CHEMISTRY

Overall grade boundaries

Higher level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 18	19 - 32	33 - 43	44 - 55	56 - 65	66 - 76	77 - 100

Standard level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 15	16 - 29	30 - 42	43 - 53	54 - 64	65 - 76	77 - 100

Higher and standard level internal assessment

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0-9	10-15	16-21	22-27	28-31	32-37	38-48

General comments

As ever the range of work submitted was wide but there was plenty of material that indicated that many schools are conducting excellent practical programmes and the students are benefiting as a result. In general the senior moderating team felt that there has been an improvement in the overall suitability of the work evidenced and in the organisation of the samples. The students and teachers at many schools have been praised in the 4/IAF feedback forms from the moderators and it is hoped that this improvement is reproduced in future sessions.

As in November 2006 the moderating team were working to instructions from the Principal Moderator that emphasised that teachers are the primary markers and that moderators should support the teacher wherever possible. Moderators are not primary marking and if the teachers grading is a plausible interpretation of the criteria then it should be supported.

Guidance was then given as to when and how moderators should and should not change marks as follows:

“ A. When to mark down

Planning (a):

- The research question, hypothesis and/or independent and controlled variables are given by teacher. Mark the relevant aspect down to ‘n’. A general aim is fine if the students have significantly modified it (e.g. made it more precise).
- The hypothesis has not been explained or the explanation is clearly counter to theory as can be reasonably expected to be known by an average IB chemistry student (eg. ‘reaction rate will decrease with increasing temperature because ………’). Award ‘p’ for second aspect.

Planning (b):

- A method sheet is given which the student follows without any modification or **all** students are using identical methods. Moderator gives n, n = 0
- Teacher gives c, c, c but it is clear that the students have been told what apparatus and materials they require. Maximum moderator can award is n, c, c = 2.

Data Collection:

- A photocopied table is provided with heading and units that is filled in by students. Maximum moderator can give is p, n = 0.
- The teacher gives 3 (c, c), but the student has only recorded quantitative data (e.g., in titration) and qualitative data such as colors of solutions, indicator, color change etc. are missing. Moderator gives p, c = 2. However, do not be overzealous and penalize DC every time a student does not find qualitative data to record.
- Student has not recorded uncertainties in any quantitative data. Maximum ‘p’ for first aspect.
- Student has been repeatedly inconsistent in use of significant digits when recording data. Award ‘p’ for second aspect.
- In purely qualitative DC tasks such as establishing a reactivity series. Too often the students 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.

Data Processing & Presentation:

- A graph with axes already labelled is provided (or students have been told which variables to plot) or students follow structured questions in order to carry out data processing. Moderator gives c, n = 1.
- No evidence of errors being propagated (HL) or total random error being estimated in any way (SL). Maximum award c, p = 2. Remember that best fit

line graph is sufficient to meet requirement for error and uncertainty propagation.

Conclusion & Evaluation:

- Structured questions are given to prompt students through the discussion, conclusion and criticism. Depending on how focussed the teacher's questions are and on the quality of students' response the maximum award is partial for each aspect the student has been guided through. You have to judge purely on the students input.
- Teacher gives c, c, c = 3 but the student has only indicated as a criticism that they ran out of time. Maximum moderator can give is c, n, p = 1.

B. When not to mark down.

In the following cases, support the teacher's stance as they are aware of their own expectations of the students.

Planning (a):

- Dependent variable has been given by teacher or student has made no mention of dependent variable (surprisingly it is not featured in aspect 3 descriptor!)
- You disagree with the explained hypothesis but you feel that it is a reasonable application of IB level knowledge.
- The hypothesis explanation is simplistic but the only one possible within the framework of the task (eg. Student predicts vitamin C contents of juices based on evidence supplied by packaging.) In this case support the teacher but feedback to teacher as to the poor suitability of the task for meaningful hypothesis generation.
- 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).
- There is a list of variables and it is clearly apparent from procedure which is independent and which are controlled.

Planning (b):

- 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 equipment list. Give credit for equipment clearly identified in a stepwise procedure. Remember we mark the whole report.
- Do not insist on +/- precision of apparatus to be given in apparatus list. This has never been specified to teachers and the concept of recording uncertainties is dealt with in DC.

- 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.

Data Collection:

- In a comprehensive data collection exercise possibly with several tables of data the student has been inconsistent with significant digits for just one data point or missed units out of one column heading. If you feel the student has demonstrated that they were paying attention to these points and made one careless slip then you can still support maximum mark under ‘complete not meaning perfection’ rule. This is an important principle since often good students responding in full to an extended task unfairly get penalised more often than students addressing a simplistic exercise.
- Student has not included any qualitative observations and you cannot think of any that would have been obviously relevant.
- Purely qualitative DC such as in establishing a reactivity series. These are currently allowable but not recommended since they do not facilitate recording of uncertainties. Please feedback to that effect. However when marking do make sure that it is genuine raw data (see section A above).
- No table title when it is obvious what the data in the table refers to. I have seen students do all the hard work for DC 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.

Data Processing

- Errors and Uncertainties

The expectation in chemistry, as described in the TSM 1, is:

“Standard level candidates are not expected to process uncertainties in calculations. However, they can make statements about the minimum uncertainty, based on the least significant figure in a measurement, and can also make statements about the manufacturer's claim of accuracy. They can estimate uncertainties in compound measurements, and can make educated guesses about uncertainties in the method of measurement. If uncertainties are small enough to be ignored, the candidate should note this fact.

Higher level candidates should be able to express uncertainties as fractions, $\Delta x/x$, and as percentages, $(\Delta x/x) \cdot 100$. They should also be able to propagate uncertainties through a calculation.

Note: Standard level and higher level candidates are not expected to construct uncertainty bars on their graphs.”

> Note that a best-fit line graph is sufficient to support ‘c’ for the second aspect at both SL and HL.
>
> For both DC and DPP, if the student has clearly attempted to consider or propagate uncertainties (according to whether HL or SL) then support a teacher’s award even if you feel that the student could have made a more sophisticated effort. Please **do not** punish a teacher or student if the protocol is not the one that you teach i.e. top pan balance uncertainties have been given as +/- 0.01g when you may feel that if we consider the tare weighing then it should be doubled. Moderation is not the time or place to establish the favoured IB protocol.
>
> **Conclusion and Evaluation**
>
> - Simply apply the principle of complete not meaning perfect. For example if the students 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, be a bit more critical in the third aspect that the modifications are actually relating to the cited sources of error. ”

Finally the moderators were guided:

> “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 mark upwards.”

The range and suitability of the work submitted

As always a range of practical programmes of varying suitability were presented for moderation this year but there was a heartening improvement in standards and compatibility with the Internal Assessment criteria. There were a good number of schools who submitted challenging work which reinforced learning and provided a suitable opportunity for assessment. Compared with previous May sessions a smaller number of schools were still not undertaking a suitable practical scheme of work and were failing to appropriately address the assessment criteria. It is disappointing that some of these schools were not implementing recommendations given on the previous year’s 4/IAF feedback form.

It would be pleasing to see more investigations that give the opportunity to more able students to stretch themselves and apply their knowledge. For example, for many Higher Level candidates a planning exercise to see which factors affect the rate of a reaction is quite undemanding, with the hypothesis being extremely straightforward since the background theory is so well known.

With regard to Planning (b) often the similarity of response from all the candidates in the sample indicated that further instructions had been given but not evidenced for the moderator. One investigation in particular, the thiosulphate/acid rate experiment, is falling into disrepute as many reports are seen using identical materials, quantities and methods to those seen in commonly available laboratory manuals. Either the teacher has supplied the method at some stage or the students are using unreferenced sources. Neither scenario is acceptable for internal assessment, and teachers in such cases should reflect whether the task is truly providing an opportunity for realistically assessing students’ skills in planning an investigation.

There was very little evidence of the use of data-logging techniques in the samples sent for assessment. The fact that very few students refer to data-logging in planning activities indicates that they are not yet familiar with the technology concerned. There is no reason why data-logging cannot be incorporated into successful planning or CE tasks, and with careful forethought as to how much students input is possible even into Data Collection and Data Processing.

This session saw the continuation of a trend of the last few May sessions with fewer cases where teachers had denied students the opportunity to fulfil criteria for themselves by having supplied focussed aims in Pl(a), detailed procedures in Pl(b), pre-formed data tables (DC), step-by-step guidance on how to do calculations (DPP) or guiding questions (CE) when these various criteria were to be assessed. That said there were more reported problems of this nature than in the November 2006 session and so there is still room for improvement at a number of schools.

Candidate performance against each criterion

Planning (a)

This criterion was generally well fulfilled with students able to pose a research question, make a sensible hypothesis with some level of explanation and to identify the relevant control and independent variables. One significant reason for some candidates not fulfilling this criterion was that the set task was too narrow to allow the candidates to make their own decision as to which variable(s) should be the independent variable and which others should be controlled.

Planning (b)

This criterion was fulfilled to a similar extent as in previous years. Candidates generally selected suitable equipment and devised appropriate strategies for carrying out investigations. An investigation that requires the teacher to specify the equipment or methodology is not appropriate for assessment of Pl (b). Teachers sometimes over-plan and set up an investigation leading to only one possible procedure, and this denies candidates opportunity to achieve in this criterion. Both Pl (a) and Pl (b) should evoke different responses from different candidates within the same class.

A common weakness in Pl (b) is the lack of control of variables even though candidates have identified variables to be manipulated or controlled when addressing Pl (a). The most common example of this omission was that students failed to control or monitor reaction temperature when undertaking a kinetic study of a significantly exothermic reaction. Another failing of a large number of candidates was the absence of quantitative information regarding reactant concentrations, masses, volumes, etc. One common reason for incomplete fulfilment of Pl (b) was that the candidates often did not plan to collect sufficient data. They should consider repeat trials and if a graph is to be plotted a minimum of five data points is recommended.

Data Collection

Most candidates had been presented with suitable data collection tasks (although some schools still assess DC when only a very small amount of data, such as a single titration trial, has been collected) and their performance was generally good with candidates independently able to present data in suitably constructed tables with appropriate column headings and units. An increasing number of students were correctly recording uncertainties in their quantitative data but there was frequent inconsistency in the use of significant figures. More candidates than in previous sessions took the opportunity to record qualitative data when it was clearly present and significant (e.g., the evidence of incomplete combustion in an enthalpy of combustion determination).

