Chemistry TZ2 (IBAEM & IBAP)

Overall grade boundaries

Higher level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 17	18 - 32	33 - 45	46 - 56	57 - 67	68 - 78	79 - 100

Standard level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 16	17 - 32	33 - 43	44 - 54	55 - 64	65 - 74	75 - 100

Internal assessment

Component grade boundaries

Higher level

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

Standard level

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

General comments

The range and suitability of the work submitted

The May 2012 session was similar to May 2011 in terms of the suitability of the work submitted for assessment of the criteria. Generally the samples were well presented and the procedures were followed. Most teachers gave feedback using c, p, n or 2,1,0 notation with a good proportion giving at least a few written comments to explain their marking awards.

In comparison to the situation five or more years ago, the appropriateness of the assessed work has improved significantly and now most schools recognize that the Internal Assessment component requires special attention from both teachers and students alike. The quality may still be variable, such is the nature of the students themselves of course, but at least the work is assessable by the criteria in most cases. Increased support for teachers through face-to-face and online workshops, plus of course the Online Curriculum Centre, is hopefully having a permanent positive impact on global understanding of the requirements. The one frustration is that there are a number of schools who do not act on the same feedback comments from moderators in the 4IAF form on IBIS year after year. Possibly the DP Coordinator is not forwarding the feedback to the teacher which is such a pity for all concerned, especially the students.

Many schools restricted their assessment to two investigations with all students responding to the same two Design tasks that were then assessed for DCP and CE as well. This is permissible but more variety in the range of design tasks set to a class and the number of investigations over which the candidates are assessed would be welcome as this encourages independent learning and the development of a wider range of reporting skills, as well as for students to legitimately benefit from the regulation that only best two scores per criterion count.

The most disappointing aspect of this session was the fact that more schools than ever before were submitting Design assessments which were purely theoretical exercises and there had been no follow up experimental phase. Although this is permissible by the regulations it is seen later in this report that this trend has led to a lowering of quality of Design achievement. Equally importantly the lack of practical implementation has also deprived students of the opportunity to fully participate in a valuable exercise in inquiry and practical problem solving while denying them the chance to feel the sense of ownership and excitement that comes from carrying out their own designed investigation.

In tasks being assessed for Data Collection and Processing fewer teachers now provide instructions that gave too much support to the students in terms of guidance on how to record or process the data which has helped improve attainment. Some schools limited the processing of data to excessively simple tasks which involved only very basic numerical manipulation such as finding an average or subtracting two numbers to find a temperature change. This approach is clearly below expectations.

There are still too few assessments that challenge students to determine a quantity from a graph rather than make a simple qualitative comparison, something that would benefit Higher Level candidates especially.

Candidate performance against each criterion

Design

Aspect 1

This was generally well addressed with many students being able to phrase a focussed research question and to identify most variables with an award of at least Partial, and in many cases Complete. One recurring failing was that students incorrectly identified the dependent variable as the derived quantity (e.g. “rate of reaction” or “enthalpy of reaction”) rather than the actual measured variable, such as time for a given volume of gas to be produced or the temperature increase of the reaction mixture.

Aspect 2

This was consistently the most challenging of the Design aspects and Partial was the most frequent award.

One common weakness as in previous years was that many students failed to identify any procedural methods to control or at least monitor the control variables that they had earlier identified as needing controlling. For example if in a kinetics investigation temperature is identified as a control variable then the reaction mixture temperature (and not the surrounding room temperature as was frequently stated) should be controlled through use of a water bath or at least monitored with a thermometer or probe.

Two other weaknesses more frequently arose this year possibly owing to the fact that we saw an increase in the number of Design tasks set without an associated practical phase. Firstly very many student designs contained insufficient procedural detail for the reader to be able to reproduce the experiment. Not including details on how standard solutions were to be made up or what volumetric glassware is to be used, or not stating how to make up a salt bridge in an electrochemical cell or forgetting to think about drying an electrode in an electroplating investigation were among the common failings. The lack of an action phase certainly was the main factor in an increased number of absurdities appearing in students' designs, for example the use of extreme and unrealistic concentrations of acid up to 30M or the measurement of the mass gain in electroplating after only 15 seconds of current flow.

If teachers can ring fence sufficient time for the students to undergo the iterative process of initial planning, followed by trial experiments, followed by finalized written design, prior to the main action phase then achievement in this criterion will be enhanced.

Aspect 3

There was a good level of fulfilment of this aspect with most students able to design realistically for the collection of sufficient data. The only group of candidates who possibly missed out on any marks in this aspect were those who, as mentioned earlier, had not had the opportunity for any hands-on development of their designs and had submitted unrealistic procedures that would not have collected any relevant data at all.

Data Collection and Processing

Aspect 1

There was generally a good level of fulfilment with most candidates able to present data in suitably constructed tables with appropriate column headings, units, uncertainties and relevant qualitative data. There was however frequent inconsistency between the number of decimal places of the raw data compared to the cited uncertainty.

Aspect 2

Where schools had set meaningful processing tasks the outcomes were varied as would be expected of a criterion that challenges students' quantitative skills.

Where the assessment focussed on numerical calculations, often in stoichiometry, the students could usually process the data to reach the desired result with no or few significant errors. One area, enthalpy determinations, saw a variety of standard of response. Some students appropriately graphed temperature against time and extrapolated in order to compensate for heat loss as they calculated the temperature change after mixing reactants. Very few students however took into consideration the heat capacity of the calorimeter, something that should really be an expectation for at least Higher Level candidates.

The use of graphs was more encouraging than in previous sessions although still too few candidates were challenged to determine a quantity from the graph and in most cases a qualitative comment on the observed trend was the sole outcome.

Aspect 3

In general there was a good level of fulfilment and many candidates secured at least Partial, although some inappropriate sketch graphs were presented and some schools still persisted in only presenting bar graphs which are seldom appropriate for most investigations in our field.

To secure Complete, the candidates must take uncertainties into consideration and either propagate them through the calculation or to treat them in graphical analysis through the construction of a best-fit line. In both cases this often proved problematic. Propagating errors through a calculation is clearly a demanding expectation and many students found it difficult. It is a pity that this requirement is causing so much anxiety amongst students and teachers since it is a small requirement. The effort being put into propagating uncertainties (often for no reward) seems to be deflecting from the conceptual insight that should be gained through practical work. Securing the mark through constructing a best-fit line should have proved easier, but poor selection of the trend line in Excel meant that many candidates did not meet the standard.

Conclusion and Evaluation

Aspect 1

It was more common during this session for candidates to compare their results to literature values where appropriate. A significant proportion of candidates were then able to identify whether the difference indicated the presence of system error or could be explained by random error alone. Also only a small proportion of candidates presented any justification of their conclusions in terms of whether it was coherent with accepted theory.

Aspect 2

As last year, Partial was the most common award for this criterion with most students able to identify sensible sources of error but few being able to evaluate whether the source of error accounted for the direction of the deviation from a literature value encountered.

Aspect 3

This criterion was satisfied to a similar uneven extent to previous sessions with many good responses but a similar number of very superficial, simplistic or unrealistic contributions. Suggestions limited to increase the number of trials (even when the repetitions had been satisfactory for school level) or making use of unspecified more sophisticated equipment were fairly common and of little merit.

There still persists a trend in teachers to over-rate very simplistic evaluations or suggestions often not related to cited errors. Another rather common approach is to award Complete for suggestions that address cited limitations, but which are largely affected by the poor quality of the preceding evaluation. Several schools showed to have benefited from feedback and their approach was more accurate than during previous sessions and this is very encouraging.

Manipulative Skills and Personal Skills

All schools entered marks for these criteria.

Application of ICT

Most schools had checked the five ICT requirements at least once on the 4PSOW although the assessed work submitted rarely corresponded to these investigations so it is hard to evaluate the appropriateness of the tasks. Happily, where data logging was involved in assessed investigations, we did not see the overwhelming number of pages of printed out data being included, a problem that had affected previous sessions.

Recommendations for the teaching of future candidates

- Candidates should be made aware of the different aspects of the criteria by which they are assessed.
- Teachers should endeavour to give their students the opportunity to carry out the practical phase associated with their Design investigations.
- All investigations for the assessment of DCP must include the recording and processing of quantitative data. Solely qualitative investigations do not give the students opportunity to fulfil this criterion completely.
- All candidates, both Higher and Standard Level, need to record, propagate and evaluate the significance of errors and uncertainties.
- Teachers are encouraged to set some DCP tasks that will generate a graph that will require further processing of the data such as finding a gradient or intercept through extrapolation.
- Instruction of appropriate use of graphing software especially the construction of best-fit lines would benefit many candidates.
- Candidates must compare their results to literature values when relevant and include the appropriate referencing of the literature source.
- When assessing the CE criterion, require candidates to evaluate the procedure, cite possible sources of random and systematic errors, and provide suggestions to improve the investigation following the identification of weaknesses.
- Teachers should ensure that they act on specific feedback given by the moderator in the 4IAF feedback that is released through IBIS shortly after the results release.

Communication with moderators

Before moderation for the session started, guidance was given as to when and how moderators should and should not change marks. Teachers are asked to take note of these instructions with respect to the preparation of samples for future sessions.

Design (D)

Aspect 1

- If a teacher has supplied the research question then this nullifies the first half of the criterion. However if they have satisfied the second half partially (for example, by correctly identifying a good number of control variables) then “partial” can be awarded overall for aspect 1.
- If the teacher has specified the independent and control variables then the second half of the aspect is nullified. It could be felt that it has also completely focussed the research question so the final aspect 1 award could be “not at all”.
- If the teacher has identified just the independent or just a control variable then “partial” can still be awarded.
- The teacher is allowed to specify the dependent variable when setting the task.

