensure that in equations the difference between directed and reversible arrows is understood.
- stress the difference between chemical bonds and intermolecular forces.
- give further practice to writing organic mechanisms.

Standard level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 6	7 - 12	13 - 17	18 - 20	21 - 24	25 - 27	28 - 40

General comments

This paper identified the 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 options. In general candidates did not appear as well prepared as in other years.

The 53 G2 forms that were returned conveyed teachers' impressions of this paper. In comparison with last year's paper 89% of respondents felt that it was of a similar standard, 3% thought it a little easier and 8% considered it a little more difficult. 94% of respondents thought the level of difficulty was appropriate. Syllabus coverage was considered to be good by 66%, satisfactory by 26% and poor by 8%. Clarity of wording was considered good by 70% and satisfactory by 30% of the respondents. The presentation of the paper was considered good by 79% and satisfactory by 21% of the respondents.

This was generally a straightforward paper with some very accessible marks. Schools where most or all the candidates answered the same two options achieved the best results. The majority of the candidates knew the subject material well. Most candidates seemed able to complete the paper in the space provided.

However, there were schools where the candidates seemed unfamiliar with most of the subject material and left many areas of the question paper blank. Answers lacked precision in terms of the wording used and explanations were often vague. Responses to questions lacked chemical detail and particularly for Options D, E and F some responses tended to be journalistic rather than based on chemical facts and principles.

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

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

- Interpreting infrared spectra of various compounds
- Distinguishing between ^{1}H NMR spectra of various compounds
- The characteristic properties of 2 – amino acids
- The equations to form triglycerides from glycerol and fatty acids
- Comparing the structures of two different fatty acids.
- Comparing the composition of cholesterol and with phospholipids such as lecithin
- The potential risks associated with developing nanotechnology
- Distinguishing between different types of liquid crystals
- Advantage of using morphine as a strong analgesic
- Outlining the major stages in new drug development
- Outlining how the multi-stage distillation converts sea water to fresh water
- Structure of benzene
- Organic reactions
- Organic mechanisms

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

The areas which seemed well understood were:

- Reasons for using analytical techniques
- The operating principles of a double-beam IR spectrometer
- The functions of oral contraceptives in the female body
- Comparison between weak and strong analgesics
- The meaning of the terms: therapeutic window, tolerance and placebo effect
- The gases involved in global warming
- The effects of global warming
- Antioxidants

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

Option A – Modern analytical chemistry

Question A1

In (a) candidates were able to state at least one reason for using analytical techniques but struggled to state a second. For part (b) candidates often missed discussing the change of dipole moment. In part (c) candidates had a reasonable understanding of the operating principles of a double-beam IR spectrometer, but others missed specific chemical details and often confused the IR spectrometer with the mass spectrometer. Part (d) illustrated candidates' ability at linking wave numbers from IR spectra to correct bonds but they did not always provide adequate explanations for their choices.

Question A2

In (a) most candidates correctly determined the difference in the number of peaks in the ^{1}H NMR spectra of 1- bromopropane and 2 – bromopropane but neglected to mention or misinterpreted the differences in area under the peaks. In (b) many candidates provided superficial answers that did not correctly relate the different proton environments in the body to the generation of a 3 dimensional image of body organs. This was one question where journalistic responses were seen.

Option B – Human biochemistry

Question B1

Apart from the general formula in (a), many candidates had difficulty providing the characteristic properties of 2 – amino acids. The characteristic properties are clearly identified in the syllabus details. Most candidates could name the correct bond types in part (b).

Question B2

Candidates could not write an equation for the reaction between glycerol and stearic acid to form a triglyceride. Where candidates did write the correct equation they often did not balance the equation correctly. In part (b) many candidates did not correctly recognize the difference in the number of carbon – carbon double bonds in the two fatty acids, nor the location of the double bonds and hence the significance of the omega-3 and omega-6 terminology. Some candidates correctly identified that these fatty acids cannot be synthesised by the body and hence are essential. In part (c) candidates could not distinguish between HDL and LDL, often referring simply and inadequately to 'good' and 'bad' cholesterol. Candidates had great difficulty comparing the composition of cholesterol with lecithin. An elemental comparison was required.