Teachers were prone to over-reward their students in purely qualitative DC tasks with full reward being given for poorly phrased observations that either lacked detail or were not primary observational statements.

Data Processing and Presentation

Most schools had appropriately assessed DPP in quantitative tasks and the overall standard was satisfactory although a few schools still unwisely used purely qualitative investigations for DPP assessment. It was pleasing to see that an increased number of schools encouraged meaningful treatment of errors or uncertainties in DPP, although a sizeable minority of schools have yet to address this requirement.

Once again a disappointment was the relatively small number of graphs presented for moderation and their poor quality overall. Common failings were the inappropriate scaling, the inability to construct a reasonable best-fit line, the presentation of inappropriate sketch graphs when a greater accuracy of plotting was required, as well as the poor use of Excel. Contemporary versions of Excel can be used to great effect in DPP but the normal expectations of graphing , i.e. labeled axes with units, best-fit lines and curves, etc, must still be observed, as well as the candidate’s individual contribution being evident. A graphing program that does not permit user control over the processing or output is not suitable for assessment of this criterion.

Few candidates undertook further processing of the data such as finding a gradient or intercept through extrapolation and teachers should really set tasks that will require them to do so. This is especially relevant to Higher Level students where the extraction of quantitative information from a graph is an important higher order skill.

Conclusion and Evaluation

It was common this session for candidates to compare their results to literature values where appropriate which is encouraging. This criterion also requires a valid conclusion with an explanation that is based on the correct interpretation of the results and this is often missing. There is very little evidence that candidates make any attempt at background reading or research in order to interpret their findings. Most candidates did attempt to evaluate the procedure and list possible sources of error. Very few candidates were able to assess if the final result was explainable by random error or required the consideration of systematic errors. Some candidates were able to make appropriate suggestions to improve the investigation following the identification of weaknesses, although many were only able to suggest simplistic or completely unrealistic improvements.

Manipulative skills

In general, the practical programmes provided adequate scope for assessment of this criterion.

The Group 4 Project

All schools provided evidence for participation in the Group 4 Project for each of the candidates in the sample. This is an essential requirement of the IB programme. Many schools seemed to have undertaken stimulating and imaginative projects. It is worth teachers noting that a significantly large proportion of schools use the Group 4 Project as an ideal opportunity to stimulate group collaboration within an interdisciplinary framework and assess the Personal Skills criteria, but do not award grades for the written criteria. This approach is recommended for the May 2008 session and will become standard practise from May 2009 onwards.

Recommendations for the teaching of future candidates

The following recommendations are made for the teaching and assessment 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 is strongly encouraged.
- It is essential to ensure that students 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 achieve criteria, and hence should not provide too much information/help for the Planning (a), Planning (b), Data Collection, Data Processing & Presentation and Conclusion & Evaluation criteria.
- Teachers should consult TSM 1 regarding the consideration 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.
- For the May 2008 session continue to encourage candidates to form a hypothesis that is directly related to the research question and is explained in terms of chemistry concepts, usually at the molecular level.
- Candidates should be encouraged to consider repeat trials, calibration or generation of sufficient data to undertake graphical analysis, when designing procedures for Pl (b).
- Candidates must record qualitative as well as quantitative raw data, where appropriate, including units and uncertainties where necessary.
- 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 errors, 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 facilitate 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.
- In May 2008 evidence for participation in the Group 4 Project by each candidate in the sample must still be submitted with evidence of individual contribution.
- 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 *Vade Mecum* before submitting work for moderation.

Higher level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 10	11 - 14	15 - 19	20 - 23	24 - 27	28 - 30	31 - 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. 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 184 G2's that were returned. 25% found that it was of a similar standard, compared with last year's paper, 2% felt that it was a little easier, 42% thought that it was a little more difficult and 31% were of the view that it was much more difficult. 62% felt that the level of difficulty was appropriate, 37% felt that it was too difficult and only 1% thought that the question paper overall was too easy. Syllabus coverage was considered satisfactory by 35% and good by 62%. In addition, 37% felt that the clarity of wording on the paper was satisfactory and 59% felt that the wording was good. The presentation of the paper was considered satisfactory by 22% and good by 77%.

The main difficulty for candidates on this paper related to those questions where they had to *apply* chemical principles to solve a particular problem. These questions are referred to explicitly below. As there appeared to be a number of questions of this nature on the paper this year, this may reflect the above consensus that the overall paper was viewed somewhat more challenging than normal based on the G2 statistics. Candidates should ensure that they have gained ample practice at *applying* the principles of a particular topic, rather than sticking rigidly to a particular style or type of question, which may have appeared on previous examination papers. Some examples of questions of this nature are clearly seen in this year's Paper 1, which may serve as good practice questions for candidates preparing for future examinations.

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

The difficulty index (the percentage of candidates achieving each correct answer) ranged from 92.50% to 14.31%, and the discrimination index, an indication of the extent to which questions discriminated between high- and low-scoring candidates, ranged from 0.58 to 0.15 (the higher the value, the better the discrimination).

The following comments were made on selected individual questions:

Question 2

Several respondents felt that this question was unnecessarily difficult to test a simple concept. Although the question itself was somewhat challenging, with a related difficulty index of 45.08%, the question clearly tested a key component of the curriculum.

Question 3

In this question on the reaction of calcium carbonate with sulphuric acid, one respondent commented that since calcium sulphate is insoluble that the reaction would stop. 76% of candidates in fact choose the correct answer, B.

Question 5

This question related to the emission spectrum of the hydrogen atom, and one respondent raised the question as to whether the Balmar, Lyman and Paschen series of hydrogen spectral lines should in fact be covered as part of the curriculum. In section 2.2 of the guide, it is clearly stated that series should be considered in the UV, visible and IR regions of the line emission spectrum of hydrogen.

Question 6

One respondent felt that this redox related question was quite challenging. However, 53% of candidates cited D as the correct answer, and the question in fact had a corresponding discrimination index of 0.58, which was the question (along with Question 23) with the highest discrimination index on the entire paper, making it a good discriminator. As was seen elsewhere in Paper 2, the chemistry of Group 7, the Halogen group did pose problems for several candidates this year, and there did appear to be a weakness in some fundamental chemical concepts in this area.

Question 7

Several respondents felt that the incorrect statement (statement III - “melting points decrease from Na → Ar for the period 3 elements”) was ambiguous. This was considered, but it was thought that because it included the term “for the period 3 elements”, that in fact this was clearly incorrect.

Question 8

A number of respondents commented that the use of isomeric is not appropriate in relation to the two compounds, $[Co(NH_3)_5Br]SO_4$ and $[Co(NH_3)_5SO_4]Br$., which is incorrect, as these are two classic examples of ionization isomers, which is one well-known class of isomerism in transition metal chemistry. The question itself clearly involved candidates determining the +3 oxidation state of cobalt in both isomers, and involved a simple derivation of the +3 state, based on the zero charge of the ammonia ligand, the -2 charge of the sulphate and the -1 state of the bromide. At HL, candidates should be able to determine the oxidation states of transition metals in transition metal complexes, based on knowledge of the standard rules of oxidation numbers, which is part of 10.1.2 of the core. Overall, this question was correctly answered by 54% of candidates.

Question 11

One comment on the wording of this question referred to the use of the syntax, “in order of increasing”, which may render some confusion for candidates, whose mother tongue is not English. Although the question could easily be rewritten to incorporate the use of the less than (‹) sign, this syntax has been used on several occasions in the past on papers, and teachers should ensure that students are familiar with the style of question asked on IB Chemistry papers, by closely examining previous papers. Another respondent suggested that this question was off the syllabus. The guide clearly states in 4.2.7 that the shape and bond angles for species with four charge centres on the central atom should be known. An important point should be stressed here that although the guide does list suitable examples of molecules and ions, which could be used in the coverage of molecular geometries, these lists are not exclusive and candidates should be prepared to *apply* VSEPR Theory to species with two, three, four, five or six charge centres (electron domains), at HL.

Question 12

One respondent stated that both XeF_4 and XeO_4 have a square planar geometry. This is incorrect. XeF_4 is clearly square planar, whereas XeO_4 is tetrahedral.

Question 13

In this question on hybridization, some respondents felt that the question was very difficult. This was borne out by the statistics, with only 33% of candidates getting the correct answer, which is B. One respondent also felt that the question was somewhat unclear. The question did in fact incorporate a number of steps, namely, the determination of the full structural formula of each molecule and the related Lewis structure, the determination of the molecular geometry at each nitrogen centre and hence the hybridization at each nitrogen. The question itself was very clear as to what candidates had to work out. However, this question would have proved problematic for candidates who were not used to questions of this nature. Once more, candidates need to be prepared to answer questions involving the application of principles, especially at HL.

Question 14

Some respondents stated that this question on average kinetic energies of gases was not on the curriculum and was too difficult. However, close to 50% of candidates obtained the correct answer, and in fact the question related directly to Topic 5.1.4 of the guide.

Question 16

The correct answer for Question 16, was that in an endothermic reaction, bonds in the reactants are stronger than the bonds in the products. A number of respondents stated that this is only actually true for total bond energies, which is correct, and it would have been better if the question was worded in this regard. However, the question itself was reasonably well answered, with close to 57% getting the correct answer, and hence after careful deliberation it was felt that the wording of the question did not detract from students obtaining the correct answer from the list of possible answers provided.

Question 17

Only 14% of students got the correct answer, C, to this question. The main difficulty here related to the fact that in the balanced equation given in the question, the stoichiometric coefficient for $C_6H_6(l)$ was in fact two, which meant that most candidates, opted for A, as the correct answer, and hence failed to take into account the fact that standard enthalpy of combustion relates to one mole only. Hence, although there was nothing wrong chemically per se with the actual wording of the question, it would have been far more accessible to students if the equation had instead been written as $C_6H_6(l) + 15/2O_2(g) \rightarrow 6CO_2(g) + 3H_2O(l)$. In addition, as the guide does not explicitly state that students should know the standard enthalpy change of combustion (which relates to one mole), it was decided that the question would be eliminated from statistical consideration.

Question 18

Candidates are required to know the definition of lattice enthalpy, according to 15.2.1 in Topic 15: Energetics, of the curriculum. Again, this is another example of candidates applying a given principle to a question.