When not to mark down for aspect 1

- The independent and controlled variables have been clearly identified in the procedure but are not given as a separate list (the whole report must be marked and there is no obligation for candidates to write reports according to the aspect headings).

Aspect 2

- If the procedure lacks sufficient detail, so that it could not be followed by the reader in order to reproduce the experiment, the maximum award is “partial”.
- Candidates do not need to make a description of the precision of apparatus in the apparatus list or procedural steps because that is assessed in DCP aspect 1, in the raw data uncertainties.
- If a teacher has given students the full procedure then award “not at all”.
- If a teacher has given a partial procedure then consider what can be awarded for the candidate's own contribution. The most probable award here is “partial”.
- If a candidate has used a partial method from another source then that source should be acknowledged. Again a moderator should consider what can be awarded for the candidate's own contribution. If a candidate has completely taken a design from another source then award “not at all”, even if the source is acknowledged.

When not to mark down in aspect 2

- Similar (not word for word identical) procedures are given by different candidates for a narrow task. Moderators should comment on poor suitability of task on 4/IAF form.

- No equipment list is present but the information is provided elsewhere, for example, in the stepwise procedure.

- The +/– precision of apparatus is not given in an apparatus list.

- Routine items such 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 and so don't need listing. Moderators should support the teacher's stance here.

Aspect 3

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

- If the candidate has designed a procedure so poorly that no relevant data would be collected then moderators should award “not at all”.

- If the candidate has planned for less than five data points (if a graph is to be produced) or has not planned for any repeats in quantitative determinations (for example, titrations or calorimetry, etc.) moderators should award “partial”.

The material / apparatus

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

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

Data collection and processing (DCP)

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

Aspect 1

This aspect refers to the written record of raw data, not the manipulation of the equipment needed to generate it (that is assessed in manipulative skills).

Moderators should not mark down if the teacher has given detailed step by step procedural instructions, this may have been marked down in design aspect 3 if it is a design assessment task not in DCP.

If a photocopied table is provided with heading and units that is filled in by students then the maximum the moderator can give is n = 0.

- If the candidate has only recorded quantitative data (for example, colour changes in titration, observation of soot due to incomplete combustion in calorimetry, residual solid left in a beaker when reaction has excess solid reactant, bubbles being released when a gaseous product is formed are missing) then the moderator should award "partial".

- Moderators should not be overzealous and penalize aspect 1 every time a candidate does not find qualitative data to record. Sometimes there is no obviously relevant qualitative data to record.

- If a candidate has not recorded uncertainties in any quantitative data then the maximum award is "partial".

- If the data is repeatedly to an inconsistent number of decimal places or in disagreement with the stated precision then "complete" cannot be awarded. Moderators should support the teacher if there is just one single slip in a large body of data where all the rest is consistent with each other and the stated uncertainty.

- In tasks such as establishing a reactivity series, too often the candidates put in a reaction equation as opposed to the observation. This cannot be supported and will reduce first aspect to 'partial' or 'not at all' depending on how much other raw data is present.

When not to mark down aspect 1

- When the candidate has not included any qualitative observations and the moderator cannot identify any that would have been obviously relevant.

- If the candidate has been inconsistent with significant digits for just one data point or missed units out of one column heading in a comprehensive data collection exercise possibly with several tables of data. The principle "complete does not mean perfection" is significant in this case as otherwise good candidates responding in full to extended tasks get penalized more often than candidates addressing simplistic tasks.

- When there is no table title and it is obvious what the data in the table refers to. With the exception of extended investigations it is normally self evident what the table refers to and the section heading "Raw data" is sufficient. Again "complete does not mean perfection".

Aspect 2

- If a teacher has given the method of calculation or told the students which quantities to plot then the moderator should award "not at all".

- If a candidate has made an error in a calculation leading to an incorrect determined quantity then the award may be "partial" or "not at all" depending on the severity of the error.

- If a graph with axes already labelled is provided (or candidates have been told which variables to plot) or the candidates have followed structured questions in order to carry out data processing then the moderator should award “not at all”.
- If a candidate has simply plotted raw data on axes with no trend line then moderators should award “not at all”.

Aspect 3

- If the candidate's method of processing cannot easily be followed then the maximum award is “partial”.
- The candidate must report any final quantitatively determined quantity to a number of significant figures that is consistent with the precision of the input data. Failure to do so will reduce the maximum award to “partial”.
- Moderators should not punish inconsistent significant figures reported in the middle of a stepwise calculation if the final answer(s) is(are) reported appropriately.
- If there is no evidence of errors being propagated through a calculation then “partial” at best. Moderators are reminded that a best fit line graph is sufficient to meet the requirement for error and uncertainty propagation.
- The error propagation should be correctly followed through to a reasonable extent according to either the protocol in the Teacher support material (TSM) or another accepted protocol. Moderators should try to support the teacher if the candidate has made a sincere attempt even if there is a small flaw.

When not to mark down aspect 3

- If inconsistent significant figures are reported in the middle of a stepwise calculation and the final answer(s) is(are) reported appropriately.
- If the candidate has clearly attempted to propagate uncertainties even if it is felt that the candidate could have made a more sophisticated effort, the moderator should not punish the teacher or candidate if the protocol is not the one that the they teach, i.e. top pan balance uncertainties have been given as +/– 0.01g.

Conclusion and evaluation (CE)

If structured questions are given to prompt candidates through the discussion, conclusion and criticism then, depending on how focussed the teacher's questions are and on the quality of candidates' response, the maximum award is “partial” for each aspect the candidate has been guided through. Moderators should judge purely on the candidate's input.

Aspect 1

- The conclusion can take many forms depending on the nature of the investigation. It could be a clear restatement of the determined numerical quantity (for example, the molar mass or activation energy), a statement of the relationship found, etc. Such a clear statement should be awarded “partial”. To secure “complete” the candidate must comment on systematic / random error and where appropriate relate this to literature values. The comment on systematic / random error may well come after the sources of error have been discussed.

Aspect 2

- The moderator should check that the candidate has identified the major sources of error. Other possible sources may be present but overly long lists containing less important points are not required.

- There is no written requirement to state the direction of each source error so we are not looking for an explicit statement. However, the candidate's comments on significance of sources of error must be *consistent* with direction of error. For example, heat loss to the environment is considered the main source of error when the experimentally determined enthalpy value is actually greater in magnitude than the literature value and therefore implying another more major source of error in the other direction. This inconsistency would reduce the aspect award to "partial".

When not to mark down aspect 2

- Moderators should apply the principle that "complete does not mean perfection". For example if the candidates have identified most sensible sources of systematic error then the moderator can support a teacher's award even if they think one more can be identified.

Aspect 3

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

Other Issues

Simplicity

If a task was too simple to truly meet the spirit of the criteria, moderators should comment on the 4/IAF as to the unsuitability of the task giving full justifications but should not necessarily downgrade the particular candidate. This does mean that candidates achieve marks in DCP for brief work on limited data but if they have fulfilled the aspect's requirements within this small range moderators should support the grade.

Data logging

Data logging is encouraged even in assessed work. The key axiom to be followed is that the candidates are to be assessed on their individual contribution to the assessed task. To judge this, moderators should be guided by the teacher who knows exactly what the candidates had to do. Moderators should apply the normal standards regarding expectations of data presentation (units, uncertainties, etc.) and graphs (best fit lines, axes labels, suitable scales, etc). Where there are concerns as to whether the candidates have had sufficient input, moderators should comment in the feedback to the school on the 4/IAF.

Higher level paper one

Component grade boundaries

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

General comments

This paper consisted of 40 questions on the Subject Specific Core (SSC) and Additional Higher Level (AHL) 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 209 G2 forms that were submitted. 95.2% reported the level of difficulty to be appropriate, 0.5% thought it to be too easy and 4.3% too difficult. In comparison with last year's paper, 70.9% considered it to be of similar standard or a little easier, 23.2% considered it to be a little more difficult and 1.5% much more difficult. Clarity of wording was considered good or satisfactory by 98.6% and the presentation of the paper was considered good or satisfactory by 99.0%.

The statistics above were also reflected in the general comments where the paper in general was very well received by teachers, who found it broad in range and challenging in depth. A number of respondents especially liked some of the newer questions included on this paper. Some commented that it was interesting to see inclusion of structures of some drugs and biological molecules. Even though a few respondents felt that these may have given an unfair advantage to candidates taking Options B and D in Paper 3, it should be noted that this certainly was not the case and all questions were strictly based on AS's from the core and AHL and not the options. There are many very interesting chemical structures that can be discussed in the teaching programme underpinning core chemical principles (such as functional groups etc.) and candidates should be able to apply these core principles.

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

Question	A	B	C	D	Blank	Difficulty Index	Discrimination Index
1	416	3297	274	3145	11	44.03	0.56
2	1270	4771	395	681	26	66.79	0.19
3	4183	1796	799	335	30	58.56	0.38
4	87	333	4540	2170	13	63.56	0.28
5	5160	484	587	896	16	72.24	0.43
6	430	5495	796	412	10	76.93	0.23
7	752	4196	662	1521	12	58.74	0.51
8	435	356	5478	841	33	76.69	0.42
9	707	4753	876	792	15	66.54	0.5
10	333	39	75	6692	4	93.69	0.14
11	5230	176	478	1253	6	73.22	0.52
12	3707	2840	317	267	12	51.9	0.44

13	809	2061	562	3699	12	51.78	0.48
14	415	276	6348	94	10	88.87	0.22
15	1792	1782	550	3000	19	66.95	0.35
16	4888	222	1520	501	12	68.43	0.52
17	334	379	6034	375	21	84.47	0.35
18	6839	158	94	49	3	95.74	0.08
19	6173	379	67	510	14	86.42	0.26
20	1863	180	576	4505	19	63.07	0.43
21	556	670	513	5395	9	75.53	0.41
22	2903	360	3540	312	28	49.56	0.28
23	940	653	656	4846	48	67.84	0.56
24	734	5161	212	1022	14	72.25	0.47
25	854	591	323	5358	17	75.01	0.24
26	672	397	4921	1130	23	68.89	0.37
27	443	430	5804	449	17	81.25	0.33
28	146	5465	174	1346	12	76.51	0.45
29	1954	506	4323	336	24	60.52	0.42
30	906	789	91	5341	16	74.77	0.4
31	181	365	3824	2688	85	53.53	0.58
32	1653	3393	1908	175	14	47.5	0.45
33	4723	2165	118	121	16	66.12	0.39
34	385	1212	462	5069	15	70.96	0.46
35	1360	3979	497	1264	43	55.7	0.4
36	1149	5170	669	118	37	72.38	0.45
37	5266	496	812	512	57	73.72	0.51
38	374	5369	488	868	44	75.16	0.45
39	612	215	5925	360	31	82.95	0.37
40	904	788	2061	3340	50	46.76	0.42

Total candidates: 7143

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

The difficulty index ranged from 95.74% to 44.03%, and the discrimination index ranged from 0.58 to 0.08.

