

CHEMISTRY TZ2

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

Overall grade boundaries

Higher level

| | | | | | | | |
|--------------------|--------|---------|---------|---------|---------|---------|----------|
| Grade: | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Mark range: | 0 - 17 | 18 - 33 | 34 - 46 | 47 - 56 | 57 - 67 | 68 - 78 | 79 - 100 |

Standard level

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|--------------------|--------|---------|---------|---------|---------|---------|----------|
| Grade: | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Mark range: | 0 - 16 | 17 - 32 | 33 - 44 | 45 - 55 | 56 - 67 | 68 - 78 | 79 - 100 |

Higher and standard level internal assessment

Component grade boundaries

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

The range and suitability of the work submitted

It is encouraging that the standard overall has improved since the introduction of the new assessment criteria. The new 0 - 6 scale has provided candidates with greater opportunities to score better marks for the work they have conducted. This has been especially important when the teacher has provided too much information and the candidate has still been able to receive credit for their input. The new scale system is much more in line with the IB philosophy of awarding marks based on what candidates can do rather than what they have failed to do.

The schools appear to have a better understanding of the criteria and which investigations to assess against the criteria. Very few schools are now assessing DCP with purely qualitative investigations or providing candidates with tables to fill in or providing step by step instructions for the calculation phase (DCP Aspect 2) or the conclusion and evaluation phases (CE).

There still seem to be some schools that are providing their candidates with very simplistic tasks. Although the moderation process is designed to support schools, this is not always possible if the task chosen by the teacher does not provide an opportunity for the candidates to fully demonstrate that they can meet the demands of each criterion.

More importantly simplistic tasks often fail to develop the candidates' practical skills and their understanding of the fundamentals of the course.

The vast majority of schools met the minimum requirements for the SL (40 hours) and HL (60 hours) courses recommended. There tended to be a balance of topics covered and logical progression of knowledgs and skills developed. The schools are making greater use of the Online Curriculum Centre (TSM) for ideas. This has led to a greater uniformity of practical work between schools and subsequently a decrease in diversity. It is, however, a real concern that candidates are still being given very narrow design tasks in which almost all cases, prevent candidates from being able to select meaningfully, an independent variable and then designing a focussed research question. The other problem it creates is that most candidates come up with nearly identical methods and subsequently the authenticity of candidate work is often questionable. It is almost certain in some instances that the teacher has had greater input than is declared on the written and verbal instructions provided by the school for moderation.

Although each criterion is only required to be assessed twice, it is encouraged that candidates are provided with a number of opportunities to be assessed against the criteria and then receive appropriate feedback through written comments and c,p,n notation. It was evident from 4/PSOW forms that there are a number of schools which appear to assess the criteria only twice. Although, it is possible that these schools are recording only the best two marks for each of the criteria and are exposing their candidates to more opportunities other than those declared on forms 4/PSOW.

Candidate performance against each criterion

Design

As stated above, most of the design tasks set by the schools were open-ended and provided candidates with the opportunity to select from a good range of independent variables and then formulate a focussed research question.

Aspect 1

Most candidates scored at least a partial for this aspect. The major problem was with the teacher providing the research question or providing a very narrow task.

Aspect 2

Candidates had some difficulty with this aspect. The main issue here was that the candidates did not indicate explicitly how they were going to control or manipulate the variables. If a candidate has identified a variable to be controlled in Aspect 1 then they must indicate how they are going to control that variable (or monitor it if this is not possible to control) for Aspect 2. Candidates often selected temperature as a variable to be controlled in an exothermic reaction for Aspect 1 and then indicated that they would carry out their investigation at room temperature for Aspect 2. This is clearly not controlling nor monitoring the variable selected.

At times it was difficult to determine whether candidates were using the appropriate equipment as they were not including the size of equipment nor the concentration of solutions used. Candidates need to be aware that their methods need to be reproducible.

Aspect 3

There was significant improvement in this aspect with the majority of candidates selecting a range of five for the independent variable or planning to carry out repeats when a trend or pattern was being investigated.

Data Collection and Processing

Candidates tended to score best in this criterion, especially in Aspects 1 and 2. The vast majority of schools provided candidates with tasks that allowed them to demonstrate a range of data collecting and processing skills.

Aspect 1

Most candidates scored well in this aspect. However, there were still a significant number of schools that do not require their candidates to record qualitative data when it is clearly present and quite clearly important to do so. The consistent use of significant figures and uncertainties is something that many schools need to address.

Aspect 2

Most candidates were able to receive some credit for this aspect. The main problem was with candidates who attempted to graph data and then not take it to the next obvious step of calculating some sort of rate or relationship.

Aspect 3

There is no doubt that there has been a real improvement in this aspect. Schools are clearly spending more time on formative tasks to ensure greater success with error propagation and the appropriate use of significant figures. The graphical work has in general improved also.

Conclusion and Evaluation

Many conclusions and evaluations are still superficial and candidates still do not seem to appreciate the importance of their calculated random error and systematic error when comparing their calculated value against a literature value.

Aspect 1

Although most candidates received some credit for this aspect, they still struggled to make a sensible concluding statement and compare their calculated value against a referenced literature value. Many candidates still do not seem to understand the difference between random and systematic error and their significance. However, it was very pleasing to note that the very best candidates were starting to explain and support their results using theory they had learned in class or had researched and referenced. Although this is not mandatory with respect to the requirements of Aspect 1 it is however good practice and provides the candidate with an excellent opportunity to crystallize their understanding.

Aspect 2

Most candidates were able to identify some appropriate errors and weaknesses and therefore gained some credit. However, very few candidates were able to indicate whether the error/weakness that they had identified supported their value calculated and its variance with the literature value. The practicals that determined a trend rather than a numerical value provided a real challenge for candidates with respect to determining errors/weaknesses as very few candidates looked critically at their processed data (normally in the form of a line or curve of best fit).

Aspect 3

A similar number of candidates compared to previous sessions were able to provide meaningful improvements. However, candidates should be encouraged to explain more fully how they are going to carry out their improvements and indicate what sort of impact they will have on the outcome.