Question 19

Some respondents felt that this question was difficult. However, 70% of candidates cited A as the correct answer, and this was found to be the 9th easiest question on the paper.

Question 20

This question, which involved candidates determining the order of reaction for iodide and hydrogen peroxide drew a number of diverse comments from respondents on the G2 forms. Although many felt that the question required good mathematical judgement, and was significantly more difficult than previous years, student performance in fact was quite reasonable, with 54% obtaining the correct answer, which would be expected for a question of this nature. The question gave time data (in s), as opposed to the more typical rate data. Once more, candidates should not expect the same format in questions each year, and if one understood the basic principle of rate as the reciprocal of time, then this question should not have been perceived in any way as being problematic. Another respondent stated that there was an assumption in the question that candidates knew that starch and iodine react to form a blue colour. Again, the question might have been better worded in this regard, and have included some additional statement such as due to the formation of iodine. However, this information was clearly implied in the question and students would have been able to answer the question without this specific knowledge.

Question 22

For the reaction $SO_2(g) + Cl_2(g) \rightleftharpoons SO_2Cl_2(g)$, the units of ΔH were given as -85 kJ. One respondent felt that kJ mol^{-1} should be used here. When considering this, ΔH_r is generally defined as: $\Delta H_r = \sum n\Delta H_f$ (products) - $\sum n\Delta H_f$ (reactants). As ΔH_f's would be given in kJ mol^{-1}, multiplying by n mol, would mean the units of ΔH_r are more typically cited in kJ.

Question 23

This question was a standard equilibrium-type question on the determination of K_c. One respondent stated that the question lacked additional information in order to determine the value of K_c. As 4.0 mol of R are present at equilibrium, then K_c is simply calculated $(4)^2/(2)^2 = 4.0$, since $K_c = \{[R][S]\}/\{[P][Q]\}$.

Question 25

According to five respondents, Question 25 was deemed to be a difficult question, with one respondent asking whether candidates would know the meaning of K_w and K_a and one respondent stating that it would have been better to use the equation $NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$. This is a further example of a question, where candidates had to *apply* their knowledge of basic principles to answer a given question. In this case, students had to use the relationship $K_w = K_a \times K_b$, which is explicitly given as an assessment statement in Topic 18.3.6 of the guide and apply it to the equation $NH_4^+(aq) + H_2O(l) \rightleftharpoons NH_3(aq) + H_3O^+(aq)$.

Question 28

Some respondents felt that this question was difficult. However, 71% of candidates gave the correct answer, as A, namely NaOH(aq) and $CH_3COOH(aq)$.

Question 29

One respondent suggested that it was unnecessary to provide the three equations in this question on the strongest oxidizing and the strongest reducing agent. This of course is invalid, as it is necessary to know which species is being reduced and which species is being oxidized in the first instance to answer the question.

Question 30

The main comment on this question related to the description of the process of oxidation taking place at the negative electrode in a voltaic cell and at the positive electrode in an electrolytic cell. In the current guide, positive and negative electrode terminology is invoked in Topic 10.3, although it is correct to state that many teachers may prefer to describe the process of reduction taking place at a cathode and oxidation taking place at an anode. Both terms in fact have been incorporated into the new syllabus. However, in the current curriculum, in 10.3.4, the teachers note states that the latter description (*i.e.* the fact that oxidation takes place at the anode and reduction takes place at the cathode) is not actually required, and hence this is the reason why negative and positive electrodes would be used in a question of this type in the current syllabus.

Question 33

One respondent stated that this question has been asked previously. It should be noted that in most papers there may be some questions (or at least similar type questions) which would have been asked at various times on previous papers. Often this in fact can be the case when particular questions might have been answered poorly on previous papers.

Question 34

One respondent stated that this question which was based on the linkage present in nylon, was based on memorization as opposed to a clear test of the actual knowledge of chemical concepts. It should be pointed out here, that Paper 1 is based on Objectives 1 and 2 type questions and hence it is expected that there will be a percentage of the 40 questions, which will be based purely on Objective 1 type questions. These questions in fact should be deemed as good, accessible questions which may in fact benefit weaker candidates sitting Paper 1. Question 34 in fact, although an Objective 1 type question, was the 12th most difficult question on the entire paper, with only 46% stating, A, the amide link, as the correct answer.

Question 35

This question involved candidates stating the correct IUPAC name for 3,3,4-trimethylhexane. Some respondents felt that this question was outside the scope of the syllabus, as it involved nine carbon atoms. The guide (Topic 11.2.2) states that students must be able to state the names of alkanes up to C_6 and that branched-chained alkanes must also be considered. The interpretation of the assessment statement here is that no example will be asked having a basic long-chain carbon atom stem greater than hexane. However, as soon as branched-chain alkanes are written, there may well be more than six carbons *in total* in the molecule. However, the C_6 component in the assessment statement refers to the hexane stem. In this example, the stem involves C_6, and hence it is clearly expected that candidates should be able to determine the correct IUPAC name of such a structure.

Question 37

One respondent felt that this question was difficult. However, 53% of candidates correctly cited that propanol (B) was the correct answer. This question is a straight-forward question on fundamental organic chemistry.

Question 38

One respondent stated that it was difficult to answer this question on proton NMR without providing the corresponding spectrum. This question is based on the determination of the ratio of peak areas, given a condensed structural formula, and it is not necessary to provide a spectrum.

Question 39

This question was based on basic S_N1 and S_N2 type reactions, which should be well known to candidates.

Question 40

This question involved the mass spectrum of C_3H_6O. One comment on the G2's stated that it would have been better if the question stated that the molecule shows major peaks ONLY at *m*/*z* values of 58, 43 and 15. This is a valid comment and the question might have been better written if this was included. However, it was the better candidates who did get this question correct, since the difficulty index was 45.24%. The main assumption here is that CH_3CH_2CHO would also have had a peak at $m/z = 29$, due to the loss of the -CHO fragment, which is given as a note in Topic 20.13 of the guide. Another respondent stated that ethers are not included in the syllabus. In 20.13, a M_r value of 31, corresponding to the loss of CH_3O, is in fact stated, and hence it would be expected that for answer C, $CH_3CH_2OCH_3$, a peak at $m/z = 31$ would also be evident.

Higher level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 14	15 - 29	30 - 38	39 - 48	49 - 58	59 - 68	69 - 90

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 Higher Level course. The paper allowed the broad range of candidates the opportunity to demonstrate their knowledge and understanding. In general, however, answers lacked precision in terms of wording used and explanations were often vague. At some schools candidates seemed unfamiliar with most of the subject material and left areas of the question paper blank.

Candidates must pay particular attention to the number of marks allocated to each question and write their answers accordingly. Calculations must be shown clearly and should be checked for accuracy, significant figures and units where appropriate. Candidates must pay attention to the action verbs stated in the questions. Similarly, candidates must read questions correctly and answer them as required – on occasions, only part questions were answered and it was not uncommon for the reasoning to be missing when it was asked for.

Recall, understanding and ability to express chemical ideas with both clarity and precision was poor for a proportion of candidates but in contrast there were candidates who displayed the above abilities to a commendable standard.

The 166 G2 forms that were returned conveyed teachers' impressions of this paper. In comparison with last year's paper 70% felt that it was of a similar standard, 17% thought it a little easier, 11% considered it a little more difficult. 97% of respondents thought the level of difficulty was appropriate. Clarity of wording was considered good by 74% and satisfactory by 25% of the respondents. The presentation of the paper was considered good by 83% and satisfactory by 17% of the respondents.

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

- Empirical formulae calculations such as those outlined in Q4(c)

- Significant figures
- Determination of units in calculations
- Drawing clearly labelled diagrams particularly in Q1(f)
- Electrochemistry/calculation of standard electrode potentials
- Writing equations (both redox Q2/Q3 and acid/base Q8 (d) reactions of oxides)
- Explaining properties of compounds according to their structure and bonding
- Definitions (such as standard electrode potential, standard enthalpy change of formation, optical isomers, weak acid, unsaturated hydrocarbons, even isotopes)
- Understanding the differences between electronegativity and electron affinity
- Organic chemistry
- Calculation of pH using K_a values.
- Explanations of the effect of changes on the position of equilibrium
- Explanations of evidence for strong and weak acids

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

- Describing the formation of σ and π bonds
- Hybridization
- Drawing Lewis structures
- Kinetic Molecular Theory
- Deriving and Writing rate expressions
- Brønsted - Lowry acid/base theory
- Calculating the pH of a weak acid
- Writing and naming structural isomers
- Calculating $\Delta S^{\ominus}$ and $\Delta G^{\ominus}$
- Determination of spontaneity based on $\Delta G^{\ominus}$ reasoning
- Electron configuration
- Oxidation of alcohols
- IR – identification of absorption bands in the infrared spectra given the structural formulae.

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

Section A

Question 1

(a) Most candidates were able to determine the order of NO and Br_2 as second and first order respectively. Many candidates determined the orders mathematically, and hence showed good understanding of the principles. A number of candidates did not give a reason for the correct response and hence did not score the marks.

(b) The rate expression was easily determined, particularly where part (a) was completed correctly. Even where candidates did not complete part (a) correctly they were given credit by error carried forward (ECF) where appropriate. Common errors with the weaker candidates included: writing the equilibrium law, missing the rate constant, writing the rate constant as K, which is the equilibrium constant as opposed to lower case k, which is used for rate constant. This was not penalized by examiners but teachers should emphasis the correct use of symbols for quantities.

(c) Candidates often made calculation errors, made errors with significant figures and found the determination of units challenging. A common mistake involved units of $dm^{-6}\ mol^{-2}\ s^{-1}$ instead of the correct units of $dm^6 mol^{-2} s^{-1}$.

(d) (i) Many candidates answered this question satisfactorily, being familiar with the fact that temperature was the only factor that changed the value of the rate constant. In part (ii), most candidates were able to state that the rate of change of the bromine concentration would decrease, (but only a few cited the actual factor involved – this was not required for the mark)

(e) The responses to this question varied significantly from the idea of heterogeneous catalysis being very well answered with comprehensive answers including graphical representations to other candidates not describing ***how*** a heterogeneous catalyst work but often described ***what*** a heterogeneous catalyst was. The major omission in the responses included candidates that did not include that the surface of the homogeneous catalyst was involved in the reaction.