Question B3

Some candidates provided the structure of the functional group requested rather than the name as asked for in the question. This emphasises the need for candidates to read questions carefully and address what is requested.

Option C – Chemistry in industry and technology

This was one of the least popular options and candidates struggled with many of the questions.

Question C1

About half the candidates could define the term *nanotechnology*. Some candidates, however, inadequately defined the nanotechnology as 'very small' technology or technology on the 'nano scale'. Candidates had considerable difficulty describing the structure and properties of carbon nanotubes and often speculated very vaguely on the impact of nanotechnology. Responses were often superficial.

Question C2

Candidates were able to define liquid crystals but often confused the two diagrams. Candidates also had difficulty distinguishing between thermotropic and lyotropic crystals and providing suitable examples for each. This emphasised again that candidates had not learnt definitions accurately with correct chemical terminology.

Question C3

Candidates were not adequately able to compare a fuel cell with a lead-acid battery nor did they demonstrate a strong understanding of how a fuel cell was constructed or worked.

Option D – Medicines and drugs

This was one of the most popular options.

Question D1

Most candidates could provide reasonable advantages for using aspirin over paracetamol in part (a) and were able to distinguish between the ways mild analgesics and strong analgesics relieve pain in part (b).

A substantial number of candidates failed to identify the tertiary amine in the structure of morphine. Candidates were inaccurate in drawing a circle around the amine group in part (c). Either just the nitrogen atom or nitrogen atom with its three neighbouring atoms should have been circled. A large number of candidates confused the ester with an ether or carbonyl group as the functional group found in heroin but not in morphine. Most candidates recognized the disadvantage of using morphine but they had extreme difficulty in stating a specific advantage for using morphine as a strong analgesic.

Question D2

Many candidates had difficulty explaining the term *therapeutic window*. Frequently they thought it referred to the time the drug was active in the body rather than an issue of dosage. They fared better with explaining the terms *tolerance* and the *placebo effect*. Candidates had more difficulty providing specific information about the drug development process, especially with respect to animal testing and human testing. Candidates needed to use accurate chemical terms when outlining the major stages in the development of a new drug.

Question D3

In part (a) most candidates were able to describe the difference between the effects of moderate and high doses of depressants, although they often confused depressants with stimulants. Candidates frequently confused oxidation and reduction or failed to provide a reason as to whether the chromium was oxidised or reduced by ethanol. This highlighted, again, the need for candidates to answer all parts of the question.

Option E – Environmental chemistry

This was also one of the most popular options.

Question E1

Some candidates were not able to provide two more major greenhouse gases. Many candidates stated NO_2 rather than N_2O as a greenhouse gas. Candidates also had some difficulty explaining which greenhouse gases were most significant. Candidates only gave the name of the most significant greenhouse gas but did not provide an explanation. Although most candidates were able to discuss two effects of global warming, some candidates confused global warming with the depletion of the ozone layer. Candidates were also expected to discuss the effects of global warming rather than just restate the question by stating that the atmospheric temperature would increase.

Question E2

In part (a) the term *biochemical oxygen demand (BOD)* was not well known. Very few candidates could explain that it is related to the level of organic waste in the water measured at a specific temperature for a specific time period. In part (b) candidates correctly recognized that oxygen is less soluble in hot water. Some candidates, however, simply restated the question and indicated that the dissolved oxygen concentration would decrease. Very few candidates adequately explained the effects of fertilizer run off on the dissolved oxygen level of the river and did not provide a reasonable description of eutrophication.

Many candidates understood that oxygen gained electrons in (c) (i) and that the oxidation number of manganese dropped from +4 to +2 in (ii). However, they struggled to calculate the moles of dissolved oxygen.

The answer of 1×10^{-4} mol was often given rather than the correct answer of 5×10^{-5} mol. In part (d) most candidates could not outline the multi-stage distillation process. Many confused this process with reverse osmosis or described sewage treatment.