The following comments were made on selected individual questions:

Question 12

One respondent suggested that they would have liked to have seen the inclusion of London dispersion forces in brackets in the question as an alternative to van der Waals'. Although the term London dispersion forces certainly has been given as an alternative to van der Waals' in markschemes in both P2 and P3 previously, in the current guide in the Teacher's Note corresponding to AS 4.3.1, the term actually used is van der Waals' forces, and it was felt by the paper author that to include the term London dispersion forces in brackets would have made this question look rather long from a reading perspective.

Question 15

There were a number of G2 comments on this question and some respondents felt that although most candidates would probably have chosen D as their best answer, based on their understanding that reaction of aspirin with sodium hydroxide would involve a neutralization reaction between the hydroxide and the carboxylic acid functional group, leading to an exothermic reaction, some felt that the question was ambiguous due to a potential hydrolysis reaction between the ester and sodium hydroxide. In general, the majority of candidates chose D (66.95%), followed by A, which showed misunderstanding of the fact that in III., an exothermic reaction is involved since the reaction involves combustion. Based on the G2 comments however, it was decided at GA to accept in fact two answers for this question, both B and D based on the fact that both I. and III. involve clear exothermic reactions, which candidates should know since combustion is involved, testing AS 5.1.2 in the guide.

Question 19

One respondent stated that the graph in A looks more like a first order reaction than a second order reaction. In this question, C is ruled out as the rate-concentration plot would represent a clear zero-order reaction. B is also ruled out as a zero-order reaction will involve a straight line. D is also a straight line. Hence, by a process of elimination A must be the answer, as a second-order reaction will involve a curve for a concentration-time plot. It is true to say that a first-order reaction will also involve a curve for a concentration-time plot. In fact a first-order concentration-time curve is an exponential curve and a second-order concentration-time curve is a quadratic curve, which appears somewhat to have greater depth if the two are compared. It can be difficult to distinguish the two plots in fact based on experimental data, but this was not an issue for this question as second order was clearly mentioned in the question and B, C and D could be eliminated also. The question in fact was the fourth easiest question on the paper for candidates, with 86.42% of candidates getting the correct answer A.

Question 22

Some respondents commented on the use of the term exponential. It is a valid point that "exponentially" does not appear explicitly in the guide and hence should not have appeared in the question (though in the teaching of graphical interpretation in AS 11.3.1, this would seem a suitable place to introduce this important type of term to students). However, candidates who did not understand the word *per se* should have been able to get the final answer, C, by knowing that the relationship between vapour pressure and temperature is not a decrease and nor is it a linear relationship, which rules out A, B and D.

Question 25

There were five G2 comments on this question. Some respondents stated that they would have preferred to see a 2D drawing of the structure. However, students of chemistry should be encouraged to visualize structures in 3D (not just 2D) and this type of ball and stick representation has been given in several previous examination papers in the current curriculum. Candidates generally did reasonably well on the question, with 75.01% of candidates getting the correct answer D.

Question 29

One respondent stated that asking for ion movement in solution was confusing. However, candidates are expected to know this as part of their understanding of voltaic cells, and ion movement has been asked previously in papers. Both the movement of ions in solution and across a salt bridge should be covered in the programme. 60.52% got the correct answer C.

Question 30

One respondent stated that it would have been better if the electrode potential half equations had equilibrium signs as in the Data Booklet. It is true that they could have been represented in this way (though not necessarily). This certainly did not have an impact on the question itself. 74.77% of candidates got the correct answer D.

Question 31

One respondent stated that mentioning the fact that the same current passes through each cell may have been better than using the term in series. This is a fair point. The question overall was reasonably challenging with 53.53% of candidates getting the correct answer, C.

Question 32

One respondent stated that choices B. 3-methylbutan-2-one and C. 2-methylbutan-3-one would lead to the same structure. However, according to the guide, candidates should be able to apply IUPAC rules to name compounds containing up to six carbon atoms involving a ketone. Hence, applying IUPAC rules, the only answer is in fact B as the compound will be numbered with the lowest number on the ketone. It was surprising that candidates had difficulty naming this compound, and the question proved to be the third most challenging question on the paper, with less than half getting it correct (47.50%). The question had an associated discrimination index of 0.45.

Question 35

One G2 comment stated that in Stage 1 it would have been better if the condition of heat was not given, as temperature increases the likelihood of a possible elimination reaction, suggesting that C also might be a possible answer. It is true that it might have been better if warm was stated instead of heat. However, the aqueous state was given for the sodium hydroxide (as opposed to ethanol), so the main product in Stage 1 would be substitution and candidates are always meant to choose the best answer in a multiple-choice question. When the data was examined it was found that 55.70% of candidates chose B as the correct answer, followed by A and then D. Very few candidates went for C.

Question 37

One respondent stated that in the reaction of benzoic acid with ethylamine, an ammonium salt forms first, which upon heating converts to the amide. This is a correct statement and although this additional information could have been added to the stem, omission of it would not have impacted candidates choosing A as the correct answer based on the choices given. 73.72% of candidates got the correct answer.

Higher level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 12	13 - 25	26 - 36	37 - 46	47 - 56	57 - 66	67 - 90

General comments

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

Teachers' impressions of the paper were conveyed by the 208 G2 forms that were submitted. In comparison with last year's paper, 61% felt that it was of a similar standard, 13.7% thought that it was a little easier, 2.4% felt it was much easier, 17.6% a little more difficult and just 1% were of the view that the paper was much more difficult. 92.8% considered the level of difficulty of the question paper appropriate, 2.4% too easy and 4.8% too difficult. Clarity of wording was considered good by 54.8%, satisfactory by 43.8% and poor by 1.4% of respondents. The presentation of the paper was thought to be good by 62.1%, satisfactory by 36.9% and poor by 1.0%.

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

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

- Determination of reaction rate from experimental data
- Unit conversions, for example from m^3 to cm^3
- Writing redox half-equations
- Explaining trends in lattice enthalpies
- Drawing Lewis structures and deducing the bond angles and shapes of molecules
- Outlining the use of radioactive isotopes
- Salt hydrolysis and associated explanations
- Delocalization of electrons
- Explanation of physical properties in terms of structure and bonding
- Explanation of the action of buffer solutions
- Reaction conditions for organic mechanisms

- Precise definitions in general, such as isotopes, empirical and molecular formulas, hybridization, buffer solution, isomers.

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

Topics generally well answered included:

- Determination of limiting reagent and calculation of theoretical yield
- Calculation of empirical and molecular formulas
- Bond length and bond strength
- Calculation of enthalpy change
- Electron configurations
- Entropy and spontaneity
- Identification of primary, secondary and tertiary halogenoalkanes.

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

Section A

Question 1

Candidates were very familiar with a graph of amount of product against time and most easily explained why the curve reached a maximum in (a). Using the graph to calculate rate of decomposition in (b) was more difficult with only a minority of candidates recognizing that the rate is the gradient of the tangent at 120s. Some candidates attempted to use parts of the curve as approximate straight lines rather than draw a tangent, and most candidates calculated an average rate over the first 120 seconds. However, despite the concerns of teachers, the majority of candidates had no difficulties in stating the units of the rate as mm s^{-1}. A G2 comment stated that the calculation of a gradient was particularly difficult for maths studies students, but this question does not exceed the mathematical requirements listed in the subject guide. In part (c) most candidates could correctly deduce the oxidation numbers and write them in the accepted style. Some scored partial marks as they wrote the oxidation numbers as 1– or 2–. The use of Roman numerals and words (zero) is also not acceptable. Only the very best candidates were able to correctly write half-equations for the decomposition of hydrogen peroxide even though the products of decomposition were given in the stem of the question.

Question 2

This question in general was well answered. In part (a), the majority of candidates were able to correctly write an equation, although a common error was to use MgCl for the formula of magnesium chloride, and most candidates correctly determined the limiting reagent in (b). In (c)(i) the theoretical yield of hydrogen was correctly calculated by most, although some divided or multiplied by 2 even when the equation was correct. This question was the only place in the paper where significant figures were evaluated and several candidates lost the mark for stating the answer to only 1 significant figure. Part (c)(ii) proved more difficult for the majority of candidates. Most candidates used the gas equation but did not realize that using the units in the question gave the answer in m^3 and hence they did not convert correctly to cm^3. Many candidates used molar volume at room temperature or standard temperature and pressure. Part (d) was answered reasonably well with many candidates scoring at least 1 mark, suggesting that they were familiar with this experiment. Several candidates did not think back to earlier answers they gave and said that the reaction had not gone to completion, or that not all the Mg reacted or that HCl was impure. A few candidates gave some very trivial reasons such as mistakes in measurements or faulty equipment.