(f) This question was generally well answered by candidates. The enthalpy level diagram was usually drawn. However, some candidates did not labelled $E_{a.}$ and $E_a(cat)$ accurately on the diagram or label the axis.

Question 2

Surprisingly a number of candidates had problems with this question.

(a) The major errors included: the equation was often unbalanced, the equation was written the other way round or a combination of Fe^{3+} and Ag^+ was used as reactants. A number of candidates also only provided the half equations for the reaction and did not combine them to produce a complete redox reaction as requested in the question.

(b) The definition of the *standard electrode potential* was not well known by many candidates. Candidates often described it incorrectly as the energy or current rather than potential difference between a standard half-cell and standard hydrogen electrode. The concept of ‘standard’ was not well expressed.

(c) Many candidates were able to calculate the correct value. However, some candidates incorrectly multiplied the standard electrode potentials by the coefficients in the equation.

(d) The flow of electrons through the external circuit from the more reactive iron to the less reactive silver electrode was typically answered correctly, although the weaker candidates incorrectly drew the arrow on the salt bridge, indicating a lack of understanding of what was required by this question.

Question 3

(a) Candidates often did not correctly identify both the oxidising agent and the reducing agent or had them in the reverse order.

(b) This was found very challenging even by the better candidates. The 5:2 stoichiometric ratio for Sn^{2+}: MnO_4^- was often determined correctly but candidates found it difficult to balance the H^+ ions.

Question 4

Again many candidates found the stoichiometric calculation of this question challenging. Candidates did not display adequate working or displayed none at all and this prevented some candidates from gaining marks through *error carried forward*.

(a) A number of candidates did not attempt this question. Many candidates also wasted time using unnecessary complicated calculations by first determining moles, using $pV = nRT$ of the gases rather than applying Avogadro's law to calculate reacting volumes of gases. A number of candidates carelessly missed calculating the volume of O_2(g).

(b) Candidates managed this question well. The mathematical interpretation was favoured when candidates answered this question. Quite a few candidates failed to score full marks as their analysis omitted any quantitative factor. A number of candidates also did not explicitly state the effect of temperature and volume separately.

Weaker candidates made incorrect use of arguments involving kinetic energy demonstrating their lack of understanding.

(c) (i) This was generally poorly attempted by numerous candidates. A common omission, was not converting the amount of H_2O calculated to the amount of H present. Some candidates failed to determine the mass of oxygen in the organic compound and thus were unable to determine its empirical formula. Working was not always set out which prevented some candidates from gaining marks through *error carried forward.* Although all data was given to three significant figures, calculations appeared from one to even eight significant figures.

The syllabus does clearly state that candidates should be able to determine a simple formula from suitable experimental data.

(ii) The molar mass of the compound was generally correctly calculated as was the molecular formula and with the application of *error carried forward* it did allow candidates to score the two marks, where appropriate, despite their errors in part (i).

Question 5

(a) The meaning of the term *weak acid* was generally articulated well. A number of candidates incorrectly used a pH range for the definition.

(b) An equation for the reaction of the weak acid, propanoic acid, with water was done well but numerous candidates did not use the equilibrium arrow sign rather than an arrow to illustrate complete dissociation. Many candidates were able to identify one conjugate *Brønsted-Lowry* pair.

(c) Generally the question of stating two methods, other than measuring pH, which could be used to distinguish between propanoic acid and nitric acid of the same concentration was done poorly. The question also asked for a reason in each case, and this was typically not given. Answers such as titrating with a base to see which acid requires the less amount of base shows conceptual weakness by candidates in this topic. In the case of the reaction with alkali, very few referred to the fact that the *temperature change* will be different for propanoic acid and nitric acid, since it is less dissociated.

(d) Determination of the pH of 0.100 mol dm^{-3} solution of propanoic acid given the pK_a value was generally varied significantly from candidate to candidates. Stronger candidates coped adequately with this question while weaker candidates tried to calculate the pH using the incorrect formula pH = log $[H_3O^+]$.

Section B

Question 6

This was by far the most popular question in Section B and candidates found it very accessible.

(a) Candidates were asked to predict and explain the effect of adding a reactant or adding a base on the position of equilibrium. In many cases the reason was missing – simply stating that it is due to Le Chatelier's principle was not deemed a sufficient explanation. Similarly, many candidates did not recognize that adding the base would remove the H^+ ions present. There is no effect of adding a catalyst on the position of equilibrium as a catalyst increases the rate of the forward and reverse reactions **equally** – this last part was missed by a good number of candidates.

(b) The explanation for the effect of increasing the temperature on the value of the equilibrium constant for an exothermic reaction was often missed.

(c) Instead of looking at the addition of H^+ from HCl that favours the forward reaction (since H^+ was a reactant) to use up some of the H^+ added, some candidates incorrectly tried to explain that the chloride ions displaced bromide ions in solution while others attempted to incorrectly explain that Cl^- would react with Br_2.

(d) Definition of the term *standard enthalpy change of formation* was not well known by candidates: some stated it as energy required rather than change in enthalpy; others stated it incorrectly that the reactants and product needed to be in the gaseous state, and many mentioned but did not define standard conditions of 298 K and 1 atmosphere pressure. Many candidates only scored 1 out of 2 for this reason.

(e) Calculation of the enthalpy change for the complete combustion of but-1-ene given appropriate data was generally done well, but with some candidates calculating a positive rather than negative value. Surprisingly, some candidates were not able to deduce, giving a reason, whether the reactants or products are more stable for the exothermic reaction. Comparison of the enthalpy change for the complete combustion of but-1-ene with that of but-2-ene generally varied.

(f) Many candidates were able to calculate the standard entropy change for the reaction. However, careless mathematical errors were made by candidates. Also, it was a common error for candidates to use the units for $T\Delta S$ (J mol^{-1}) that were different than for ΔH (kJ mol^{-1}). Some candidates did not include the units for ΔG in their answer. Hence one of the most typical errors included the lack of conversion to common units of either ΔS or ΔG and for temperature. A number of weaker candidates used degrees Celsius rather than Kelvin.

(g) Predicting, giving a reason, the spontaneity of a reaction knowing its negative ΔH and positive ΔS value was a challenge for some candidates but many candidates managed this question well. The application of *error carried forward* allowed for the allocations of marks even when (f) was incorrect. Candidates were able to explain the relationship well.

Question 7

(a) Many candidates attempted to draw the correct Lewis structures, state the shapes and predict the bond angles although the structures were at times poorly drawn, and sometimes were missing the non-bonding electron pairs. The omission of square brackets and the negative charge for was frequently observed.

(b) Explanation of bonding and structure given physical properties was generally not done well. Some candidates did not recognize that both melting points were high, that the one that does not conduct in any state had to be a network covalent structure and the other that conducts in the liquid state and aqueous solution is an ionically bonded network lattice structure, both with strong bonds throughout the structure. Many candidates used chemical terminology loosely referring to molecules and intermolecular forces.

(c) Many candidates defined hybridization mixing/combining of atomic orbitals and the type of hybridization shown by carbon in fullerene, graphite and diamond. The explanation of why graphite and fullerene conducted was not always well answered with candidates failing to answer with pi bonding or the delocalised electrons.

(d) Comparison of how orbitals overlap in the formation of sigma (σ) and pi (π) bonds was generally well done and some gave clear diagrams to show the overlap either along the inter-nuclear axis for a sigma bond or sideways overlapping of parallel p orbitals for a pi bond. Many candidates correctly stated the number of sigma and pi bonds in $H_2CC(CH_3)CHCH_2$.

Question 8

(a) The operation of the mass spectrometer was generally well done although some candidates did not identify the formation of positively charged ions (by the bombardment of fast moving electrons), or that the deflection depends not just on the mass of the ion, but rather on the mass/charge ratio.

(b) The meaning of the term *isotopes* was not always defined well. Typical errors included candidates interchanging the terms element and atom. Some candidates were not able to set up the equation to calculate the percentage abundance of the two isotopes of rubidium ^{85}Rb and ^{87}Rb knowing its relative atomic mass. Candidates had some difficulty writing the electron configuration of Fe^{3+}; a few started with noble gas configuration although the question asks for the full electron configuration.

(c) Although many candidates were unable to define *electronegativity* correctly (the ability of an atom to attract a bonding pair of electrons), most were able to correctly explain why the noble gases are not assigned electronegativity values. Candidates were generally able to state and explain the trend in electronegativity across period 3, but had difficulty explaining why Cl_2 rather than Br_2 would react more vigorously with a solution of I^-.

(d) Although many candidates were able to state the acid-base properties of period 3 oxides MgO, Al_2O_3 and P_4O_6, most were unable to write equations to demonstrate the acid-base properties of the three compounds listed, particularly for Al_2O_3.

Question 9

This was the least popular question in section B. Candidates who attempted this question, however, tended to do well.

(a) Some candidates failed to state the presence of **carbon** to **carbon** multiple bonds in an *unsaturated hydrocarbon*.

(b) Many candidates correctly wrote the equation for the conversion of ethane to ethanol and identified it as an addition or hydration reaction. Some candidates incorrectly described the reaction as a hydrolysis reaction.

(c) Although many candidates correctly described the complete oxidation of ethanol and name the organic product ethanoic acid, some did not identify the oxidizing agent and the colour change. Many could not state the condition for the process, namely heating under reflux. In general, however, candidates were able to provide more detail than in previous sessions.

(d) H_2O as a product was often missing in the equation for the reaction between ethanol and ethanoic acid. Many candidates did not indicate the use of the acid catalyst H_2SO_4 or H_3PO_4. Many candidates correctly identified the ester formed as well as stating a use for it.

(e) Identification of absorption bands in the infrared spectra given the structural formula was well done.

(f) Candidates were able to identify the formation of ethanal on partial oxidation of ethanol and were able to identify one difference in the respective ^1H NMR spectra of ethanal and ethanoic acid. However, most missed the similarity of having two peaks in the ratio of 3:1.

(g) The majority correctly defined the term *isomer*, and drew the functional group isomers of C_3H_6O. However, the meaning of the term *optical isomer* was more difficult to state. Many candidates were correctly able to draw the alcohol with the molecular formula $C_4H_{10}O$ which exhibits optical isomerism and identify the chiral carbon atom containing four different groups on it. Candidates were also typically able to draw the other three alcohol isomers (other than the optical isomer) of the same molecular formula and identify the tertiary alcohol (2-methylpropan-2-ol) as the one that does not undergo oxidation.