Question E3

Many candidates wrote correct equations (including the radical symbol for the free radicals involved) for the formation of O_3. Candidates generally were able to explain the advantages of hydrocarbons over chlorofluorocarbons in the atmosphere. Commonly candidates discussed the contribution of hydrocarbons to the greenhouse effect but some stated that hydrocarbons were expensive and some did not provide an advantage of the use of hydrocarbons. This was another area where candidates did not address all parts of the question.

Option F – Environmental chemistry

Another popular option.

Question F1

Part (a) was generally poorly answered. Many candidates found it difficult to explain why naturally occurring pigments are coloured in terms of their ability to absorb and reflect light. Candidates commonly correctly stated anthocyanins as the pigments in cranberries and strawberries, but they mistakenly gave β-carotene or carotenes as the answer for (c) (i) instead of the name of the *class* of pigments, carotenoids. Only the better candidates readily understood the connection of the carbon-carbon double bond to oxidation and its relationship to the colour of the pigment.

Question F2

In part (a) most candidates could define the term *antioxidant* and state two naturally occurring antioxidants and their sources. Candidates were usually able to state two traditional methods of extending shelf life for food. Candidates were not able to discuss an advantage or disadvantage of using natural antioxidants as they often confused natural and synthetic antioxidants.

Question F3

Most candidates recognized that genetically modified foods come from genetically modified organisms. However, candidates generally thought of genetically modified foods as coming only from plants. Candidates did not discuss the advantages of genetic modifications in animals or for example in terms of environmental friendly pesticides.

Candidates struggled to discuss the concerns of using GM foods. Many candidates provided general and simplistic responses. For instance candidates just stated that GM foods were unnatural and therefore bad, showing no understanding of the real concerns.

Option G – Further organic chemistry

This was another popular option. However, overall the questions in this option were not well answered. Many candidates demonstrated only a superficial understanding of organic reactions and mechanisms.

Question G1

In part (a) most candidates described benzene as a ring structure with 6 carbon atoms. However, there appeared to be confusion about the delocalized electron properties of the benzene ring. About half of the candidates who attempted the option thought there were alternating double bonds in the structure. Fewer candidates commented on bond length or bond angles in benzene. Very few candidates were able to provide the correct value for the enthalpy of hydration of benzene to cyclohexane in (b). In part (c) some better candidates provided the correct structure for the product for the reaction and identified the mechanism correctly as nucleophilic substitution. Many candidates could not adequately explain why bromobenzene does not react with the hydroxide ion.

Question G2

The more capable and better prepared candidates correctly stated the Grignard reagent formed and the first of the two products in part (a) (ii). Even the better candidates, however, could draw only one (usually B) or 2 correct structural formulas of the products in the reactions in (b).

Question G3

Very few candidates were able to explain even a partially correct mechanism using curly arrows. Those candidates who did attempt this question often only scored a mark for stating the organic product formed. A substantial number of candidates did not attempt this question in Option G.

Recommendations and guidance for the teaching of future candidates

- Teachers are strongly advised to refer to past examination papers and the corresponding mark schemes to assist candidates with examination preparation.
- Teachers should ensure that definitions covered in the assessment statements for each option are well known by candidates.
- Candidates should be given guidance as to the level of depth expected in responses to questions. Journalistic answers to questions will not suffice.
- Candidates need to read questions carefully to ensure they answer appropriately and precisely.
- Teachers should encourage candidates to note the number of marks allocated to a question and correlate this to their response to ensure it is sufficiently detailed.
- Candidates should read questions carefully to avoid missing responding to parts of the question.
- Chemical equations should be given wherever possible to support the processes discussed in options. Candidates should practice writing balanced equations.
- Organic mechanisms should be clearly described.
- Strongly encourage candidates to answer questions only on the options they have studied.
- Candidates need to be aware to of the importance of command terms. Candidates must know the meaning of the different command terms that appear in the assessment statements and in the examination papers.
- Teachers should emphasise the importance of clearly set out calculations
- Significant figures should be considered in all calculation type questions.
- Candidates should read questions carefully to avoid errors in units.