Question 3

Many candidates had difficulty correctly explaining the trends in lattice enthalpy values in (a), referring to atomic radii or the attraction between the metal nucleus and valence or bonding electrons, and giving explanations that sounded like descriptions of first ionization energy or covalent bonding. In (b) most candidates scored one mark for stating that the Mg ion has a greater charge than Na ion. Few also mentioned that the size of the Mg ion is less than the Na ion. Most candidates correctly identified sublimation or atomization of Li in (c)(i). Vaporization was the most common error. In (c)(ii), many candidates forgot to divide the bond enthalpy of fluorine by 2. Some had difficulty finding the enthalpy of atomization of fluorine in the Data Booklet, and some obtained all the correct values but did not put the correct signs on the values when using Hess's Law.

Question 4

Many candidates had difficulties with the Lewis structure of the nitrate ion, putting too many electrons around the nitrogen atom or omitting the negative charge. They did better with XeF_4, giving correct shape and bond angles. Some candidates lost marks for omitting lone pairs from the F atoms, and some had only 4 negative charge centres around Xe. Some teachers expressed concern that only exceptions to rules were being examined, but both NO_3^- and XeF_4 are listed as examples to use in the teacher's notes.

Question 5

A precise definition of isotopes was rarely given by candidates, with many referring to elements rather than atoms in (a)(i). In (a)(ii) many candidates scored a mark for the use of radioactive iodine and several also scored for the explanation of why its use is potentially dangerous. Those who lost marks gave vague responses such as it is radioactive or harmful. Part (b) caused more problems for candidates with only the better ones able to describe the use of carbon-14 in carbon dating. The majority of candidates scored a mark for stating that carbon-14 has a known half-life. Some confused candidates thought that carbon-12 is radioactive and decays to form carbon-14.

Question 6

Many candidates answered that CH_3COONH_4 is neutral, and several correctly explained why. One G2 comment asked if candidates were expected to know that the pK_a of ethanoic acid and the pK_b of ammonia are similar. Candidates are expected to be familiar with the Data Booklet and the information it contains, and the assessment statement 18.1.6 reinforces this. However, although several candidates stated that $Cr(NO_3)_3$ is acidic very few could explain this. Teacher's notes for assessment statement 18.3.1 clearly states that the effect of charge density of the cations of d-block elements should be considered. Common errors included statements that the nitrate ion reacts with water to produce nitric acid.

Section B

Question 7

Question 7 was a popular one and well-answered in general. Part (a) required definitions which were not well known but most candidates determined the empirical and molecular formulas and correctly drew the structural formula of the carboxylic acid. Fewer candidates could correctly draw the structural formula of an ester. Identification of the stronger and longer carbon-oxygen bond was answered correctly by nearly all candidates, but explaining the bond lengths in the propanoate ion was only answered correctly by the very best candidates. Even those who realized that the electrons are delocalized did not give a complete explanation and often scored only 2 marks out of 3. In part (b) many candidates struggled to define hybridization, frequently referring to overlapping of orbitals. Most could state that the carbon atom in methane is sp^3 hybridized and that the molecule is tetrahedral, but few gave detailed responses about electron configurations or repulsion of electron pairs. However, most candidates correctly identified the hybridization of carbon in diamond and graphite, and explained why graphite conducts electric current. In (c) few candidates knew that Al_2Cl_6 is a covalent compound and that Al_2O_3 is ionic. Some answers mentioned many types of bonding for one compound. Many candidates could state at least one product for the reaction between aluminium chloride and water, but few seemed to know that the reaction is vigorous and gives off fumes of HCl(g). Answers were accepted as equations with correct state symbols, or as descriptions.

Question 8

Part (a) was generally answered well, with most candidates drawing clear enthalpy diagrams. Many lost one mark, however, for labelling the y-axis as energy rather than enthalpy. Most candidates stated that products are more energetically stable and gave correct explanations. Calculations of the change in heat energy were quite well done too. In part (b), few candidates realized that this was a question about the differences between a strong acid and a weak acid. Good candidates had no problem with (c) but weaker candidates used the mass of the ammonium chloride to determine the enthalpy change. A minority of candidates confused heat energy change and enthalpy change. Calculation of pH in (d) proved challenging for some and straightforward for others. Those who knew how to perform the calculations generally also correctly stated an assumption. Most candidates correctly described a buffer solution in (e). Several candidates had difficulty calculating the concentrations of ammonia and ammonium ions in the buffer but managed to calculate the pH correctly (some with ECF). The explanations of why the pH of the buffer differs from the pH of ammonia and the action of the buffer when a few drops of nitric acid are added were poorly done and would have been better with the use of equations and references to equilibrium. Answers to (f) were quite general. Many candidates simply said that bromocresol green changes colour with no further details, or said that the indicator had different colours in acid and alkaline conditions. Most candidates scored 1 mark for stating that the pK_a is in the middle of the pH range.

Question 9

Most candidates had no difficulty with the full electron configuration of Fe in (a) but many could not write the abbreviated electron configuration of Fe^{3+}, losing 3d electrons ahead of 4s. Some G2 comments suggested that the word abbreviated caused problems, but this is stated in the teacher's notes and most candidates seemed to have no difficulty with the term. Descriptions of cyanide ions acting as ligands were particularly well expressed but some candidates had difficulty explaining why Fe^{3+} ions are coloured, referring to excited orbitals emitting light. In part (b) nearly all candidates correctly stated the equation for production of SO_3 from SO_2, but incorrectly named the catalyst. Most candidates scored 1 mark for stating that a catalyst provides an alternative reaction pathway with lower activation energy, but neglected to mention that more molecules have sufficient energy to react. Some candidates remembered previous questions and referred to the effect of a catalyst on an equilibrium instead of answering the question. Most candidates identified at least one economic benefit of using a catalyst in the Contact process although some simply said that yield was increased. Decreasing entropy was recognized by most and explanations of the reaction becoming less spontaneous at higher temperatures were well done. In part (c) most candidates identified the symbols of the Arrhenius equation. Many calculated the activation energy, although several calculated the gradient from the graph rather than using the equation of the line of best fit. (This was accepted, but made the question much harder than intended.) Several candidates also calculated the numerical value of A correctly.

Question 10

In part (a) most candidates correctly named both compounds but did not state both the catalyst and heat as necessary conditions for the production of ethyl methanoate. Several candidates had difficulty in deducing the structure of the simplest repeating unit but most knew the uses of the product. About half the candidates could identify a suitable catalyst in part (b), with many suggesting dichromate(VI) ion or nickel instead of concentrated acid. The reagents and conditions necessary for converting an alkene to a bromoalkane and then to an alcohol were well known although it was rare for a candidate to recognize that HBr needs to be anhydrous. Some teachers felt that knowing catalysts and conditions is not stated on the syllabus. Assessment statements 10.6 and 20.5 state that reagents, conditions and equations are required. Most candidates correctly explained the effect of chlorine rather than bromine on the rate of the substitution reaction. The definition of isomers in (c) was reasonably well answered, as was the drawing of structural formulas and identification of them as primary, secondary or tertiary. Few candidates correctly explained why substitution occurs on the marked carbon, with many simply stating that it was bonded to the bromine. Some candidates showed that they were well prepared to draw substitution mechanisms while others had imprecise arrows or had the curly arrow coming from the N instead of the lone pair or negative charge on the carbon, and hence wrote the transition state with a CN–C bond. Most candidates correctly stated the reagent and catalyst needed to reduce the nitrile to an amine. In part (e), some candidates gave the correct products of the elimination reaction but most thought it was another substitution question.

Recommendations and guidance for the teaching of future candidates

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

- Candidates must learn the common definitions on the syllabus.

- Candidates must consider the units and the appropriate number of significant figures for the final answer in calculations.
- Candidates should practice converting units during calculations, particularly with gas laws.
- Candidates should give answers in decimal form and not as fractions when doing calculations.
- Candidates should practice writing equations.
- Candidates should practice drawing reaction mechanisms.
- Candidates should use the number of lines and the marks as a guide as to how much to write. Write answers in the boxes provided and if the answer does not fit in the box, indicate that the answer is completed on a continuation sheet. However, the use of continuation sheets should not be encouraged as it can mean longer answers than necessary are provided.
- Candidates must use the **latest** Data Booklet during the chemistry course so that they are familiar with what it includes. Some schools are still using old editions of the Data Booklet. The Data Booklet must not only state on the front cover “First examinations 2009” but also within the front cover should state “Revised edition published September 2008”.
- Candidates should set out calculations logically and legibly and “keep going” with calculations because errors are carried forward so that a correct method in a later part of the question is rewarded. All steps in the calculation should be shown.

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

Teachers’ impressions of the paper were conveyed by the 207 G2 forms that were submitted. 69.2% felt that the paper was a similar standard to last year, 16.7% felt it was a little more difficult or much more difficult while 8.7% felt it was a little easier or much easier. The majority (91.7%) of the teachers who responded felt the level of difficulty was appropriate, with only 6.3% feeling it was too difficult. For clarity of wording 51.9% felt it was good and 43.7% satisfactory. Finally, for presentation of the paper, 64.4% chose good and 34.1% satisfactory.

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

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

- Describing and explaining the different forms of chromatography
- The interactions between amino acid chains
- The formation of alloys by metals
- Equations for reactions in fuel cells and batteries
- Explaining the workings of liquid crystals
- The historical development of penicillins
- Reactions involved in ozone depletion
- Explaining the directing effects of substituents in benzene rings.

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

The areas which seemed well understood were:

- The factors affecting the colour of transition metal complexes
- Understanding and explaining the effect of conjugation on colour in organic molecules
- Drawing structures of dipeptides
- Identifying chiral centres in molecules
- Equations for the reactions involved in the formation and removal of air pollutants.