Recommendations and guidance for the teaching of future candidates

- Teachers should emphasize the importance and use of significant figures and units.
- 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 errors in units.
- Candidates should read questions carefully to avoid missing parts of the question.
- Teachers should emphasize the importance of clearly set out calculations.
- Candidates should learn definitions accurately.
- Candidates should practice drawing and naming organic compounds.
- Candidates should practice questions from past papers and refer to their mark schemes.
- Candidates need to be aware too of the importance of action verbs. Candidates must know the meaning of the different actions verbs that appear in the assessment statements and in the examination papers.
- Candidates should, where appropriate, illustrate their answers with simple, neat and well-labelled diagrams.

Higher level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 7	8 - 14	15 - 20	21 - 26	27 - 32	33 - 38	39 - 50

General comments

174 G2 forms were received which gave teacher's perceptions of the paper, 70% felt that the paper was of a similar standard to last year while just over 12% felt it was a little easier and

18% more difficult. For the level of difficulty 94% found it to be appropriate, 2% felt it was too easy and the remainder felt it was too difficult. Over 95% felt that the syllabus coverage, clarity of wording and presentation of the paper were satisfactory or better.

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

As this was an option paper the level of difficulty really depended upon the degree of understanding of each particular topic and there was no specific area which proved to be more difficult than the others.

The options proved to be of equal difficulty and many candidates gained very similar marks for each of the two options. The paper proved to be a good discriminator, with the best students scoring higher marks. Option B and C appeared to be the most popular, E and G the least.

Areas where considerable difficulty was found included:

- The intoximeter
- Naming functional groups accurately
- The 3-D structure of compounds
- The shape of the stereoisomer of cisplatin
- The names of NO and CH_3CHO
- The equation for the cracking of C_8H_{18}
- Nuclear equations for disintegration /fission and fusion
- Distinction between active and passive solar heating
- Calculations of the mass changes in equations
- Explanation of the electrical conductivity of silicon

Generally students struggled to develop logical systematic answers to longer, unstructured questions.

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

Some candidates were obviously very well prepared for the exam and were able to show a high level of achievement. They had complete mastery of all concepts, and lost marks only because of careless errors or misunderstanding of the question. The majority of students demonstrated an acceptable level of knowledge and understanding. A large number of students had little knowledge of the basic content. It was clear from their answers that they really had no knowledge of the basic science at all. In some such cases marks were lost through omission of essential detail. Greater reference to key words in questions, "explain", "compare" *etc*. is needed if students are to direct their answers better. Generally there was a higher standard of candidates' knowledge and understanding than in previous sessions, but many candidates had rote learned and they came unstuck when questions were asked in an unfamiliar way.

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

Option B – Medicines and Drugs

B1

(a) There was some confusion regarding what was oxidized or reduced and many candidates did not give both colours for dichromate (VI).

(b) Some answers were far too general with no specific details. O-H rather than C-H was frequently mentioned. Some of the candidates couldn't understand the nature of the intoximeter method and the point that the C-H bond can absorb the specific frequency infrared light was also often missed. Many candidates thought the intoximeter was an instrument to perform blood or urine tests.

B2

(a) This was very poorly answered with many references to ketone and methyl groups. Some of the candidates did not give a correct comparison between the caffeine and nicotine structure. They only mentioned that they both have amine groups but missed "tertiary". Misunderstandings between ketone, which is a formal functional group and carbonyl was also common.

(b) This was fairly well answered but still too many students were describing bad breath, discoloured teeth *etc*. Also many believed that nicotine relaxed the smoker even when they correctly said it made them more alert!

B3

(a) A lot of general knowledge was cited here. Many students gained the OWTTE mark, but very few correctly explained mitosis or injecting DNA/RNA/genetic material.

(b) This was fairly well answered and most students knew of at least one way antiviral drugs work.

(c) If candidates scored a mark it was for the rapid rate of the mutation of the HIV virus. Very few candidates got two marks.

B4

(a) This was surprisingly problematic and a number of the candidates couldn't explain chirality.

(b) The enantionmers were very poorly drawn. Only a small number of the candidates could draw a sound 3-D structure and the corresponding correct mirror image. Planar structures were often seen.

(c) (i) This was extremely poorly answered especially with bonding types; students often made suggestions other than dative and covalent.

Frequently bond angle and shapes did not correlate, many believed the shape of cisplatin is tetrahedral which resulted in a further mistake that the bond angle is 109°.

(ii). Some of the candidates misunderstood the question and gave the structure of cis- and trans- platin rather than just the trans- one.

B5

(a) No difficulty was found here generally except for a few candidates who reversed their answers, *i.e*. they said that it was a general anesthetic that blocked pain at the site. Also, the incorrect use of vocabulary was evident. The use of 'block' pain was rare for instance. Prostaglandins were mentioned by very few and general statements of dubious scientific value were often offered. As a difference, 'unconscious' was widely used to explain the general anesthetic.

(b) Partial pressures were calculated well by the majority- a few had no idea though. Some students lost marks for incorrect units even though units were given in the question stem.

Option C - Human Biochemistry

C1

(a) This was fairly well answered with a few careless mistakes, most common of these were to use the wrong amino acids or abbreviate the peptide linkage.

(b) (i) Very few candidates identified hydrochloric acid as being needed.

(ii) Many candidates obtained two or three marks, few mentioned different absorption being due to different solubilities of amino acids.

C2

(a) The majority of candidates mentioned double and single bonds without referring to carbon-carbon and hence lost marks.

(b) There was some confusion and repetition with answers in (a) and (b) The explanation of melting point difference between saturated and unsaturated fats was fully given by some candidates, although a few of the candidates gave the incorrect explanation such as more hydrogen or more hydrogen bonds. Some students mentioned breaking bonds for the change of state rather than overcoming intermolecular attractive forces. A significant number of candidates presented comments on the amount of hydrogens which was not accepted. Many candidates also established the difference between straight hydrocarbon chains in saturated and kinked hydrocarbon chains in unsaturated fats. The full terminology was often absent with statements such as 'saturated are straight' and 'unsaturated are kinked/bent' being extremely popular. Extremely few used angles to support their arguments.

C3

(a) and (b): Generally good answers were given but many errors were made - some of the candidates totally reversed the answers for hormone with a steroid backbone and a non-steroid backbone. They regarded adrenaline as one of the steroid hormones and testosterone and progesterone as the non-steroid hormones. When describing the function of the hormone some described its effect-*i.e.* Adrenaline causes dilation of the pupils or a more rapid heart beat- this is an effect not the function- which is to prepare the body for stress- fight or flight.

C4

(a) This was answered well in general probably as so much guidance was given in the question stem.

(b) Candidates answered well but lost marks by not using key vocabulary *i.e*. rate was not specifically referred to, $E > E_a$ or collision frequency was rarely mentioned.

Some candidates drew a graph of rate against temperature to help to illustrate what happens to the rate of an enzyme-catalysed reaction when the temperature varied from 10 °C to 60 °C.

C5

A surprisingly high number of candidates could not answer this question. The hydrogen bonds were not correctly shown between thymine and adenine, and between cytosine and guanine. C=O to H-C interactions were frequently included for the T-A base pair. This was very poorly answered with many combinations offered.

Option D - Environmental Chemistry

D1

(a) (i) This was very poorly answered with few candidates knowing that visible light is the part of the spectrum which is absorbed by the surface of the earth. Many suggested ultra- violet or short wave.

(ii) Candidates had more success here saying that infared radiation was reflected from the earth. Many however, used the term long wave.

(iii) Candidates did not know how greenhouse gases absorb the radiation on a molecular level, consequently, very few used the terms “stretch”, “bend” or “vibrate”.

(iv) The responses were far too general for this question and most did not identify a step to answer this question.

(b) Most students implied that carbon dioxide was the more abundant gas while most of the others tried to earn a point by saying that this gas was “the most significant”. Fewer could give an adequate reason why methane is a significant gas in terms of its ability to absorb more radiation.

D2

(a) This question about the likely pH for acid rain was generally answered well although many students incorrectly identified a pH of 1.2.

(b) Most candidates correctly identified an oxide - although some gave nitrous oxide as causing acid rain. Greater problems were caused when they tried to write a balanced equation for the oxides reaction with water.

(c) Most students gained at least one mark here although it was common for students to lose marks through lack of detail or because of the gas they identified in the previous question and gave answers that were not accepted, *e.g*. if sulfur dioxide was their selected gas, then a catalytic converter was given as a method of reducing this gas.

D3

(a) A common error here was that candidates stated that BOD was “the amount of oxygen required to sustain life” .Temperature and time were omitted in most answers. However, many students had learned the definition and were able to pick up two marks quite easily.

(b) (i) The majority identified point B as the concentration of oxygen had dropped.

(ii) Relatively few candidates then gained the marks for explaining that organic matter had been added. The common terms used were “pollution” or “plant life”. Some also suggested eutrophication.

D4

(a) Many candidates gave either “nitrogen oxide” or “nitrous oxide” for the name of NO gas rather than stating nitrogen monoxide. A few identified it as a secondary pollutant. Either of these responses meant the allocated mark was lost. A lot of candidates failed to mention the high temperature of the internal combustion engine. Lightening and the high temperature in jet engines were not popular responses.

(b) The correct name of ethanal proved problematic for some.

D5

Candidates could give the correct mechanism for the first and the second step but some of them neglected the third hint: “oxygen atoms are involved in the formation of Cl•” , so they replaced oxygen atom with ozone in the third step . This was a relatively straightforward question as the equations to be used were in the question stem. Many candidates did not then give an adequate explanation of why one CFC molecule is able to destroy many ozone molecules in terms of the regeneration of the chlorine radical.

Option E - Chemical Industries

E1

Most candidates identified coke and limestone as the correct raw materials but they had more difficulty writing suitable equations for the processes. Most candidates listed heat as the purpose for adding coke but seldom wrote the correct equation for the oxidation of carbon to carbon dioxide. In general many were unable to cope with the equations for limestone reacting with silica.

E2

(a) A few candidates thought that only 10% of refined products of petroleum were used as fuel rather than 90%.