Recommendations for the teaching of future candidates

- Candidates should be provided with plenty of formative work so that they fully understand the requirements of each of the aspects of the criteria. Getting candidates to mark work using the criteria often helps them to better understand the requirements.
- Candidates benefit enormously from the use of c,p,n notation and written comments. Written and verbal feedback on a candidates' practical reports provides them with clear guidance on what they need to improve on for next time. The use of self reflection is also a very powerful tool for improvement.
- Teachers are encouraged to select investigations that are in-keeping with the standard of the IB Chemistry syllabus and TSM material.
- It is recommended that use of workbooks or worksheets for internal assessment is discontinued as they generally provide the structure for the collection of data and the steps for data processing.
- It is mandatory that only the work of the individual candidate can be used for the summative assessment against the criteria.
- Teachers are encouraged not to use Design tasks that have methods that are easily obtainable in standard practical manuals and texts for summative processes. If candidates do use a method they have modified from another source it is mandatory they reference it appropriately.
- For Design tasks teachers are encouraged to provide very general questions which potentially have a number of independent variables to select from. This will reduce the chance of collaboration between candidates and therefore ensure authenticity.
- For Aspect 1 of Design the candidates are required to state the relevant variables they are going to control and then explicitly state how they are going to control them for Aspect 2.
- All investigations selected for the assessment of DCP must allow for the opportunity to collect quantitative data, and where relevant qualitative data must also be recorded.
- Teachers are encouraged to set DCP tasks that will generate a graph that will require further processing of the data such as finding a gradient or intercept through extrapolation.
- For Aspect 1, candidates are encouraged to use the number of significant figures for their raw data that are consistent with their uncertainties and vice versa.
- For Aspect 1, candidates must record all relevant qualitative data. The observations noted are often a clue to the identification of errors and weaknesses which can be discussed in CE Aspect 2.

- Candidates are encouraged to record uncertainties in measurements and then to consider their implication on derived numerical quantities in DCP. Candidates are required to carry out error propagation or draw lines/curves of best fit to fulfil Aspect 3 of DCP.
- Candidates must compare their results against a referenced value where appropriate for CE. They are then required to determine the presence and significance of random and systematic error encountered.
- The candidate should identify all potential systematic and random errors through the full analysis of the procedure. The candidate can then list and discuss the errors that could have caused the variance and direction from the literature value and from this, suggest appropriate improvements or modifications.
- Teachers should not use an investigation for the summative assessment of a criterion if it does not allow candidates to meet all the requirements of the aspects of that criterion.
- Teachers should be encouraged to include all marks awarded on form 4/PSOW where the criteria have been assessed summatively.
- Evidence for participation of the Group 4 Project in the moderation sample is no longer a requirement. Entry on form 4/PSOW is now enough evidence.
- The Group 4 Project is the only opportunity for the candidates to be assessed against the Personal Skills criterion. The level awarded by the candidate is required to be recorded on form 4/PSOW against the Group 4 Project entry.
- Teachers are encouraged to implement the changes or modifications recommended by the moderator communicated in the 4IA form.
- Teachers are required to use the current 4/PSOW form or if using their own version, it must have all requirements included. Boxes where the the moderator and senior moderator can enter their marks is also a requirement.
- Teachers are encouraged to consult the Chemistry Subject Guide, the Teachers Support Material and the latest Handbook of Procedures for the Diploma Programme before submitting work for moderation.

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 Aspect 1

- Aspect 1 is really a two part aspect (R.Q. and then Variables). Complete for both parts then gets 2 marks, cp, pp, and p,n would all get 1 mark (a broad band admittedly) and (n,n will get zero).
- If a teacher has supplied the Research Question then this nullifies the first half of the criterion. However, if they have satisfied the second half partially (e.g. by correctly identifying a good number of control variables) then maybe Partial can be awarded overall for Aspect 1.

- If the teacher has specified the independent and control variables then the second half of the aspect is nullified automatically. It could be felt that it has also completely focussed the research question so the final Aspect 1 award could well be Not at All.
- If the teacher has identified just the independent or just a control variable then Partial can still be awarded.
- The teacher is allowed to specify the dependent variable when setting the task.

When not to mark down in Design Aspect 1

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

Design Aspect 2

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

When not to mark down in Design Aspect 2

- Similar (not word for word identical) procedures are given for a narrow task. Comment though on poor suitability of task on 4/IAF form.
- Do not only mark the equipment list. Give credit for equipment clearly identified in a stepwise procedure. Remember we mark the whole report.
- Do not insist on the +/- precision of apparatus to be given in an apparatus list. This has never been specified to teachers and the concept of recording uncertainties is dealt with in DCP.
- Do not downgrade a teacher's mark if something as routine as safety glasses or lab coats are not listed. Some teachers consider it vital to list them each time and some teachers consider them such an integral part of all lab work that they go without saying. Support teacher's stance.

Design Aspect 3

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

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

The material/apparatus

There is no longer a specified aspect to assess the equipment/materials list. If candidates have failed to identify suitable materials to control the variable e.g., 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 (e.g. only identifying two alkanes when looking at affect of alkane chain length on some property) then it would affect the aspect 3 award.

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

Data collection and processing

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

DCP Aspect 1

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

Do not mark down if the teacher has given detailed step by step procedural instructions (this may have been marked down in Design Aspect 3 if it is a Design assessment task. Not in DCP though).

- If a photocopied table is provided with heading and units that is filled in by candidates then the maximum the moderator can give is $n = 0$.
- If the candidate has only recorded quantitative data (e.g. colour changes in titration, observation of soot due to incomplete combustion in calorimetry, residual solid left in a beaker when reaction has excess solid reactant, bubbles being released when a gaseous product is formed are missing) then the moderator gives partial.
- However, do not be overzealous and penalize Aspect 1 every time a candidate does not find qualitative data to record. Sometimes there is no obviously relevant qualitative data to record.
- If a candidate has not recorded uncertainties in any quantitative data then the maximum award is Partial.
- If the data is *repeatedly* to an inconsistent number of decimal places or in disagreement with the stated precision then Complete cannot be awarded. Be sensible and support 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 'p' or 'n' depending on how much other raw data is present.