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

Option A – Modern analytical chemistry

Question 1

In (a), most scored both marks here for recognizing the need to replace the light source or lamp by one for the different metal. Most scored all three marks in (b) – a few omitted the concentration label or units, but the points were usually accurately plotted and a correct line of best fit drawn, and the concentration read off correctly. There were occasional examples seen of mis-plotted points and lines drawn without a ruler.

Question 2

Some did not clearly distinguish between the different requirements of (a) and (b), so there was some repetition of points in these parts. In (a), many scored two or three marks – the most common omission was the reference to adsorption required by the markscheme. It was obvious that some candidates were not familiar with column chromatography, and some answers read like descriptions of thin layer or paper chromatography. Most managed to score at least two of the available five points for the first three marks, but few scored the final mark. Although "quantitatively" appeared in bold in the question, most ignored this, while some wrote inadequate answers such as "measure the volumes of each component as they leave the column".

Question 3

The great majority scored full marks in (a) and (b). Part (c) caused more problems, with few scoring the final mark.

Question 4

Many scored both marks in (a), although some blanks were seen. Part (b) was generally well answered, with most showing a good understanding of the material being tested, although a few referred to d-d electron transitions.

Option B – Human biochemistry

Question 1

Most knew the general function of hormones in (a), although some answers referred to a specific example. In (b), most were able to name an effect of thyroxine deficiency. Part (c) caused problems for those who ignored the significance of "named" in the question. Part (d), about the unfamiliar compound dianabol, was well answered.

Question 2

A few of the attempts at (a) showed little understanding of dipeptide structures, but most indicated a clear understanding of the reaction that occurs. Although there were some instances of bonds to CH_3 being carelessly drawn, few candidates lost marks through gross errors such as NH_2—C and CH_2OH—. In (b), the interactions between side chains were generally well known, although van der Waals' forces and hydrogen bonds were sometimes interchanged. Part (c) caused problems for candidates, where often the words used did not quite match the requirements of the markscheme. In part (d), although most were able to describe the formation of the bond between iron and oxygen, far fewer scored the mark for the release of oxygen.

Question 3

Although most had some idea of what sort of answer part (a) required, it was rare to find full marks being awarded – the most common reasons were a qualitative answer for the first mark, and the absence of a reference to active sites for the third mark. In (b), the distinction between competitive and non-competitive inhibitors was well known, although a surprising number of answers contained explanations without stating the effect on V_{max}. Most sketch graphs in (c) were sufficiently well drawn to score the mark, although many would have benefited from a scale that indicated a narrow pH range; the explanation was generally well known.

Option C – Chemistry in industry and technology

Question 1

Several answers to (a) included substances ruled out in the question wording (especially transition metals), and limestone (rather than lime) often appeared, although the use of scrap iron was well known. In (a)(ii), the idea that phosphorus and silicon were oxidized (often shown in equations) was well known, but the second mark (for their reaction with lime, or to form slag) was rarely scored. Judging by the many low-scoring answers, part (b) was testing material unfamiliar to candidates. Answers to (c) often scored full marks, although some stated that rapid, rather than slow, cooling was required.

Question 2

Parts (a) and (b) required candidates to write four specific equations involving electrons. A very small number scored all four marks, while a range of errors meant that most scored far fewer marks – usually for equations containing incorrect species or because of unbalanced charges. Part (c) was better answered, with most able to gain at least one of the four possible scoring points.

Question 3

In (a), most understood the differences between thermotropic and lyotropic liquid crystals and scored both marks. Answers to (b) rarely scored full marks. Some clearly knew very little about the relevant molecular features, and many of those who did, failed to link the features with the properties. Part (c) was sometimes left blank, and few answers scored more than one or two marks. This part tested AS C.11.2, but most answers were vague and rambling and did not come close to matching the markscheme, which was very similar to the teacher's notes for this assessment statement.

Option D – Medicines and drugs

Question 1

Most equations in (a) were correct, with the most common errors being the use of $Al(OH)_2$ and $Mg(OH)_2$ instead of $MgCO_3$. Very few scored both marks in (b) because they failed to do the necessary calculations to show that aluminium hydroxide was the answer; they usually relied on comparing the 3:1 and 2:1 ratios in the equations without considering the actual amounts of each metal compound present. Part (c) was invariably correct.

Question 2

Although many scored the mark in (a), quite a few omitted the required reference to epinephrine or adrenaline. The identification of the chiral atoms in (b) was very well done. Most answers in (c) scored both marks for the familiar example of thalidomide. The structures drawn in (d) were usually correct, with the most common errors being the omission of the benzene ring or including and OH group in the ring. In (e), although the reason for using the salt was usually correct, hardly any correct ion structures were seen – most attempts were anions rather than cations.

Question 3

Most answers to (a) conveyed the idea of a mould preventing bacterial growth. Part (b) tested AS D.6.1, but although there were hardly any blanks, most answers scored poorly, even though only three of six scoring points were needed for full marks. Many answers referred to the modification of side chains. Most answers scored at least one mark in (c), or came close to it – most that did not were not specific enough or failed to mention cell walls. In (d), the β-lactam ring was usually correctly identified, as was the circled amide group. In part (d)(ii), few answers scored full marks, although most identified the relevance of the bond angles in causing ring strain. In (e), many more scored the overprescription mark than the one for modifying the side chain.

Option E – Environmental chemistry

Question 1

Part (a) was well answered, although some missed the second mark through omitting the reference to high temperature. Most obtained the mark in (b), with carbon dioxide perhaps the most common unacceptable answer. Part (c) was well answered, with few equations showing incorrect products. Although many correct answers were seen to (d), many candidates who made references to CO and NO_x failed to make it clear whether they were considering an increase or a decrease in the fuel/air ratio.

Question 2

This was a well-answered question. The most common unacceptable answers were references to acid rain being responsible for soil pollution.

Question 3

Although part (a) was generally well answered, many candidates missed the first mark through failing to refer to bonds in both oxygen and ozone. Most answers to (b) contained at least two of the three equations required. Many answers to (c) scored poorly as they contained no references to chlorine compounds. The conditions for the formation of a photochemical smog were well known in (d).

Option F – Food chemistry

Question 1

Part (a) was well answered. In (b), the only part not well done was (b)(iii), where the formation of radicals was often omitted. Both (c) and (d) were well answered.

Question 2

In (a), most recognized the presence of C=C in oils, but not the difference in length of carbon chain. The conditions for hydrogenation were well known in (b). Most answers to (c) contained at least one advantage and disadvantage of converting oils to fats.

Question 3

The half-equation in (a) was usually either completely correct or referred to a different reaction. The identification of the chiral atoms in (b) was very well done. Part (c) was invariably correct. The CORN rules were usually referred to in (d), although not as many correctly described what they were. The structure was often correctly drawn, although some were not for alanine, as required by the question. Limonene and carvone were almost the only choices in (e).

Option G – Further organic chemistry

Question 1

The curly arrow mechanism in (a) was usually high-scoring, although there were some examples of omitting electron pairs and arrows pointing in the wrong direction. Quite a few attempts omitted the carbocation intermediate. Very few errors were seen in (b).

Question 2

Parts (a) and (b) were well answered, and the most common omission in (c) was either carbon dioxide or water.

Question 3

Part (a) was generally well answered, with few errors in the mechanism in (a)(i). Part (a)(ii) was usually correct, but in (a)(iii) the explanation of the directive effect of the methyl group proved too difficult for most. Few correct equations were seen in (b)(i) – most attempted monosubstitution by chlorine, although many scored the mark for the name by the ECF principle. The explanation in (b)(ii) was generally well done.

Question 4

The comparison of phenol and ethanol acidities was well answered in (a), as was the electron withdrawing effect of the nitro group.

Recommendations and guidance for the teaching of future candidates

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

- Candidates should use the number of lines and the marks as a guide as to how much to write. Write answers in the boxes provided and if the answer does not fit in the box, indicate that the answer is completed on a continuation sheet. However, the use of continuation sheets should not be encouraged as it can mean longer answers than necessary are provided.

- Candidates should use a good quality black ink pen to avoid illegible writing and ink seeping through the paper and appearing on the following page.

- Candidates must use precise forms of wording when writing definitions.

- Candidates should practice writing organic reaction mechanisms, paying particular attention to the start and finish positions of curly arrows.

- Candidates must use the **latest** Data Booklet during the chemistry course so that they are familiar with what it includes. Some schools are still using old editions of the Data Booklet. The Data Booklet must not only state on the front cover “First examinations 2009” but also within the front cover should state “Revised edition published September 2008”.

Standard level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 7	8 - 11	12 - 16	17 - 19	20 - 21	22 - 24	25 - 30

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 181 G2 forms that were submitted. 97.2% reported the level of difficulty to be appropriate, 0.6% thought it to be too easy and 2.2% too difficult. In comparison with last year's paper, 78.4% considered it to be of similar standard or a little easier and 18.3% considered it to be a little more difficult. Clarity of wording was considered good or satisfactory by 98.4% and the presentation of the paper was considered good or satisfactory by 98.9%.

The statistics above were also mirrored in the general comments where it was generally felt that the paper was well-balanced and fair. Some respondents liked the originality of the paper and found it thought-provoking, thought some felt that there were perhaps too many questions associated with the gas laws. The three easiest questions for candidates were Q's 6, 19 and 17 in that order. The three hardest questions were found to be Q's 5, 1 and 14, also in that order. It was very surprising that candidates found Q5 the most difficult. This question is clearly on-syllabus and assesses AS 1.5.1. It is true to say that this is an AS that is not often tested on P1, but it was very disappointing that candidates did so poorly. One of the main problems for candidates was that they were not used to seeing a concentration unit of g dm^{-3}, and hence the majority gave the correct answer as A instead of D. This further emphasizes how important it is that candidates are exposed to a comprehensive laboratory programme as part to their overall education within the IB Chemistry Diploma programme. Chemistry as a discipline is part of group 4 of the IB Diploma Programmes hexagon, and as such is one of the specified experimental sciences. This is an extremely important facet in the teaching of chemistry in preparation for the programme itself. Candidates also struggled surprisingly with Q1, even though this type of question has been asked before. Most forgot to take into account the fact that in one molecule of the complex there are a total of 11 atoms, so to arrive at the correct answer, D = 6.62×10^{23} atoms, 0.100 needed to be multiplied by 11 and 6.02×10^{23}. In Q14, the main difficulty lay with thinking that CH_3F has hydrogen bonding, which is clearly does not.