(b) Many candidates wrote acceptable equations for the cracking process, but many also failed to read the question properly and ended up with an equation which did not present the compounds in the desired ratio.

(c) The majority of candidates correctly explained the reason for removing sulfur from crude oil and explained that it could be used for the production of sulfuric acid. Some lost the mark though as they failed to mention that combustion produced SO_2.

E3

(a) (i) Most obtained at least one mark by referring to melting point or density and strength. The second mark was obtained by a lower proportion often due to the use of vague terms or boiling point instead of melting point.

(ii) This was generally well answered and most candidates correctly identified atactic though few candidates got the mark for the explanation.

(b) Surprisingly this was more difficult than one would expect, and many students could not give good reasons to use plastic instead of wood and metal.

E4

(a) This was a problem question as many candidates did not know how to interpret Ellingham diagrams. Even those that obtained the correct value could not always explain the fact that ΔG must be positive to gain the second mark.

(b) Again many candidates were unable to state the temperature.

E5

(a) Very few candidates got all marks for stating brine, and sodium hydroxide and chlorine and hydrogen and then writing a correct equation. Some answers were based on molten sodium chloride.

(b) (i) Most candidates were able to correctly identify a problem with mercury.

(ii) Only some candidates correctly identified the diaphragm and wrote the correct equation.

Option F - Fuels and Energy

F1

(a) (i) Most candidates answered this part correctly, often using the value of 16 for their calculations which wasn't penalised.

(ii) Again the calculation caused few problems.

(iii) Many candidates lost the mark as they used ‘cleaner’ as their argument without specifying why. Most stated that methane is easier to ignite or transport than coal.

(iv) The concept of coal being more abundant proved tricky for some.

(b) The equation for the gasification of coal proved to be too challenging for most. Carbon dioxide was often shown as a product

F2

(a) (i) This disintegration equation of radium was generally answered correctly

(ii) Very few students correctly did this as they didn't have a neutron as a reactant

the following was typical:

$${}^{235}_{92}U \rightarrow {}^{145}_{57}La + {}^{88}_{36}Br + 2\,{}^{1}_{0}n$$

(iii) There were very few correct answers, as most students wrote He with a mass number of 4. Many ignored the term "ordinary hydrogen" and gave:

$${}^{2}_{1}H + {}^{2}_{1}H \rightarrow {}^{4}_{2}He$$

(b) The majority failed to give accepted comparisons of behaviour but, instead, described the difference in mass and charge of the alpha and beta particles Most students misinterpreted the question and described the general behaviour of these particles (like penetration powers) and some students defined alpha particles as neutral.

F3

This proved to be a very difficult question and hardly any students seemed to understand the differences between the four types of heating mentioned. Passive and active heating were mistaken by most. Quite a few produced some vague references to buildings making use of solar light but without specific references. Almost nobody correctly described the use of pumps or fans. A great deal of the answers were empty of scientific arguments or content. Direct conversion was correctly answered by more students but indirect conversion by far less. In general the favoured answer was the production of steam rather than the use of mirrors. It was quite evident that students had difficulty in establishing the difference between what was needed for the first and the second part of the question.

F4

(a) The term "mass defect" presented difficulties. There was a general "waffling around" the definition without accurate terminology.

(b) Many students only used protons and neutrons in their calculations and many did not attempt to calculate the mass defect. Quite a few of those who did, neglected to square *c*. However those that used the correct formula could get one mark for ECF.

F5

The candidates needed to explain why silicon is a better electrical conductor than sulphur; very few candidates spoke of the smaller first ionization energy, the rest of the candidates stated it was because silicon has a giant structure and incorrectly that it has free electrons. The addition of a Group III element was ignored by some and "electron holes/positive holes" were not well known. It appeared that the distinction between "exciting" and "releasing" was not well known. In spite of this, almost half did state that electrons would move from n-type to p-type materials.

Option G – Modern Analytical Chemistry

G1

(a) Most students answered this correctly. A few lost the mark as they only stated electrons are 'excited' or did not state that electrons were affected.

(b) (i) There were acceptable answers in reference to splitting and electrons moving to higher energy levels, however, few mentioned anything about the complimentary colour being transmitted.

(ii) Explaining why different ligands gave different colours caused problems. Electron densities and the absorption of wavelengths were rarely mentioned. Many candidates repeated arguments already stated in (i).

(c) (i) This was generally well answered; many correctly answered II and IV.

(ii) This was less successful - but many chose IV, however, not all could explain their choice.

G2

(a) References were often made to molecules rather than bonds and answers rarely addressed the question. General statements about IR spectroscopy were fairly common. References to a change in the dipole moment were rare.

(b) (i) Most students correctly identified the functional group.

(ii) The majority of the candidates obtained the first mark identifying the acid, but the second was achieved by few. Most students answered using the peaks value and few if any mentioned such a peak was broad or established the connection with the OH bond in acids.

(iii) The use of 'same bonds' was extremely frequent instead of stating that they had the same functional group.

(c) (i) The majority did not give acceptable answers in reference to singlet, triplet and quartet. In fact, many did not mention the terms at all.

In (ii), many of the candidates failed to provide the formulae of the compounds. Usual answers contained the R instead.

G3

Most candidates managed to get some points here, but the lack of deep knowledge was evident in most but the stronger candidates. Paper was usually chosen as the stationary phase instead of water in the paper. Capillary action and gravity rarely appeared. Many candidates produced material that portrayed rote learning rather than a clear understanding of the technique. For some, there was not a clear delineation between paper and column chromatography with the omission of some steps, *e.g.* silica/alumina. Most candidates were unable to explain that column chromatography would be more suitable because larger quantities are obtained.

Option H – Further Organic Chemistry

H1

(a) Most candidates correctly explained that free rotation was stopped by the double bond.

(b) The isomer was generally well drawn but why they were not geometric isomers was often poorly explained.

(c) Many candidates did not draw the correct isomer, having not read the question carefully. Also some candidates did not label the structures.

(d) This was not well answered and many students did not draw two correct isomers.

H2

(a) Writing the mechanism for the free radical substitution was required, and most of the candidates could give the correct mechanism but some missed out one of the propagation equations.

(b) This was generally well answered and most could name or draw the correct answer.

H3

(a) Although many correctly stated it was an electrophillic substitution the equation for the production of the electrophile was poorly done and many produced Cl^-.

(b) This was the poorest part of the option - the mechanism for methyl benzene reacting with chlorine in the presence of iron(III) chloride was not well known. Many substituted the methyl group, and those that did not drew the mechanisms poorly with little attention to detail; few gave H^+ as a product.

H4

(a) The equation for the acid dissociation was well known but often the mark was lost as equilibrium arrows were left out. The explanation was generally done quite poorly although good candidates were able to explain the electron withdrawing effect of the nitro group.

(b) More candidates had trouble with this equation but the explanation was often better.

Recommendations and guidance for the teaching of future candidates

- Many of the topics can be thought of as “general knowledge” but candidates must appreciate that their answers have to be syllabus specific if they are to gain credit and to systematically address every aspect of the question asked (and not to waste time on what is not required). Appropriate, and precise, use of chemical terminology is necessary.

- Students need to read questions more critically and make certain that they are actually answering the question that is being asked. Teachers need to work with their students to develop skills in analysing questions and stress the action verbs in their teaching.
- The mark allocation should be used by candidates as a clear indication of the length and depth of answer expected.
- Diagrams can be used to support text-based answers; however, these must be clear, in 3D if necessary, labelled and containing all bonds and atoms joined.
- Students could be encouraged to underline key words in questions so as to focus their minds more on addressing specifics required.
- Practise with past papers. Particular attention should be given to honing the skills of: writing correctly balanced equations; setting out calculations in a logical way and showing the working; the correct use of curly arrows in organic reaction mechanisms and the inclusion of the correct charge for ions and organic intermediate compounds and transition states.

Standard level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 4	5 - 9	10 - 13	14 - 16	17 - 20	21 - 23	24 - 30

General comments

This paper consisted of 30 questions on the Subject Specific Core (SSC) and was to be completed without a calculator or Data Booklet. Each question had four possible responses with credit awarded for correct answers and no credit deducted for incorrect answers.

Teachers' impressions of this paper were conveyed by the 172 G2's that were returned. 37% found that it was of a similar standard, compared with last year's paper, 4% felt that it was a little easier, 42% thought that it was a little more difficult and just 17% viewed the paper as much more difficult. 72% felt that the level of difficulty was appropriate, 1% considered the paper too easy and 28% thought that the question paper overall was too difficult. Syllabus coverage was considered satisfactory by 43% and good by 56%. Only 1% felt that the coverage was poor. In addition, 42% felt that the clarity of wording on the paper was satisfactory and 53% felt that if was good. 5% were of the opinion that the wording was poor on the paper as a whole. The presentation of the paper was considered satisfactory by 33% and good by 66%. Only 1% felt that the presentation of the paper was poor.

Although the perception statistically from the teachers reaction on the G2 forms appears that the paper was only marginally harder than last year's paper, a significant number of respondents did in fact comment that a high proportion of the questions involved quantitative reasoning involving more than one step in a problem. Six respondents felt that there were too many math based type problems. On close examination of the paper itself, it may have been slightly more difficult than in previous years. However, it was clear that poor performance in many cases was attributed to the failure of many students to apply chemical principles to problems, in particular in problems which although clearly related to certain topics on the syllabus did not include standard examples as seen in previous papers. Candidates need to be much better prepared to answer applied problems of this nature.

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 85.03% to 30.37%, and the discrimination index, an indication of the extent to which questions discriminated between high- and low-scoring candidates, ranged from 0.56 to 0.13 (the higher the value, the better the discrimination).

The following comments were made on selected individual questions:

Question 2

Some respondents found the use of the symbol A_r confusing, even though this symbol is clearly given as the symbol of relative atomic mass in Topic 1.2.3 in the guide. Another respondent stated that using a multiplication factor of four was atypical for an empirical formula type question. It must be stressed here that candidates must be prepared for all types of questions, on a given topic on the curriculum, and it should not be expected that just because a question appears to be of the same style as that seen on previous examination papers that the question involves exactly the same type of calculation or manipulation. It is imperative that students can *apply* their knowledge to all types of problems.