When not to mark down in DCP Aspect 1

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

DCP Aspect 2

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

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

DCP Aspect 3

- If you cannot easily determine the candidate's method of processing then award Partial at maximum.
- The candidate must report any final quantitatively determined quantity to a number of significant figures that is consistent with the precision of the input data. Failure to do so will reduce the maximum award to partial.
- Do not punish inconsistent significant figures reported in the middle of a stepwise calculation if the final answer(s) is(are) reported appropriately.
- If there is no evidence of errors being propagated through a calculation then award Partial at best. Remember that a best fit line graph is sufficient to meet the requirement for error and uncertainty propagation.

- The error propagation should be correctly followed through to a reasonable extent according to either the TSM's protocol or another accepted protocol. Try to support the teacher if the candidate has made a sincere attempt even if there is a small flaw.

When not to mark down DCP Aspect 3

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

Conclusion & Evaluation

If structured questions are given to prompt candidates through the discussion, conclusion and criticism then, depending on how focussed the teacher's questions are and on the quality of candidates' response the maximum award is *partial* for each aspect the candidate has been guided through. You have to make a judgement based only on the candidate's input.

CE Aspect 1

- This is another multiple Aspect. The conclusion can take many forms depending on the nature of the investigation. It could be a clear restatement of the determined numerical quantity (e.g. the molar mass or activation energy), a statement of the relationship found and so on, such a clear statement earns 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. This is fine.

CE Aspect 2

- Look to see that a candidate has identified the major sources of error. There will always be other possible sources but I do not want to force candidates into overly long lists of trivial points just so that they feel they have covered the options. I am concerned at the number of twenty page reports that we are increasingly seeing from diligent candidates that could have been condensed into a quarter of the length.
- There is no written requirement to state the direction of each error source 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 being 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 CE Aspect 2

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

CE Aspect 3

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

Other Issues**Simplicity**

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

Data logging

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

If you are concerned as to whether the candidates have had sufficient input, feedback to the teacher.

Higher level paper one**Component grade boundaries**

| | | | | | | | |
|--------------------|--------|---------|---------|---------|---------|---------|---------|
| Grade: | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Mark range: | 0 - 10 | 11 - 17 | 18 - 25 | 26 - 28 | 29 - 32 | 33 - 35 | 36 - 40 |

General comments

This paper consisted of 40 questions on the Subject Specific Core (SSC) and was to be completed without a calculator or Data Booklet. Each question had four possible responses, with credit awarded for correct answers and no credit deducted for incorrect answers.

Teachers' impressions of this paper were conveyed by the 19 G2 forms that were returned. In comparison with last year's paper, 75% of respondents considered the paper of a similar standard; 12.5% a little easier and 12.5% a little more difficult. 95% thought the level of difficulty was appropriate and only 5% considered the paper too difficult.

Syllabus coverage was considered either good (63%) or satisfactory (37%). Clarity of wording was also considered either good (47%) or satisfactory (53%). Presentation of the paper was also considered mainly good (90%) with the remainder considering the paper satisfactory.

Overall, this paper appeared to be reasonably accessible and fair based on the G2 statistics.

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

The difficulty index (the percentage of candidates achieving each correct answer) ranged from 97% to 35% and the discrimination index, an indication of the extent to which questions discriminated between high- and low-scoring candidates, ranged from 0.64 to 0.05. (The higher the value, the better the discrimination).

Comments were made on the following questions.

Question 3

As this is a common question, see SLP1 TZ1 Q.4 for comments. For HL, 44% of candidates got this question correct.

Question 4

One respondent claimed this question was difficult without the use of a calculator. However, this question could be worked out by two methods, either by carrying out the calculation $(0.69)(63) + (0.31)(65) = 63.6$ or more simply by looking closely at the four choices and the percentages given which would mean the answer has to be B = 63.6. The question proved no problem for the candidates in fact and 94% got the correct answer. This was the fourth easiest question on the paper.

Question 9

One G2 comment referred to the fact that CO is not a common molecule in the discussion of dative covalent bonds. This is not correct in fact as in the guide in the teacher's note corresponding to AS 4.2.2, CO is explicitly mentioned as one of the key examples of dative covalent bonding.

Question 12

One respondent stated that in this question it would have been better if the question asked explicitly for the molecular shape of XeF_2 . The electron-domain geometry of XeF_2 is trigonal bipyramidal, based on five negative charge centres or five electron domains, but the molecular geometry is actually linear, since the three non-bonding pairs must occupy the equatorial positions in such an arrangement based on a trigonal bipyramidal underlying stereochemistry. In the question, information was given on the bonding and non-bonding pairs based on the Lewis structure, and hence when the question referred to the shape of XeF_2 it was assumed that the molecular geometry was required and not the underlying electron-domain geometry.

Question 13

There were two G2 comments about the heavy use of condensed structural formula in the examination as a whole. In the teacher's notes corresponding to AS 10.1.3, use of the various types of structural formula (full and condensed) is referred to explicitly. Hence, candidates should be prepared for the representation of structures in either of these formats in examination papers.

Question 16

There were also two G2 comments on this question. The correct answer here in fact is A, which has the most negative change in entropy from the choices given. Perhaps the question might have been clearer if the term "most" was put in bold.

However, this did not prove to be a problem for candidates, with 75% getting the correct answer. In actual fact, for the equation $\text{C(s)} + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$, the change in entropy is actually slightly positive.

Question 17

One respondent stated that candidates may not realise that ΔG_f^\ominus of elements are zero, even though they should know based on the syllabus that ΔH_f^\ominus of elements are zero. For this reason, it was agreed to accept two answers, the actual correct answer B, but also D.

Question 26

One respondent expressed concern about working out the pH of pure water in this question without the use of a calculator. This was discussed at GA and it was felt that candidates should be able to work out the correct answer C, $\text{pH} = 7.27$, without difficulty as the calculation is not overly complicated. In fact, 54% of candidates worked out the correct answer.

Question 40

Some respondents stated that this question was ambiguous. However, the dart-board representation of precision and accuracy is a common teaching tool in many text-books on this subject and a similar question was given in the specimen paper. The question itself was not a problem for candidates with 74% getting the correct answer A, i.e. low accuracy and low precision.

Higher level paper two

Component grade boundaries

| | | | | | | | |
|--------------------|--------|---------|---------|---------|---------|---------|---------|
| Grade: | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
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General comments

This paper indicated a very broad range of capabilities as the marks varied a great deal from very low to outstanding. It was a good discriminator between those that knew the subject material and those that had a cursory understanding.