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

Question	A	B	C	D	Blank	Difficulty Index	Discrimination Index
1	325	2449	332	1572	10	33.53	0.47
2	908	3136	311	321	12	66.89	0.3
3	2304	1231	783	347	23	49.15	0.43
4	134	513	2754	1268	19	58.75	0.36
5	2055	1080	225	1317	11	28.09	0.16
6	53	19	4512	102	2	96.25	0.08
7	1184	292	2898	297	17	61.82	0.48

8	1255	282	203	2941	7	62.73	0.34
9	673	1908	631	1466	10	40.7	0.45
10	344	2967	951	408	18	63.29	0.41
11	422	66	119	4078	3	86.99	0.26
12	2961	193	648	875	11	63.16	0.55
13	781	1928	723	1230	26	41.13	0.28
14	1765	2156	419	330	18	37.65	0.46
15	199	169	3824	485	11	81.57	0.24
16	119	339	749	3469	12	74	0.38
17	4132	283	179	86	8	88.14	0.25
18	501	71	64	4045	7	86.28	0.29
19	49	4205	119	314	1	89.7	0.24
20	631	516	595	2935	11	62.61	0.53
21	1350	2740	459	127	12	58.45	0.46
22	87	2527	41	2021	12	53.9	0.41
23	2276	565	1098	741	8	48.55	0.57
24	197	3132	218	1126	15	66.81	0.47
25	1504	547	2231	373	33	47.59	0.46
26	3305	716	256	405	6	70.5	0.57
27	2907	1252	205	304	20	62.01	0.44
28	382	1006	652	2625	23	55.99	0.46
29	1170	2267	274	929	48	48.36	0.38
30	623	894	1201	1921	49	40.98	0.42

Total candidates: 4688

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

The difficulty index ranged from 96.25% to 28.09%, and the discrimination index ranged from 0.57 to 0.08.

The following comments were made on selected individual questions:

Question 2

One respondent stated that this question was particularly difficult. Although the question was challenging, 66.89% of candidates did manage to get the correct answer B. The question was the ninth hardest question on the paper.

Question 3

One respondent stated that he/she was not sure if memorization of standard pressure in Pa was required for this question. In this question candidates had first to calculate the amount occupied by 3.20 g of O_2(g). This was found by dividing 3.20 by 32.00 = 0.100 mol. Then, the volume in dm^3 was obtained by simply multiplying 0.100 by 22.4, giving an answer of 2.24 dm^3, meaning A is the correct answer. The conditions of temperature and pressure were the same at 273 K and 1.01×10^5 Pa. 49.15% of candidates got the correct answer.

Question 12

In one G2 comment it was stated that since the question is about bond angles then it would be better to use a 3D representation of paracetamol. This was not the intention of the question. Candidates had to look at the number of negative charge centres (electron domains) around the two carbon atoms and the oxygen atom in order to relate this to the associated bond angle. In the case of the oxygen atom, there are four negative charge centres suggesting that the electron domain geometry is tetrahedral but the molecular geometry is actually v-shaped (bent). Due to the lone-pair/lone-pair repulsion, the actual bond angle is reduced from the ideal bond angle of 109.5^o for α. For the two carbon atoms, one has three negative charge centres, implying a 120^o bond angle and the other has four negative charge centres suggesting a 109.5^o bond angle based on a tetrahedral molecular geometry around the carbon. 63.16% of candidates got the correct answer A. The question also had a reasonably good discrimination index of 0.55. Many candidates opted for D and simply took the bond angle based on the Lewis structure to be 90^o for the H–C–H bond. This shows again the importance of introducing the 3D nature of molecules in the teaching of geometry as part of the teaching programme. Candidates should be exposed to constructing simple 3D molecules in class (and/or engaging with computer-aided visualizations if facilities allow) and candidates should understand the inherent differences between Lewis (electron dot) structures (which do not necessarily convey angular perspectives) and ball and stick type or other similar 3D representations. VSEPR theory should be employed as a useful model in bridging these two types of representations and this is especially important in looking at structures in the teaching of organic chemistry, where 2D structural formulas are often used.

Question 13

One respondent stated that statement I. could have been better worded and stated that bonded in a sphere could be taken to mean that each atom is bonded in a sphere rather than a sphere made of all 60 atoms. This is a fair comment. 41.13% of candidates got the correct answer B and the question was the sixth hardest question on the paper.

Question 14

One respondent suggested that they would have liked to have seen the inclusion of London dispersion forces in brackets in the question as an alternative to van der Waals'. Although the term London dispersion forces certainly has been given as an alternative to van der Waals' in markschemes in both P2 and P3 previously, in the current guide in the teacher's notes corresponding to AS 4.3.1, the term actually used is van der Waals' forces, and it was felt by the paper author that to include the term London dispersion forces in brackets would have made this question look rather long from a reading perspective.

Question 16

There were two G2 comments on this question, with both saying that the question was too difficult for SL candidates, especially without the use of a calculator. This type of question has been asked on P1 several times before, and this in general was not an issue at all for candidates, with 74.00% of candidates getting the correct answer D. It is true that algebraic variables could have been used, though in this case the calculation involved is relatively simple: +50.6 +(+44.8) = +95.4 kJ and is simply the addition of two numbers, since no equation inversion is involved nor is a multiplication factor necessary.

Question 25

There were also two G2 comments on this question. One respondent stated that knowledge of this depth is off-syllabus. This is not correct. Both the movement of ions in solution and across a salt bridge should be covered in the programme. Candidates are expected to know this as part of their understanding of voltaic cells and ion movement has been asked previously in papers. 47.59% got the correct answer C. Although this was a common question with HL, certainly at SL the question was found to be more challenging and performance at HL was invariably better as discussed in the corresponding subject report for HLP1TZ2. At SL, the question was the seventh most difficult question on the paper and had an associated discrimination index of 0.46.

Question 26

Three respondents commented on this question. One respondent stated that a 3D structure should not be used here. As previously mentioned in this report, candidates should be encouraged to see a whole range of different representations of structures and in organic chemistry it is especially important that candidates are exposed to 3D representations as part of the overall teaching of organic chemistry. Another respondent stated that it would have been better if statement I. was instead given as a suitable name for the compound is pent-2-ene, which is a fair comment. This was mirrored by another respondent who stated that the molecule drawn is in fact a geometrical isomer and hence E should have been used. Although this is correct, at SL in Topic 10, it is clearly stated that the distinction between *cis* and *trans* isomers is not required (TN for AS 10.1.8), so this is the reason why reference was not given to (2E)-pent-2-ene in the question, so the respondent is correct in stating that it would be better if the term IUPAC name was not given for this reason.

Question 27

There were a number of G2 comments on this question. Many stated that the ester functional group is off-syllabus. This is not correct. AS 10.1.11 clearly states that candidates are required to know the ester functional group. One respondent also commented that it would be better to represent the structure in 2D. This has been discussed previously in relation to 2D and 3D representations. One respondent queried whether benzene ring is an actual functional group. Again, in the current IB chemistry guide, a benzene ring is cited as a functional group, according to AS 10.1.11.

Question 29

One G2 comment stated that in Stage 1 it would have been better if the condition of heat was not given, as temperature increases the likelihood of a possible elimination reaction, suggesting that C also might be a possible answer. It is true that it might have been better if warm was stated instead of heat. However, the aqueous state was given for the sodium hydroxide (as opposed to ethanol), so the main product in Stage 1 would be substitution and candidates are always meant to choose the best answer in a multiple-choice question. When the data was examined it was found that 48.36% of candidates chose B as the correct answer, followed by A and then D. Very few candidates went for C.

Question 30

One respondent stated that this question was not suitable for Topic 11. It is true that this MCQ on Topic 10 often does in fact test the AS's associated with Topics 11.1 and 11.2. However, Topic 11.3 on Graphical Techniques also is an integral part of Topic 11 and this question in fact links Topic 11.3 explicitly with the pressure-volume relationship from Topic 1.4, so is a completely suitable question for assessing this Topic 11.3, as candidates are required to interpret graphical behaviour. The question was found to be quite challenging for candidates with 40.98% of candidates getting the correct answer D.

Standard level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 7	8 - 15	16 - 20	21 - 25	26 - 30	31 - 35	36 - 50

General Comments

The range of marks was very wide; the best candidates showed a thorough command of the material and a high level of preparation. Teachers' impressions of this paper were conveyed by 181 G2 forms that were submitted. This was slightly less than the 220 returned last year and may reflect greater familiarity with the presentation of this e-marked paper. Of the 181 returned, 95.6% reported the level of difficulty to be appropriate, 1.1% thought it to be too easy and 3.3% too difficult. In comparison with last year's paper, 81.4% considered it to be of similar standard or a little easier, and 14.6% considered it to be a little more or much more difficult. Clarity of wording was considered good or satisfactory by 98.9% and the presentation of the paper was considered good or satisfactory by all respondents.

There was little evidence this year that candidates missed the transition from section A to section B; but spotting this transition is an important part of their examination preparations.

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

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

- Calculating rates from tangents to a curve
- Writing half equations for oxidation and reduction equations
- Being aware of units in gas calculations (conversion of m^3 to cm^3)
- Quoting definitions accurately
- Use of ^{14}C in carbon dating

- Explaining volatility/solubility in terms of structure and bonding
- The structure of graphite
- Drawing accurate and well-presented Lewis diagrams for molecules/ions
- Explaining why alkanes have low reactivity.