Question 3

This question was a straight-forward acid-base volumetric analysis type question. One respondent commented that diprotic acids are specifically not listed on the syllabus. However, this question is based on Topic 1.5.3 which involves the solution of stoichiometric type problems, and it would be expected that students would be able to determine problems of this nature involving potassium hydroxide and sulphuric acid. Another respondent stated that the term complete reaction may be ambiguous in the wording of the question, as some students may assume $KHSO_4$ as the final product in this reaction as opposed to K_2SO_4. It was not felt that this was a problem as the term neutralize was used in the question.

Question 8

Several respondents felt that the incorrect statement (statement III - “melting points decrease from Na → Ar for the period 3 elements”) was ambiguous. This was considered, but it was thought that because it included the term “for the period 3 elements”, that in fact this was clearly incorrect.

Question 11

Two respondents suggested that this question was off the syllabus. The guide clearly states in 4.2.7 that the shape and bond angles for species with four charge centres on the central atom should be known. An important point should be stressed here that although the guide does list suitable examples of molecules and ions, which could be used in the coverage of molecular geometries, these lists are not exclusive and candidates should be prepared to *apply* VSEPR Theory to species with two, three, and four charge centres (electron domains), at SL, irrespective of whether they obey the octet rule or not. Clearly in this question, BF_3 involves an incomplete octet of electrons, but this is in fact a classic example of a molecule involving the trigonal planar molecular geometry.

Question 12

Again in this question, there were a number of comments from respondents in relation to giving examples in the question which are not explicitly listed on the syllabus. The same sort of response as in Question 11 applies here – candidates must be able to *apply* their knowledge of VSEPR Theory to two, three and four electron domains. All examples in this question involve either three or four electron domains (carbonate – trigonal planar, sulfite – trigonal pyramidal, nitrogen trifluoride – trigonal pyramidal and phosphorus trichloride – trigonal pyramidal).

Question 14

Some respondents stated that this question on average kinetic energies of gases was not on the curriculum and was difficult. It is true that only 36% of candidates obtained the correct answer. However, the question related directly to the assessment statement dealing with Topic 5.1.4 of the guide.

Question 18

The correct answer for Question 18 was that for an endothermic reaction, bonds in the reactants are stronger than the bonds in the products. It might have been better if the question was worded more precisely with regard to total bond energies. However, the question itself was reasonably well answered, with close to 48% of candidates getting the correct answer, and hence after careful deliberation it was felt that the wording of the question did not detract from students obtaining the correct answer from the list of possible answers provided.

Question 20

One respondent expressed a view that this question was poorly worded and structured. However, this was not felt to be the case and in fact close to 65% of candidates got the correct answer here (A).

Question 23

Buffers are an integral part of the SL core syllabus, as stated in 9.4.1.

Question 24

This question was poorly answered by candidates, with only 31% of candidates identifying the correct answer as D. One respondent felt that there may have been some confusion with the wording of the question. This was not considered to be the case in fact, although the question certainly was challenging, and it appears that only the better candidates were able to answer this question.

Question 27

The only comment on this question related to the description of the process of oxidation taking place at the negative electrode in a voltaic cell and at the positive electrode in an electrolytic cell. In the current guide, positive and negative electrode terminology is invoked in Topic 10.3, although many teachers may in fact prefer to describe the process of reduction taking place at a cathode and oxidation taking place at an anode. Both terms have been incorporated into the new curriculum guide. However, in the current curriculum, in 10.3.4, the teachers note states that the latter description (*i.e.* the fact that oxidation takes place at the anode and reduction takes place at the cathode) is not actually required, and hence this is the reason why negative and positive electrodes would be used in a question of this type under the current syllabus.

Question 28

One respondent stated that this question which was based on the linkage present in nylon, was based on recall of a specific reaction (in this case the reaction of hexanedioic acid and 1,6-diaminohexane) as opposed to a clear demonstration of the application of core organic chemistry principles. However, Paper 1 is based on Objectives 1 and 2 type questions and hence it is expected that there will be a percentage of the 30 questions, which will be based purely on Objective 1 type questions. These questions in fact can be considered as good, accessible questions which can in fact benefit weaker candidates taking this paper. Another respondent thought that peptide link should have been listed, instead of amide. However, amino acids are not involved here in this reaction, and hence amide linkage is the correct answer in fact in the case of nylon.

Question 30

One respondent stated that the term “chiral carbon atoms” is not an international term. All terms such as chiral centres, chiral carbons *etc.* have been used extensively before on past examination papers, and relate to Topic 11.3.3 in the guide.

Standard level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 6	7 - 13	14 - 19	20 - 25	26 - 32	33 - 38	39 - 50

General comments

This paper identified the broad range of capabilities of candidates. Some candidates struggled with even the most basic concepts while others demonstrated a solid depth of understanding of the standard level course. In general, however, answers lacked precision in terms of wording used and explanations were often vague.

Candidates should show working out for calculation questions and should check answers for accuracy, significant figures and units where appropriate.

The 153 G2 forms that were returned conveyed teachers' impressions of this paper. In comparison with last year's paper 76% felt that it was of a similar standard, 9% thought it a little easier, 14% considered it a little more difficult and just 1% were of the opinion that the paper was much more difficult. 96% of respondents thought the level of difficulty was appropriate, 3% thought that it was too difficult and 1% too easy. Syllabus coverage was deemed good by 59% and satisfactory by 39%. 1% thought that the coverage of the curriculum was poor. Clarity of wording was considered good by 63% and satisfactory by 36% of the respondents. Only 1% felt that the clarity of the wording was poor. The presentation of the paper was considered good by 69% and satisfactory by 31% of the respondents.

Although the general impression from the teachers was that the paper itself was similar in standard to previous papers, the overall performance on this paper was noticeably weak. There were a number of key areas where this was evident – in particular in basic definition type questions (such as electronegativity, average bond enthalpy, unsaturated hydrocarbon and isomers). Candidates were not scoring full marks for these basic definitions, and this often amounted to a cumulative effect, which may have penalized the weaker candidates. In addition, in Section B, although Question 6 was the most popular question on the paper, again marks were dropped readily in the areas of structure and bonding. Hence, although the paper appeared accessible, students with poor understanding of chemical concepts faired very poorly in this paper.

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

The areas which proved most difficult were mainly:

- The concept of electronegativity,
- Bonding, the difference between *inter*- and *intra*- molecular forces
- Acid and bases.

Very large numbers of candidates had trouble with basic definitions such as "Describe the behaviour of a buffer solution", even though these have been asked for in recent past examinations. There were also marked tendencies for candidates to use terminology loosely and interchangeably. For example, some stated that AlF_3 is ionic and then talked about the bonds within the molecules and their bond angles.

In the past candidates have frequently been weak at writing equations, especially for inorganic reactions, and this year was no exception. A surprising number of candidates attempting Q7 (B) (ii) could not use the formula of nitric acid, even though it was given in Q1 of the paper.

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

- Equilibria and K_c
- The electronic structure of atoms (often beyond that needed for SL)
- The structures of organic molecules

- Names and uses of organic compounds
- Simple mole calculations.

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

Section A

Question 1

(a) Few candidates could state that rate is a change in some defined quantity w.r.t. time.

(b) Many candidates missed the statement that nitric acid was in excess, and that calcium carbonate ran out.

(c) Most candidates could draw an approximately correct curve on the graph but some had no idea of what it should look like.

(d) The majority of candidates appreciated that the rate would increase with temperature but only a minority could justify this in terms of collision frequency or kinetic energy and activation energy.

(e) A good number of students calculated the rate correctly but a significant proportion of these lost the mark for significant figures. Exceptionally, very few candidates gave answers to *more than* the required number of significant figures. Candidates were penalised for giving too few.

(f) A good number of candidates calculated the correct number of moles but some were unable to state or rearrange the equation $pV = nRT$. A significant number were then unable to work in the correct S.I. units and answers were often out by a factor of 10^3. Units were sometimes omitted.

Question 2

(a) Not many candidates could define electronegativity as the relative attraction of an atom for a ‘bonding pair of electrons’.

(b) The trend was well known but few candidates could explain why it increases across a period.

(c) Good explanations of the greater tendency of Cl_2 to oxidise I^- were few and far between. Most candidates answered the question using the concept of electronegativity.

Question 3

(a) Despite being set on Nov ’04 and any two of three marking points being accepted candidates showed little knowledge of this.

(b) Most knew what to do with the bond enthalpies but many could not count the number and type of bonds present, so often the only mark gained was for a correct subtraction.

(c) Most candidates were able to justify the enthalpy change being the same for both isomers.

(d) Many knew ΔS would increase but missed the significance of the number of moles of gas increasing.

(e) There were a number of good answers, but common mistakes involved imprecise arguments about energy. Some candidates probably had not seen this before and left it blank.

Question 4

(a) Most candidates gave a correct expression for K_c.

(b) Most appreciated that the equilibrium shifted to the right but not all were able to relate this to a decrease in the volume of gas.

(c) Most realised that K_c would decrease but many were unable to relate this to the effect of an increase in temperature on the endothermic / reverse reaction.

(d) Most knew that catalysts affect the rate of reaction and not equilibrium but were not able to justify the latter.

Section B

Question 5

This was not a very popular question.

(a) Most candidates gave a correct structure but the definition was often quite loose.

(b) A number of correct equations were given and many students were unable to state addition or hydration as the type of reaction.

(c) Very few candidates were able to state an oxidising agent and give the conditions for what must be one of the most commonly asked questions in pre-university chemistry. Some gave the colour change, many just an initial or final colour. Many knew the product was ethanoic acid.

(d) A number gave a correct equation but ignored the need for a catalyst. The name of the ester ethyl ethanoate, and its uses were generally well known.

(e) Candidates knew double bonds were needed for addition polymerisation but not many stated that two different functional groups were needed for condensation polymerisation.

(f) Most gave good definitions of isomers and could draw them. Few understood the term ‘optical isomers’ and their effect on plane polarised light. Many candidates were able to draw and label the optical isomers of $C_4H_{10}O$.

Question 6

This was by far the most commonly answered question.

(a) Most candidates stated the correct electron arrangements.

(b) The few who had been well drilled scored good marks, but many did not really understand what the question was asking in terms of metallic, intra- and inter-molecular bonding. Some talked of the Al nucleus surrounded by a sea of electrons.