Some candidates struggled with even the most basic concepts, answers lacked precision in terms of wording and explanations were often vague, other candidates demonstrated an excellent depth of understanding of the subject. However, even the best candidates were challenged by some of the newer or harder areas of the course, such as the mechanism of elimination reactions and buffer solutions. Organic chemistry questions continue to pose problems to candidates in schools where little attention is paid to this topic. Generally the paper was found to be accessible with a balance between straight-forward questions and some more challenging parts in each Section B question, with opportunity for candidates to convey their knowledge and understanding of chemistry. However, it was obvious that some candidates had no exposure to writing under examination conditions – their answers included rough, unorganized work without any clear sense of how to write answers to questions.

Candidates must read each question carefully, pay attention to the action verbs and the number of marks allocated to the question and then write their answers accordingly. Calculations must be shown clearly and should be checked for accuracy, significant figures and units where appropriate. Teachers' impressions of the paper were conveyed by the 28 G2 forms from approximately 620 Time Zone 2 schools (4.5% return).

In comparison with last year's paper, 42% felt that it was of a similar standard, 4% felt it was much easier, 8% felt it was a little easier, 38% felt it was a little more difficult while 8% felt it was much more difficult.

An overwhelming 81.5% considered the level of difficulty of the paper to be appropriate, while 3.7% thought it was too easy and 14.8% thought it was too difficult. Clarity of wording was considered good by 48.2% and satisfactory by an equal number of respondents with the rest (3.7%) considering it to be poor. The presentation of the paper was thought to be good by 57.1%, satisfactory by 42.9%.

The examining and grade award team paid particular attention to the comments on syllabus coverage that appeared on the 4.5% G2 forms returned as well as comments on the Online Curriculum Centre. On the G2 form, about a third of the respondents out of 28 considered the syllabus coverage to be poor where the rest thought it was satisfactory or good. Concerns raised were about lack of coverage of kinetics, equilibrium and bonding in the paper. While setting the paper, the examining team was aware that as broad a curriculum coverage as possible should be included but also realised that it is not always possible to cover every single topic. Kinetics had appeared in the previous year and is often asked. This was the only topic that was mostly left out (compensated by a slightly higher coverage in Paper 1; a small part appeared in question 6 on the use of a catalyst in the Haber process which required kinetics and equilibrium arguments).

Bonding was covered through a full question in Section A, question 3 which was about the bonding and structure of period 3 elements (contrary to what some assumed to be a periodicity question). Bonding questions also appeared in questions 4 and 9 where candidates were asked to draw Lewis structures and in question 5 where explanation of higher boiling points based on the type of interparticle forces was required. Question 7 specifically included aspects of equilibrium and acids-bases. Thus, the whole of part (a) was an equilibrium question as was part (b), where buffer chemistry is the focus.

Special effort was made to make the buffer question more accessible by listing the salts involved and informing candidates about which salt produces the acidic ion and which one the conjugate base ion. It then required candidates to write the ionic equation for the buffer and they had to know that an acid is a proton donor and a base a proton acceptor.

Similarly, part (a), question 8 on redox chemistry was made accessible by giving the balanced equation taking place in a voltaic cell. This was not about determining what the two half cells were made up of but, rather, a straight forward part on determining oxidation numbers, deducing the oxidation and reduction half-equations taking place at each electrode, deducing the oxidizing and reducing agents and stating the direction of electron flow between the electrodes, all well within the guide and by and large done well by candidates. It is important to note that whenever equations are asked for, these must be balanced to score points (unless the question specifically asks for it not to be balanced).

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

- Emission spectrum of hydrogen
- Trends in melting points of period 3 elements
- Types of intermolecular forces, bonding and structure
- Convention for determining enthalpy of reaction from bond enthalpies
- Drawing structures clearly to show cis and trans isomers
- Buffer solutions and how these resist change in pH
- Electrolysis of molten and aqueous sodium chloride
- Mechanism of elimination reaction
- Conditions for organic synthesis

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

- Writing correct formulas and balancing simple equations
- Volumetric analysis
- Lewis structures
- Enthalpy change calculations
- Trends in the Periodic Table
- Structures of organic compounds
- Use of curly arrows (some improvement from previous years)

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

Section A

Question 1

Most candidates were able to make a genuine attempt at calculating the amount of HCl given its volume and concentration and obtain the mark. However, a few candidates failed to convert the volume from cm^3 to dm^3 ; those doing the wrong conversion, which interestingly were applying 10^{-2} , were a minority.

Also, the calculation of the amount of excess acid was done correctly; however, some calculated the amount of acid which had reacted rather than the excess asked for. Some candidates gave the formula of the carbonic acid, H_2CO_3 instead of CO_2 and H_2O . A few candidates did not know the formula of calcium carbonate. Most candidates correctly determined the amount and percentage of CaCO_3 in the egg sample; however, some calculated the M_r of CaCO_3 wrongly and very few did the % calculation incorrectly. However, it wasn't rare to find results above 100%, even when these resulted from previous errors and it was disappointing that candidates failed to realize these were unrealistic.

Candidates struggled with the assumption made in arriving at the percentage of CaCO_3 in the eggshell sample with only a small percentage realising that one had to assume that only the CaCO_3 reacted with the acid, nothing else in the sample would react. Some of the incorrect answers were: “it contained no contaminants”, “it is 100% calcium carbonate” or “the eggshell was pure”.

Question 2

Many candidates were unable to draw a neat diagram of the energy levels in a hydrogen atom and relate it to a series of lines in the ultraviolet and visible regions of its emission spectrum. Some showed poor use of convention and lack of knowledge of the notion of a “series”. The concept of convergence though proved to be more solid than in previous sessions. Candidates who drew a good diagram indicated the line corresponding to the first ionization energy of hydrogen.

Candidates in some schools, however, appeared not to have encountered these ideas at all. Common errors were to label the first energy level as $n = 0$ rather than $n = 1$ and to only include one transition for each series. Sometimes the arrows showing the transitions were shown from the bottom up.

While more candidates managed to obtain at least a mark with regard to the first ionization energy of hydrogen, it was less common to find the correct graphical representation of the first IE with diagrams which often were unrelated.