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

Topics generally well answered included:

- Drawing a curve to show the effect of a catalyst on the reaction rate
- Oxidation numbers of atoms in molecules
- Determining the limiting reactant in a reaction
- Reaction between sodium and water
- Calculating empirical and molecular formulae from % composition
- Bromination of alkane mechanism
- Brønsted-Lowry concept of acids and bases.

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

Section A

Question 1

Part (a) was well answered but (b) was either right or wrong. Few candidates drew the tangent, many being satisfied with a gradient of 4.0/120. Although a number of G2s commented on the "unusual" units of the rate (mm s^{-1}) this did not seem to be an issue for the candidates. In (c)(i), the line was usually correctly drawn although a significant minority drew it below the original. In (c)(ii), having stated that the catalyst provides a lower activation energy, candidates rarely explained that "more molecules/particles have energy greater than or equal to the activation energy", many muddling the answer with that appropriate to an elevated temperature. Most managed the oxidation numbers in (d)(i) although there were some rather curious answers for H_2O_2. There were very few correct answers to the oxidation and reduction half equations in (ii) and this question discriminated the best candidates.

Question 2

Part (a) was scored correctly about 50% of the time but many assumed magnesium chloride to be MgCl. Many candidates were able to answer (b) correctly with ECF (error carried forward) taken into account as necessary. In (c)(i), many following through directly from (b) weren't careful enough with the significant figures of the answer and were penalized here. Part (c)(ii) required a careful calculation; most did not make the correct correction to cm^3. In (d), candidates needed to think whether the answer they gave made sense in the context of the experiment and their previous answers. It is important that candidates are exposed to a wide range of practical experiences.

Question 3

Part (a) produced a wide variety of equations, some giving Na_2O and/or H atoms as products, but (b) was generally answered correctly. In fact many answers went well beyond that required by the markscheme and would not have disgraced HL candidates.

Question 4

In (a)(i), the word *atoms* was frequently omitted from the definition; it is accepted that it would have been preferable to ask for the definition of *isotopes of an element* as specified in the syllabus. The answer in (ii) was generally correct and part (iii) caused few difficulties. The question in part (b) could have been better worded but, even so, the concept of carbon dating was not well understood. Overall, it is accepted that five marks was too great for the examination of a small part of the syllabus.

Section B

Question 5

There were some vague and convoluted definitions in (a)(i) but thereafter the calculations were well done. Where difficulty was found, was in the formula of an ester in (v), (AS 10.1.11). The answers to (b)(i) were reasonable, although it was common to state that the intermolecular bonding in methoxyethane is van der Waals'. Some G2s took issue with the examination of ethers in organic chemistry; it was, in fact, examined under AS 4.3.2. In (ii), some mentioned a "larger molecule" rather than a "longer chain" and few were able to explain the attraction (or lack thereof) between the organic molecule and water. Part (c) suggested that there is work to be done on understanding the structures of graphite and diamond. One particular mark lost was not to state that the reason diamond is hard is because the covalent bonds are *strong*.

Question 6

Part (a) was answered well although some mentioned "dissolving" instead of "dissociating". In (b), the equation was well done as was (ii); inevitably, many omitted "pair" in (iii). Part (c)(i) was generally correct. In (c)(ii) the carbonate ion was legitimately examined under AS 4.2.7; it was not well known – there were too many carbons with expanded octets and oxygens where the lone pairs had been missed. (In the HL specification, the carbonate ion's delocalization is considered.) In (iii), however, the shapes were well known. If there was to be an error made in (d)(i), it was to omit "enthalpy" from the *y*-axis and some unaccountably put the correct chemicals on the line and then reversed the names products and reactants. The calculations in (d)(iii) and (e) inevitably depended on an ability to calculate and think logically.

Question 7

This was the least popular question in section B, but was generally chosen by those who were a little more "expert". Part (a) was answered well and hydrogen atoms were rarely missing as they have been in other examination sessions. It is accepted that the answer box for (ii) would have been better without lines in it. In part (b)(i), candidates found it difficult to explain why alkanes have low reactivity – it is always more difficult to explain a negative – and *homolytic fission* was not well explained in (ii). There were many good answers to (iii), (iv) and (v). In (b)(iv), candidates were asked to state *an* equation so further substitution was accepted. Part (c) caused more trouble. The catalyst was often mis-identified in (i) (potassium dichromate seemed to be a common choice). In (ii), the condition for using HBr was rarely given (although it is accepted that it is rarely given in the texts) and the reagent for step II was sometimes given as hydroxide or ^{-}OH.

Recommendations and guidance for the teaching of future candidates

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

- Candidates must learn the common definitions on the syllabus.
- Candidates must pay attention to the beginnings and endings of bonds.
- Candidates must draw Lewis structures carefully. Odd smudges can be easily mistaken.
- Candidates should use the number of lines and the marks as a guide as to how much to write. Write answers in the boxes provided and if the answer does not fit in the box, indicate that the answer is completed on a continuation sheet. However, the use of continuation sheets should not be encouraged as it can mean longer answers than necessary are provided.
- Candidates should set out calculations logically and legibly and “keep going” with calculations because errors are carried forward so that a correct method in a later part of the question is rewarded. All steps in the calculation should be shown.
- Teachers should give candidates an opportunity to experience a wide range of experimental activities to assist with the understanding of questions with a practical basis.
- Candidates must check that both significant figures and units are correct in all calculations.
- Candidates should prepare for the examination by practicing past exam questions and carefully studying the markschemes provided.
- Candidates must use the **latest** Data Booklet during the chemistry course so that they are familiar with what it includes. Some schools are still using old editions of the Data Booklet. The Data Booklet must not only state on the front cover “First examinations 2009” but also within the front cover should state “Revised edition published September 2008”.

Standard level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 5	6 - 11	12 - 14	15 - 19	20 - 23	24 - 28	29 - 40

General comments

This paper identified a very broad range of candidate capabilities. A very wide range of performance was seen, there were some excellent responses and also there were a number of students that were insufficiently prepared for the paper. Some responses lacked precision and chemical detail. Explanations were often vague, and, particularly for options D, E and F, tended to be journalistic rather than based on chemical facts and principles. Students need to be reminded of the nature of the subject, general answers to specific questions do not score marks. Many candidates appeared to be uncomfortable with some of the more chemistry type questions in options B on human biochemistry and option D on medicines and drugs, which suggests that some students who are strong in biology struggled somewhat, it should be borne in mind that this is a chemistry paper and the emphasis should be in chemistry. Many of the weaker candidates appeared to opt for option E on environmental chemistry. However, in many cases these candidates tried to answer questions with limited specific chemical knowledge of the option itself and hence performed poorly. It is imperative that candidates are well prepared for their chosen options. Where all the candidates in a centre studied the same two options they tended to perform better than candidates who appeared to have a wide variety of choice of the options studied.

Of the 183 G2s sent in 68.9% felt that the paper was a similar standard to last year, 21.5% felt it was a little more difficult or much more difficult while 6.2% felt it was a little easier or much easier. The majority (88.8%) of the teachers who responded felt the level of difficulty was appropriate, although 10.1% felt it was too difficult. For clarity of wording 58.1% felt it was good and 40.8% satisfactory. Finally, for presentation of the paper, 68.9% chose good and 29.9% satisfactory.

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

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

- Thin layer and column chromatography
- ^{1}HNMR
- Understanding MRI
- Quaternary structure of proteins
- Explaining why iron can form alloys with other transition metals
- Stating the half equations involved at the electrodes in fuel cells and lead-acid battery
- Drawing the structure of atactic poly(propene)
- Historical facts related to the discovery and development of penicillin
- Degradation of soil and its causes
- The role of free radicals in photo-oxidation
- Describing structural features in antioxidants

- Emulsifiers and stabilizers
- Explaining the mechanisms of organic reactions using curly arrows to represent the movement of electron pairs
- Explaining the relative solubilities of 1-aminopentane and its salt
- Stating the equation for the reaction of methylammonium chloride with sodium hydroxide
- Writing extended responses with sufficient information
- Correct use of subject specific terms.

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

The areas which seemed well understood were:

- AA spectroscopy
- Hormones
- Dipeptides
- Tertiary structure of proteins
- LDL and HDL
- Annealing
- Antacids
- Describing resistance of bacteria to penicillin
- Effect of hot water on fish
- Discussing the safety issues associated with the use of synthetic colourings in food
- Identifying reaction types in organic chemistry.

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

Option A – Modern analytical chemistry

This was one of the less popular options.

Question 1

Most candidates were familiar with the need to change the frequency of the light source to that of the metal in the sample in part (a). The great majority of candidates fully scored in part (b). Only very weak candidates produced lines that were not straight.

Question 2

In (a) most candidates showed a poor understanding of the principles behind the technique of TLC and CC and a substantial amount merely described the investigation without actually addressing the question. Adsorption rarely appeared and when it did was often not properly used. Many candidates clearly did not have a good grasp of the specific roles of the mobile and stationary phases. Most candidates were able to score some points in part (b), but only very strong ones managed to fully score. The quantitative determination eluded most.

Question 3

This is a topic that showed better understanding, but many candidates lost marks as their answers did not focus on integration traces. Thus, it looks like quite a few candidates are actually proficient in this technique, but failed to interpret the question properly. Very few candidates could explain the role of ^{1}HNMR in magnetic resonance imaging. Explanations were very shallow evidencing no clear understanding of this technique.

Option B – Human biochemistry

This was one of the most popular options.

Question 1

Parts (a), (b) and (c)(i) were correctly answered by the vast majority of candidates. Those who did not score fully often suggested iodine for (b). Parts (c)(ii) and (d)(i) were in general correctly answered. Suggestion of the formulae of the group rather than the names, which is vague, was usually the reason for not scoring in the former. Part (d)(ii) proved somewhat challenging to a significant number of candidates when it was meant to be rather straightforward.