(c) Many candidates did not realise they were being asked to compare the bonding and structure of an ionic and a covalent compound. Many of those that did were extremely careless in their use of terminology, *e.g.* interchanging freely between the terms molecules and ions in AlF_3 as if it did not matter.

(d) A few good candidates had been well drilled in this type of question but for many it was a confusion of electrons, ions and molecules used inappropriately to explain conduction.

(e) There were many correct Lewis structures but also a good number with the lone pairs missing. A small number gave a correct bond angle but few could explain it using VSEPR.

(f) Calculations tended to be right or wrong in equal measure.

Question 7

This question tended to be the preserve of a few, more able candidates.

(a) A good proportion scored well with the equations being perhaps the weakest part.

(b) There were many good equations for the neutralisation but some candidates did not associate nitric acid with the formula given in question 1. The volume read from the graph was usually correct, but the concentration calculations often went awry, with a relatively small number of correct answers.

(c) This is a well known and used question which few candidates were prepared for, conductivity being the most common correct answer. (Last set May ’06 when three methods were required.)

(d) Another old favourite. Few candidates could give an accurate description of the action of a buffer solution. Even fewer could describe how to make one.

Recommendations and guidance for the teaching of future candidates

- Teachers should remember that the standard and rigour of SL is the same as HL; it is only the content of SL that differs in being a subset of HL.
- Make sure that students understand the important action verbs such as Describe and Explain.
- Make sure that adequate practical observation skills have been developed, and that students can relate these to the theory.
- When marking students’ work teachers should look for precision, not approximate answers and understanding.
- Give students ample practice on past papers. Teach them to interpret the questions and measure their answers so that they cover every marking point.

- Help students to select questions in which they know something about the whole question, not just the first part.
- Teach students to set out calculations neatly, so *error carried forward* can be applied if calculations go awry, and pay attention to *significant figures* and *units* in the *final answer*.
- If continuation sheets are used candidates should refer to this on the answer script.
- Students must not write in pencil, nor use red or green pens, even for underlining answers.

Standard level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 6	7 - 12	13 - 18	19 - 22	23 - 25	26 - 29	30 - 40

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, but this session there were many candidates who seemed unfamiliar with the material in the options and scored very poorly. A handful of candidates attempted most parts of the questions in two Options and scored zero in both. Hardly any candidates attempted more than two options.

Teachers' impressions of this paper were conveyed by the 151 G2 forms that were returned. In comparison with last year's paper, three-quarters thought this year's paper to be of a similar standard, with slightly more of the remainder considering it more difficult rather than easier. Almost all respondents thought the level of difficulty was appropriate. Syllabus coverage was felt to be good by 54% and satisfactory by 44% (2% felt it was poor), for clarity of wording, 62% of teachers felt it was good, 35% satisfactory and 3% felt it was poor. The presentation of the paper was considered good by nearly three-quarters and satisfactory by the remainder.

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

This examination revealed weaknesses in candidates' knowledge and understanding in all Options. These included:

Option A – a lack of care taken with setting out calculations, including units and appropriate numbers of significant figures.

Option B – the distinction between the breathalyser and intoximeter in the detection of ethanol.

Option C – the distinction between chromatography and electrophoresis in the analysis of proteins.

Option D – a lack of understanding of the greenhouse effect and the use of correct terminology to describe and explain it.

Option E – an understanding of the reactions occurring in the blast furnace in the extraction of iron.

Option F – the inability to write correct nuclear equations.

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

Once again there were some excellent scripts seen from some candidates, probably from those who had been taught two (or perhaps three) options, rather than from those who had been allocated little teaching time or who had made their choice of options on the day of the examination. It is clearly in the candidates' interests that teachers cover two options thoroughly, rather than allow their students to study a variety of options on their own.

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

Option A – Higher Physical Organic Chemistry

A1

In (a), most candidates chose the correct four classes from the Data Booklet but usually identified only one in the second part. Weaker candidates left (b) incomplete or gave impossible structures based on C_3H_6O. A disappointing number gave structures that did not contain the numbers of atoms in C_3H_6O, including CH_3CHO. The most common error was to omit the positive charge from the formulas of otherwise correct fragments. Some candidates wrote inaccurate formulas, such as COH^+ instead of CHO^+.

A2

This was generally well answered, although there were more errors than expected in (a)(i), such as having the orders for C and D the wrong way round, or stating that the doubling of both rate and concentration indicated second order. Although the values in the table were easy to work with, some candidates struggled with the order with respect to D because none of the values of [C] were the same. Quite a few candidates scored consequentially in (a)(ii) and (a)(iii), and a disappointing number attempted equilibrium expressions in (a)(ii). In (b), more candidates seemed to be familiar with the concept of *half-life* applied to nuclear disintegrations rather than to first-order chemical reactions.

A3

Several errors appeared in (a), such as including water on the left but only H^+ on the right, showing OH^- as a product, and omitting the reversible arrow. Parts (b) and (c) were generally well attempted, with better candidates achieving full marks.

Option B – Medicines and Drugs

B1

Answers to (a) were disappointing, with some candidates unable to explain the redox nature of the reaction or to give both colours in (i), while in (ii) many candidates did not appreciate the use of infra-red radiation in the intoximeter, believing that it is used to test blood or urine samples. Most candidates were able to select three correct examples in (b).

B2

This question was about stimulants in general, and three in particular. The best candidates scored well, but many gave effects in (a) and (c) that were identical or incorrect, and the structural comparison in (b) produced many inaccurate descriptions of functional groups, such as amine instead of amide and ketone (for caffeine). Short-term and long-term effects in (c) were often given in the wrong sections.

B3

High scores were rare in this question, with most answers lacking essential detail. In part (a), there were few references to viral DNA, but rather more answers along the lines of "viruses infect a host cell and take it over". In (b), common answers were along the lines of "viruses block cell action".

Option C - Human Biochemistry

C1

In part (a), many correct structures were seen, with the peptide bond being more likely to be correct than the rest of the structure. Errors seen included abbreviations such as –C–O–N–H–, missing hydrogens, while some candidates gave only the two amino acid structures and showed which atoms were eliminated in the reaction. Part (b) was poorly done, with many answers reading like descriptions of electrophoresis or a hybrid of this and paper chromatography.

C2

Better candidates scored well in this question, although a surprising number failed to identify the ester group in (a). In (b), many candidates overlooked the fact that saturated fats contain double bonds in the ester group; the presence of double bonds without reference to carbon-carbon was not accepted. Weaker candidates tended to refer to the breaking of C–C and C=C bonds in part (c).

C3

Again, better candidates scored well in this question. The commonest error in the scripts of good candidates in (b) was to write about the correct hormones but in the wrong sections, for which partial credit was given.

Option D - Environmental Chemistry

D1

Many candidates consider that they know some facts about the greenhouse effect, but several answers in which every part was attempted scored few marks, and in some cases, no marks at all. In (a), few included visible radiation in (i), in (iii) bonds were said to break, and in (iv) few referred to step III, as required by the question. In (b), methane was sometimes stated to be more abundant than carbon dioxide, and quite a number suggested that methane's importance was due to its combustion to form carbon dioxide. In (c), few mentioned the thermal expansion of the oceans, although this appears in the teacher's note for the assessment statement being tested.

D2

In (a), many candidates chose 1.2 or 6.2 as likely pH values for acid rain, and a disappointing number chose carbon dioxide as the substance responsible for it. Methods of removal of oxides were well known, but not the equations for their reactions with water, while the effect on marble statues in (b) often used inappropriate terms such as dissolves, corrodes or erodes.

D3

This was generally well answered, although weaker candidates were unable to score well in (a). Apart from lack of detail, a common error was to state that the oxygen was needed to sustain fish life.

Option E - Chemical Industries

E1

Most candidates managed to mention three industry location factors in (a), but in (b) two correct equations were rarely seen.

E2

In (a), a surprising number of candidates had the purposes the wrong way round. Most candidates chose the correct compound in (b) but often failed to give a correct reason – "bigger" and "denser" were commonly seen. Few candidates could produce a correct equation in (c), but the removal of sulfur in (d) was much better known.

E3

The structure of the propene monomer in (a) was often wrong – brackets were more often seen than a C=C double bond. The properties were often correctly stated, although a surprising number chose the inappropriate "boiling point". The properties in (b) were usually correctly identified.

Option F - Fuels and Energy

F1

Most candidates knew about the formation of coal from plant matter in (a); the most common error was to use phrases such as "a long time", which was not accepted as equivalent to millions of years. Answers to (b) were generally good, but in (c) few correct equations were seen – many attempts included the non-flammable carbon dioxide as a product.

F2

Part (a) was attempted by the majority of candidates, but high scores were rare. Common errors included the omission of atomic numbers, the use of the alpha symbol in place of He (both with and without the mass and atomic numbers), and the lack of a neutron on the left-hand side of the fission equation. A surprising number of candidates could not identify two differences in the behaviour of alpha and beta particles in an electric field, although the calculation in (c) was usually correct.

F3

Scores were generally low in this question, and there were many examples of long, rambling answers with zero scores. Most candidates did not distinguish correctly between active and passive methods, and many failed to mention photovoltaic cells in the conversion of solar energy to electricity.

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 action verbs, candidates are advised to bear in mind the following points in this paper:

- Use a reversible arrow in equations where the reversible nature of the reaction should be known, *e.g.* in industrial processes such as the manufacture of ammonia, and the dissociation of weak acids in aqueous solutions.
- Practise writing a variety of equations (including ion-electron half-equations and nuclear equations), paying careful attention to balancing and the inclusion of charges and electrons where appropriate.
- Practise setting out calculations in a logical way, including a few words to indicate what process is being used, showing each step, and emphasising the final answer by underlining.
- Do not give a long list when asked for two or another specified number of answers.
- Avoid the use of everyday or journalistic language, and use correct scientific terms, such as "of lower density" instead of "lighter", and radiation "absorbed and re-radiated by" instead of "bouncing off" or "being reflected by"

Finally, some advice that is not specific to chemistry - The number of lines for a question part is meant to suggest the amount of space for a typical response, although some candidates write answers that are longer than the spaces available. Such candidates should complete their answers in the white space below the lines where possible, in preference to writing a few words on a continuation sheet. If they must use continuation sheets in this way, then they should indicate in the booklet that the particular answer is continued elsewhere.