Question 3

This seemed to be a good discriminator of candidates’ knowledge and understanding. There was a general failure to recognize the relationship between different types of bonding with the melting points of period 3 elements. The explanation for the increase in the melting point from Na to Al seemed to be particularly poorly done with much confusion between ionization energy and melting points of metals. Many gave vague explanations or contradictory answers where the reference to intermolecular forces was quite common. References to atoms were plentiful and confusion with covalent bonds more abundant than expected. Not many candidates mentioned the increase in positive charge for the cations from Na to Al. Also, there was little mention of the increase in delocalized electrons from Na to Al.

Trying to explain why S_8 has a higher melting point than P_4 caused many problems for candidates. There was failure to appreciate that both S_8 and P_4 are simple molecular substances with van der Waals’ forces between molecules, not covalent bonding. S_8 being the larger molecule with a higher M_r and greater number of electrons experiences greater van der Waals’ forces. More candidates obtained at least part mark with many correctly identifying Si as forming a giant covalent network. However, argon produced many contradictory answers including “no intermolecular forces between the atoms”.

Question 4

Most candidates gave the correct balanced equation for the reaction between hydrazine and fluorine. A few did not balance it or gave H_2F as the formula for HF. However, the Lewis structures given for hydrazine and N_2 varied quite a bit. The main problems were missing lone pairs on the N atoms, drawing a double or triple bond between the two nitrogen atoms in the hydrazine molecule or drawing a simple or double bond in the nitrogen molecule. There were many correct calculations to determine the enthalpy change for the reaction; however, candidates’ use of the wrong convention is still a concern as is a worrying number of schools used older editions of the Data Booklet with different bond enthalpies.

Most candidates were able to suggest which mixture was a better fuel based on the enthalpy changes. However, many candidates did not say that HF is a weak acid or that HF is toxic, so the reaction with O₂ was more environmentally safe than with F₂. A matter of serious concern is the number of candidates who identified nitrogen as harmful to the environment or a greenhouse gas.

Question 5

Only a handful of candidates gave the correct definition of the term *stereoisomers*. Some stated that these had the same chemical or molecular formula with no reference to structural formula. Stereoisomers are compounds with the same structural formula, but with a different arrangement of the atoms in space. A majority of candidates drew correct formulas of the two geometrical isomers of 1,3-dichlorocyclobutane, but some missed the names of the compounds. Even when the notion of *cis* and *trans* seemed to be generally understood, the poor representation of molecules proved challenging for some where difference between the 2 isomers drawn was not at all clear.

A few candidates did not realise that the compound was cyclobutane and not straight chain butane. Nomenclature also emerged as a hindrance in the correct grasp of the topic with some candidates showing structures that had little resemblance to the names.

A good number of candidates identified the *cis* isomer as having the higher boiling point because it is more polar and experiences stronger dipole-dipole interactions between the molecules. Many candidates failed to provide enough details for the type of intermolecular interaction. A number of candidates incorrectly identified the *trans* as the polar molecule with the higher melting. Quite a few of the weaker candidates used arguments in terms of packing of the molecule and failed to score any mark.

Section B

Question 6 was the most popular choice for candidates. More than 90% of them chose it as the first question to answer. The second most popular was question 8, then 7; question 9 was the least popular.

Question 6

This, the most popular optional question was reasonably well completed although precise explanations were beyond many candidates. Many attempted to explain every property in terms of the stability of filled and half filled energy levels and did not include a discussion of electrostatic forces involved. Most candidates gave the correct answer, atomic number, as the property used to arrange the elements in the periodic table. Generally, the definition of electronegativity was good, but some made the error of saying that it was the attraction of one electron only; others did not specify that it is the ability of an atom to attract a shared electron pair in a covalent bond. The reason for the increase in electronegativity across period 3 was incomplete most of the time.

Not many mentioned the increase in number of protons and decrease of atomic size. However a few candidates correctly said that the shielding was similar.

Reasons why a sodium ion has a smaller radius than a sodium atom solicited incomplete answers. The answer requires the number of shells, electrons and protons of both the ion and the atom. Many candidates correctly said that Na⁺ had the same number of protons but one electron less so the pulling effect on the electrons was greater. Not many candidates gave the electronic structure or number of shells of the two ions, P³⁻ and Si⁴⁺, to explain their difference in ionic radius.

The graphical question on successive ionization energies of sodium was well answered by many. Typically, they explained how the successive ionization energies of sodium are related to its electron configuration from the data given. Most candidates realized that aluminium's outer electron is in the 3p orbital so further from the nucleus and thus easier to ionize than magnesium. Similarly, sulfur has a paired electron in the 3p sub-shell and the repulsion between paired electrons is greater than in phosphorus which has a half filled p sub-shell.

Many candidates did not give sufficient answers to the part on transition elements. Some realised that it was a Lewis acid-base reaction where the electrons are donated by the water molecule to Fe^{3+} . Explanations given for the colour of complex ions continue to be muddled and the language used imprecise. Many wrote of "a split d **orbital**" rather than the d sub-level being split into two sets of orbitals (of different energies). The colour seen was often attributed to electrons emitting those wavelengths in transitions from higher energy to lower energy d orbitals rather than the transmitted visible light being the complementary colour of the one absorbed.

Few complete answers were given about economic significance of the use of a catalyst in the Haber process. A point that was missing often was that because the reaction is exothermic the forward reaction would be favoured (and the yield) if the temperature is lowered, but this would bring about a slower reaction so a catalyst is necessary to reach the equilibrium faster. However, there were misconceptions both in as far as catalysts and energetic is concerned. It was surprising to see the number of candidates who referred to activation energy but used the concept incorrectly. Few candidates established a connection with equilibrium.

Question 7

This was the second least commonly answered question. With the exception of the part on buffer chemistry where very few appreciated what was happening, the question was reasonably well done.

While many candidates gave the correct K_w expression, it was not uncommon to either find the value of the constant or $K_w = K_a \times K_b$ given as the answers. A few included $[\text{H}_2\text{O}]$ in the expression. Candidates recognised that increasing the temperature shifts the equilibrium to the right, but most did not explain why, namely to use up some of the heat supplied.