Question 2

Parts (a) was answered well by the great majority of candidates with only weaker candidates failing to score. Part (b) showed that most candidates were familiar with the topic and managed to score even if not fully. Part (c) though was in general poorly answered.

Question 3

Most candidates answered part (a) correctly. One respondent stated in the G2 form that “students are not required to know a major source of LDL”, which is a fair comment and will be addressed in future paper editing. Part (b)(i) proved more challenging and many candidates lost marks resulting from the use of vague terms as “double bonds” rather than “carbon to carbon double bond”. Weaker candidates merely copied the structures from the Data Booklet and even strong candidates often failed to correctly refer the position of the carbon to carbon double bonds. In (b)(ii) most candidates stated the meaning of the term essential correctly.

Option C – Chemistry in industry and technology

This was one of the least popular options.

Question 1

In (a) a considerable number of candidates correctly named scrap iron/steel and lime, with less suggesting either Al or Mg. Many candidates were able to state the need of reacting P and Si with oxygen either with descriptions or by means of correct equations. The final removal of the oxides was rarely fully described, with only stronger candidates stating the formation of silicates or phosphates. Some confused the conversion of pig iron into steel using an oxygen converter, with the extraction of iron in the blast furnace. Part (b) was very poorly answered with most candidates providing general explanations of the formation of alloys. Part (c) was answered correctly by the vast majority.

Question 2

Very few correct answers were seen in parts (a) and (b). Answers in part (c) clearly indicated the need for deeper studying of this topic.

Question 3

In (a) most candidates were aware of the differences between HDPE and LDPE, but often failed to fully score as they referred to intermolecular forces in a rather vague, instead of specific, manner. Most candidates found it difficult to draw the structure of atactic poly(propene) in part (b)(i). Most candidates were very familiar with the difference in structure of isotactic and atactic poly(propene), but many failed to fully score as their responses lacked the required specificity for the intermolecular forces.

Option D – Medicines and drugs

This was also a very popular option.

Question 1

Most candidates were very familiar with at least one of the two equations. Some did not read the question carefully and stated the equation for magnesium hydroxide instead of magnesium carbonate. Unfortunately many lost points in (b) as they did not carry through the calculations corresponding to the provided data and some did not realize that a calculation was required. Parts (c) and (d) were mostly correctly answered.

Question 2

Many candidates had difficulty answering part (a) and they often reworded the question rather than providing an answer. Another common mistake was to provide a general, instead of a specific, reply. A good number described sympathomimetic in terms of the action of the drugs on the body, rather than stating that they mimic adrenaline. Parts (b) and (c) were answered well by many candidates. Part (d) was answered quite well by many well-prepared candidates. Some weaker candidates stated ketone in (d)(ii) and others failed to score in part (d)(iii) as they omitted the amine was tertiary.

Question 3

Weaker candidates often seemed to be making up answers, rather than having learnt about the discovery and development of penicillin. Most candidates showed they were familiar with the circumstances that led to the discovery of penicillin and correctly answered part (a). Part (b) showed more shallow answers where the use of subject specific terms was not widely spread. Nonetheless, save for the very weak candidates, most managed to score at least partially. In (c) many candidates gave detailed descriptions of the interference of penicillin in the formation of cell walls, but it was not rare to see this connected with the bursting of the cell or the statement that this led to increased osmotic pressure without taking water into consideration. It was rather uncommon to find answers including β-lactam ring's reactivity. The vast majority of candidates were aware of problems related to bacteria becoming resistant.

Option E – Environmental chemistry

This was one of the less popular options.

Question 1

Part (a) required candidates to describe the production of CO and oxides of nitrogen in the internal combustion engine. Most candidates were able to relate the first one to incomplete combustion and the second to reactions between nitrogen and oxygen. Many candidates failed to fully score as they did not include high temperature for the latter while others presented a reaction between oxygen and carbon instead of a hydrocarbon for the former. Most candidates correctly stated one pollutant gas in part (b) with some candidates not scoring the mark because they did not read the question carefully and stated "particulates" while the question asked for "pollutant gas". Part (c) was answered well by many candidates although there were some very odd suggestions for catalysts, but it was not uncommon to see the wrong oxide of nitrogen (N_2O or NO_2). A significant number of candidates failed to state which direction they were making the change of the fuel/air ratio in (d), so they did not score the marks. When the change of fuel/air ratio was specified then the changes in the amounts of NO_x and CO were understood.

Question 2

Many candidates clearly had an understanding of the connection between irrigation and salinization as well as the consequences of this condition. Only the best candidates could establish a connection between the increasing use of pesticides/fertilizers and its consequences. Nutrients depletion was not very well addressed and many candidates merely reworded the question.

Question 3

Many candidates gave detailed definitions of BOD in (a) even when they failed to fully score as they omitted that the measurement requires a set time period. Weaker candidates defined it as the amount of oxygen needed to support an ecosystem evidencing poor understanding. Some candidates scored well on part (b), but there were many weak responses. Many lost marks as they stated wrong charges for the phosphate ion or wrote incorrect formulae. Part (c) was answered very well by the vast majority of candidates.

Option F – Food chemistry

This was a quite popular option.

Question 1

Most candidates answered part (a) correctly. In (b)(i) even when many candidates were able to relate photo-oxidation to unsaturated structures not as many scored as they failed to state "carbon to carbon" double bond. In (b)(ii) rancidity is the term that most were clearly familiar with. Part (b)(iii) was poorly answered with very few candidates knowing this is a free radical mechanism involving homolytic bond fission. Parts (c) and (d) were only answered well by the strongest candidates. Most did not know the terms "phenol" or "tertiary butyl" in particular, with these terms not being in SL core there is a need to specifically teach them.

Question 2

Most candidates compared structural features of fats and oils, but many failed to score as they missed the required specificity of carbon to carbon double bond in (a). A significant number of candidates compared melting points which was not part of the question and very few were able to state the difference in the length of hydrocarbon chains. Many candidates gave detailed descriptions of the process to score both marks in part (b), but some failed to score the second mark by omitting the need of a catalyst/pressure and/or heat. Many candidates were able to correctly suggest two advantages but failed to correctly state two disadvantages in part (c). Very often marks were lost as result of poor use of subject specific terms.

Question 3

Emulsions keeps on being a topic that deserves closer attention. Vague arguments were presented in parts (a), (b) and (c) with only stronger candidates fully scoring. Part (d) showed that this topic is understood well by many, even when answers were at times poorly structured and therefore difficult to follow.

Option G – Further organic chemistry

This option was attempted by the least number of candidates.

Question 1

While many candidates were able to draw the correct product in part (a) many had difficulty in fully scoring, with some presenting very odd mechanisms. When curly arrows were used to represent the movement of electron pairs, it was not clear where they started from and ended. Part (b)(i) was correctly answered by the vast majority of candidates, but only about half correctly answered (b)(ii).

Question 2

Part (a) resulted in most candidates fully scoring. Mechanisms though, still prove challenging for many even when a relevant amount of candidates were able to draw the correct product. In part (c), while many students were aware of the need of water, it is important for them to realize that an acid is also required for this hydrolysis. Part (d) was answered quite well by many well-prepared candidates.

Question 3

Many candidates had difficulty answering this question. While there is evidence of some familiarity with the inductive effect resulting from the methyl group the phenomenon was often poorly described and its results not properly understood. It was not rare to find answers where the C atom was identified as responsible for this effect. Quite a few candidates stated answers in terms of the definition of bases, but without establishing any clear connection with the inductive effect. This was observed both in parts (a) and (b). Part (c) was poorly answered with very few candidates establishing the relevance of the lack of polarity of the hydrocarbon chain and even less being able to state the formation of an ionic salt in HCl. Part (d) was very poorly answered with only the strongest candidates stating a correct equation.

Recommendations and guidance for the teaching of future candidates

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

- Options should be taught in class as they are an important part of the programme. It is important that the recommended time is devoted to cover the two options thoroughly and in depth (there was evidence that some areas had not been covered by some schools). Students who are left to teach the material themselves generally do not perform well.

- Teachers should stress the importance of correctly writing balanced chemical equations and formulas.

- Candidates must read the questions carefully, ensure they answer exactly what has been asked precisely (vague answers rarely gain the marks) and from the perspective of a chemist, using appropriate terminology and not give superficial or journalistic answers (avoid the use of everyday language but rather use correct scientific terms).

- Candidates should prepare for the examination by practicing past exam questions and carefully studying the markschemes provided.

- Teachers should emphasize the importance of clearly setting out calculations, showing each step, and addressing units and significant figures in the final answer.

- Candidates should practise drawing accurate structures of organic molecules, checking that the valency of each atom is correct, and always include hydrogen atoms in full structural formulas.

- Candidates must use the **latest** Data Booklet during the chemistry course so that they are familiar with what it includes. Some schools are still using old editions of the Data Booklet. The Data Booklet must not only state on the front cover “First examinations 2009” but also within the front cover should state “Revised edition published September 2008”.

- Candidates must be fully familiar with organic reaction mechanisms in Option G and pay special attention to the correct use of curly arrows to represent the movement of electron pairs in mechanisms.

- Candidates must learn the common definitions on the syllabus.

- Use the number of lines and the marks as a guide as to how much to write. Write answers in the boxes provided and if the answer does not fit in the box, indicate that the answer is completed on a continuation sheet. However, the use of continuation sheets should not be encouraged as it can mean longer answers than necessary are provided.

- Candidates that attempt more than the required number of options rarely, if ever, benefit from such strategy.
- Candidates should practise analytical structural determination. This should involve not merely establishing visual differences but also being able to provide the correct name for functional groups as required in the syllabus details.