Candidates generally concluded that formation of more H^+ and OH^- ions gives a higher value of K_w . A significant number of candidates were able to state the effect of increasing temperature on the pH of water (it decreases) but failed to explain why. Some simply incorrectly stated that the pH would not change.

Many candidates gave the wrong formulas for the acid and the conjugate base **ions** of the buffer or offered NaH_2PO_4 and Na_2HPO_4 as the answers. Some candidates gave good answers about the effect of adding a small amount of a strong acid or a strong base, but they could not write correct equations to show these two effects.

Nearly all candidates correctly said that the ammonia solution is a weak base because of partial dissociation and $[\text{OH}^-]$ would be less than 0.1 to give a pH less than 13. The majority of candidates correctly identified the pH around 4 – 6 because it is a titration between a strong acid and a weak base. When writing the equation for the reaction of ammonia and water some candidates did not write the equilibrium sign. The K_b expression was correct in most cases. However, many did not recognise that at the half-equivalence point both the base and the conjugate acid concentrations are equal. The $\text{p}K_b$ and K_b were correctly calculated from the pH of the solution by many candidates. However, most failed to realize that at the half-equivalence point the capacity of the buffer is optimum.

Question 8

This was the second most popular question. The oxidation number of lead in Pb, PbO₂ and PbSO₄ were given correctly by most candidates; however, these were incorrectly given by some as 0, II and IV or as 4⁺ and 2⁺, which are used to denote charges on ions instead or some candidates gave the wrong oxidation state for lead in PbSO₄ with +10 being a favourite. The equation for the reaction at the anode in the voltaic cell was correctly written by many candidates who also obtained the second mark by the use of $\text{Pb}^{4+} + 2\text{e}^- \rightarrow \text{Pb}^{2+}$. The number of candidates providing the more accurate version of the reaction at the cathode, namely: $\text{PbO}_2 + 4\text{H}^+ + 2\text{e}^- \rightarrow \text{Pb}^{2+} + 2\text{H}_2\text{O}$ was substantially lower. The correct direction of flow was provided even by weak candidates with still many recognizing the oxidizing/reducing agents for the reaction in the voltaic cell.

Most candidates were able to place Ag, Cu and Pb in the correct order with the strongest reducing agent first although some equations given were not balanced. However, explanations were sometimes sloppy with statements such as "Pb is the strongest reducing agent because it reduces Cu and Ag" instead of Cu^{2+} and Ag^+ . Most candidates chose the correct oxidizing agent that could oxidize Cl⁻ but not F⁻.

Electrolysis of molten sodium chloride was less well answered with incorrect use of states of matter and a lack of appreciation of their significance. In electrolysis of a concentrated solution of NaCl, many attempted to give explanations in terms of position in the electrochemical series without explaining the significance in terms of oxidising/reducing strength or the concentration of chloride ion. The half-equations taking place were not always correct. Sometimes the electrons were on the wrong side or the electrodes were reversed.

The part on electroplating was well answered although many did not pick up on the fact that, in this question, the anode is inert, leading to incorrect oxidation half-equation for the reaction at the positive anode. This question is an alert for teachers as it shows how easy candidates are taken by surprise by unexpected situations which are intrinsic to Aim 8.

Question 9

This was the least popular question but one in which the more able candidates made a reasonable attempt; however, the weaker candidates struggled. The colour change when bromine water is added to an alkene was well answered by most candidates although some either did not state the colour of bromine or stated that it becomes clear, rather than colourless. Most candidates deduced the correct Lewis structure of chloroethene although some did not include the lone electron pairs on the Cl. The formula of the repeating unit of the polymer poly(chloroethene) was generally done well.

Although the structures of the simple organic compounds were drawn well, many candidates did not score well in describing reaction mechanisms and conditions. Candidates seem unaware of the requirement or unable to write **balanced** organic equations.

A few candidates tried to deduce the mechanism of the conversion of 1-bromopropane into 1-butylamine rather than give the two simpler equations expected. Many candidates failed to mention that the elimination of HBr from bromoethane requires hot alcoholic NaOH or KOH.

The mechanism for the elimination of HBr from bromoethane presented challenges to many candidates and some gave a nucleophilic substitution mechanism instead. The curly arrow coming out from the OH⁻ was sometimes shown originating on H and not from the lone pair on the O. Even though there is a marked improvement from previous sessions the problem of unclear/wrong beginning/ending of curly arrows persists. Very few candidates opted for the E₁ mechanism. The correct structure of ethene was overwhelmingly produced.

In the two stage conversion of but-2-ene to butan-2-one, the structural formulas of the two reagents were well done by most candidates and the first stage was mostly done correctly, but the second stage had sometimes some of the reactants or products missing. Candidates had difficulty identifying the reagents and conditions for the two stage conversion.

Recommendations and guidance for the teaching of future candidates

In addition to the advice about reading the questions carefully, correctly addressing all points and paying attention to mark allocations and action verbs, candidates are advised to bear in mind the following points in this paper:

- Show the working for all calculations so that the chance of obtaining error carried forward (ECF) marks is maximised
- Learn the common definitions on the syllabus
- Consider the units and the appropriate number of significant figures for the final answer in calculations
- Practise writing balanced equations and half equations
- Always label the axes on graphs
- Practise drawing graphs
- Practise deducing Lewis structures

Consider the various steps of the common organic reaction mechanisms, with focus on the positions of curly arrows and reaction conditions. Some attention should be given to elimination reactions here in this context.

Additionally, teachers are strongly advised to use the latest Data Booklet in their teaching and during practice exams, and refer to past examination papers, their mark schemes and Examiner Reports to assist candidates with examination preparation.

Higher level paper three

Component grade boundaries

| | | | | | | | |
|--------------------|-------|--------|---------|---------|---------|---------|---------|
| Grade: | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Mark range: | 0 - 8 | 9 - 16 | 17 - 21 | 22 - 26 | 27 - 31 | 32 - 36 | 37 - 50 |

General comments

This paper identified a very broad range of candidate capabilities. Some candidates struggled with even the most basic concepts and factual knowledge while others demonstrated an excellent depth of understanding of the higher level options. In general candidates did not appear well prepared. There were schools where the candidates seemed unfamiliar with most of the subject material and left many areas of the question paper blank. Answers lacked precision in terms of the wording used and explanations were often vague. Responses to questions lacked chemical detail and particularly for Option D, E and F some responses tended to be journalistic rather than based on chemical facts and principles.

Candidates managed the more guided questions where they had to 'define', 'name' or 'state' but struggled when asked to 'explain' a chemical concept or idea. Candidates could not identify the key point to gain full marks.

The 22 G2 forms that were returned conveyed teachers' impressions of this paper. This number was less than half the number of G2 forms that were submitted last year. The comments received on the G2 forms are considered very important feedback by the IBO and are reviewed thoroughly. Teachers are strongly encouraged to complete the G2 forms in future. In comparison with last year's paper 50% of respondents felt that it was of a similar standard and 32% considered it a little more difficult while 14% and 4% felt the paper was a little easier and much more difficult respectively. This contradicts the overall performance by candidates which was slightly better than last year's. 64% of respondents thought the level of difficulty was appropriate while 29% and 12% thought that it was too difficult and too easy respectively. Syllabus coverage was considered to be good by 20% and satisfactory by 52% and poor by the remainder. Clarity of wording was considered good by 46%, satisfactory by 46% of the respondents and poor by the remainder. The presentation of the paper was considered good by 54% and satisfactory by 42% of the respondents and poor by the remainder.

The most popular options were B and D while options C and F were least popular. From the G2 comments it was felt that Options A and G were harder than the other options and harder than last year.

Candidates' handwriting this year seemed also worse than in the past, making it very difficult to be read by examiners at times. Hand-writing will become even more important once electronic marking comes on board in 2012. Also candidates' spelling of chemical terminology seemed far worse than it has been in previous years.

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

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

Option A

- Use of atomic absorption spectroscopy in quantitative analysis
- Use GLC for detection of drugs (although specified in the syllabus), confusion of GLC with TLC.
- The use of retention time in GLC
- Relating type of chromophore to its UV or Vis absorption

Option B

- Respiration as an example of redox reactions rather than the purely biological concept
- Use of $q = mc\Delta T$

Option C

- Nanotechnology: candidates were able to describe applications rather discuss implications of its use
- Addition polymers and how their properties can be modified

- Explaining the behaviour of specific thermotropic crystals
- Industrial production of sodium chloride via different types of cells

Option D

- Combinatorial and parallel syntheses of drugs

Option E

- The Greenhouse effect
- Specific reactions, e.g. ozone decomposition and PAN formation

Option F

- Chemical differences between saturated and unsaturated fatty acids

Option G

- Grignard reagents
- Accurate representation of reaction mechanisms including the correct use of curly arrows to represent the movement of electrons

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

The areas which seemed well understood by candidates were:

Option A

- Reasons for using analytical techniques
- Explanation of IR absorption by specific molecules

Option B

- The functions of proteins
- Condensation of amino acids and bonds that hold together the different levels of structures of proteins
- Differences between RNA and DNA

Option C

- Definition of nanotechnology
- The advantages and disadvantages of using poly(ethene)

Option D

- Comparison between weak and strong analgesics
- Common depressants and their effects

Option E

- The gases involved in global warming
- The effects of global warming

Option F

- Antioxidants
- Solubility of anthocyanins and carotenoids
- The meaning of shelf life and factors that affect the shelf life of food

Option G

- Factors affecting the acidity of carboxylic acids

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

Option A - Modern Analytical Chemistry**Question 1**

Most candidates were able to state at least one use of analytical techniques. Some candidates referred to NMR in body scanners. This was not accepted. Candidates needed to give reasons for the use of analytical techniques not examples of analytical techniques.

Question 2

Candidates were familiar with the fact that the lamp in atomic absorption spectroscopy needed to emit the wavelength that would be absorbed by the element being investigated. Few candidates knew what happened to the Cu^{2+} ions in the atomizer. The ion needed to be converted to a ground state gaseous **atom**. Many candidates just stated that the sample needed to be turned into a gas. Few candidates referred to the dehydration of the sample.

The need to construct a calibration curve for interpolation of absorbance of the sample to determine the concentration of an unknown was seldom answered. Many candidates did not read the question well and just explained the Beer-Lambert or the general principles of a spectrophotometer.

Question 3

Candidates understood this area well and related IR absorbance to the change in dipole moment as stretching and bending of bonds occur.

Question 4

Candidates struggled with part (a) but did attempt to draw the second chromatograph and often scored at least one mark. Candidates often missed the point that in this hypothetical situation the alcohols would have eluted earlier with the changed condition, giving a smaller retention time.

Details of the stationary phase and mobile phase of the HPLC and GLC were known by many candidates. Candidates confused TLC with GLC in part (d). The syllabus is clear in this area but candidates just did not know the detail required.

Question 5

Candidates recognised that β - carotene consisted of conjugated $\text{C}=\text{C}$ double bonds but often answered, that because of this it absorbed ultraviolet radiation. Few candidates could explain that less energy was required to excite the electrons due to the conjugation.

Option B - Human biochemistry**Question 1**

Most candidates seemed to manage this question to varying degrees. Those candidates that struggled with this question either did not know that $q = mc\Delta T$ or made the following errors: incorrect mass of water, failure to convert to kJ per 100 g, use of incorrect number of significant figures in final answers or making calculation errors due to careless use of their calculators. Candidates should be encouraged to use clear unambiguous mathematical symbols e.g. \times for multiplication and not a dot (\cdot). Also candidates should not use, for example E8 for 10^8 .

Question 2

Most candidates were able to list four major functions of proteins in the human body. Energy storage was not considered as a major function of proteins. Candidates were able to draw the structure of two different tripeptides; however, common errors included candidates not clearly demonstrating the bonding between the relevant atoms. These links should be marked clearly and accurately. Candidates were also familiar with the bonding involved in the primary, secondary and tertiary structure but they struggled to describe and explain the tertiary structure of proteins.

Question 3

Many candidates did not know what is meant by dietary fibre or its importance. This is a clearly articulated assessment statement in the guide. Candidates often used general knowledge concepts resulting in journalistic responses.

Question 4

Many candidates were able to solve this straight forward calculation question. The major errors candidates made included comparing the ratio of the masses provided rather than working out the ratio of the number of moles of linolenic acid to iodine. In this instance candidates were not awarded any marks because they clearly did not understand the concepts involved. Candidates could also calculate the number of carbon-carbon bonds from the formula of linolenic acid.

Question 5

Many candidates didn't read the question correctly and just answered all they knew about respiration, rather than concentrate on the redox and energy yield aspects requested in the question. Candidates should ensure they answer the question directly, including all the necessary chemical terms. The overall equation for aerobic respiration was well known.

Question 6

Most candidates were capable of describing all three differences between RNA and DNA. Candidates must be aware that they should use the names of bases not just what they think is an acceptable symbol such as U or T but rather uracil or thymine.

Option C - Chemistry in industry and technology**Question 1**

Many candidates could not accurately distinguish between physical and chemical techniques in manipulating atoms to form molecules. Also implications were not discussed in part (c) but candidate answers often referred to applications. Candidates need to read questions carefully to address what is required.

Question 2

Responses varied significantly in this polymer question. In some instances candidates were not able to recall the name of the polymer but gave a good description of the process and property effect on the polymer. In these instances candidates were still able to score full marks.

Question 3

This question was very poorly completed by most candidates. Candidates were usually able to name another example of a lyotropic liquid crystal and define thermotropic and lyotropic liquid crystals. However, candidates struggled to give an example of a thermotropic liquid crystal and often confused this with providing an example of the use of thermotropic liquid crystals.

In part (c), even when a thermotropic liquid crystal was mentioned in the previous question, candidates struggled to score in this part because they described the general functioning of liquid crystals which was asked in a previous paper. This was another example where candidates either did not read the question correctly or did not know and just wrote what they knew about.

Question 4

In part (a) many candidates just gave vague references to keeping ions out or separate rather than providing the specific answer that it was only permeable to Na^+ ions. Both parts (b) and (c) were also answered poorly with the exception of Hg loss to the environment which was remembered quite frequently and some references to the increased efficiency of the membrane cell.

Option D - Medicines and Drugs**Question 1**

Most candidates answered this question correctly with the exception of part (c), indicating some confusion.

Question 2

In general, the knowledge about the mechanisms of antiviral drugs activity was incomplete and responses were vague and even journalistic at times. Candidates should use more specific terminology.

Question 3

Mild and strong analgesic mechanisms were in general known by candidates, which was not always the case with the advantages and disadvantage of opiates use. Responses in some instances were vague. Candidates struggled to explain why heroin is a more potent drug than morphine. An explanation based on differences of the polarity of the molecules was expected.

Question 4

Many candidates were able to name three depressants and describe one effect of a moderate dose of depressants on patients.

Question 5

Candidates were not familiar with combinational and parallel chemistry used to build compound libraries. Details of the chemistry were not known and the understanding demonstrated was only superficial. Answers to the role of computers in drug design were better expressed with most candidates managing to score at least one mark in part (b).

Question 6

The structural formula for the second isomer of the anti-cancer drug was often correctly drawn. The type of isomerism displayed was not always correctly identified. Often the stereoisomerism was answered. This was not acceptable because it was too broad as it includes both optical (incorrect answer) and geometrical (the accepted answer).

Option E - Environmental chemistry**Question 1**

Most candidates were able to name at least one greenhouse gas in (a). In part (b) candidates did not describe how the greenhouse gases cause the greenhouse effect despite this type of question being asked many times in past papers. Candidates continue to demonstrate the usual confusion about greenhouse gases reflecting/trapping energy rather than absorbing radiation. The implications of global warming were well known but candidates often did not score marks because they did not relate the implication to food production.

Question 2

Most candidates were able to name a source of each type of radioactive waste but in some instances a radioactive isotope was mentioned. In part (b) the type of radioactive waste that could be disposed by vitrification followed by long-term storage underground and ion-exchange and adsorption on iron(II) hydroxide etc... were often confused.

Question 3

Many candidates could name two alternatives to CFCs and at least one disadvantage of their use. Candidates could not write the relevant equations for the two-step mechanism of ozone decomposition. They clearly just had not learned the equations. In part (d) many candidates recognized the difference of wavelength need as a result of different bonding in ozone and oxygen but struggled to explain it clearly.

Question 4

Few candidates named VOCs and NO_x as responsible for the formation of photochemical smog but most recognised the need for temperature inversion or cities in valleys. Once again the relevant equation was not known. Very few candidates were able to write the equation for the formation of a PAN.

Option F - Food chemistry**Question 1**

Candidates managed this quite well. A common error that candidates made was to confuse shelf life with expiry date of food. Most candidates could clearly describe the factors that can affect the shelf life of food.

Question 2

Very few candidates responded with the required structural differences between saturated and unsaturated fatty acids. Although candidates mentioned the existence of double bonds, they often omitted it saying it was a C=C double bond. A large number of candidates did not read the question carefully and rather than discussing the structural differences of the fatty acids they described the differences in physical properties such as boiling point and melting point. In part (b) candidates stated the need for hydrogen but were not very familiar with the other required conditions of a catalyst and temperature range. Candidates were aware of the advantages of hydrogenated fats and oils.

Question 3

Generally parts (a) and (b) were well answered. Some answers, however, lacked accurate use of terminology. For example, candidates stated that antioxidants prevented instead of delaying oxidation and that synthetic antioxidants were not safe rather than they need regulation to ensure safe use. In part (c) candidates struggled to differentiate between the reducing and chelating agents and often named a synthetic rather than a natural source of each type of antioxidant.

Question 4

Most candidates deduced correctly the solubility of anthocyanins and carotenoids but their explanations were often vague and did not refer to the structure of these molecules.

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

Candidates managed the correct bromopropanes and some converted these into the correct Grignard reagents but most candidates managed the structures in the final section of the flow chart. Part (b) was the best done mechanism on the option. Candidates must take care to accurately draw the position of the curly arrows illustrating the movement of electrons.

Question 2

Candidates managed this question very well. Most candidates realised that the presence of a halogen increased acidity but the explanations tended to be vague. Part (b) and (c) were well answered with the exception of 3-chloropropanoic acid being thought of incorrectly as most acidic.

Question 3

Many candidates gave the correct equation but only the more capable and better prepared candidates were able use equations and curly arrows to represent the alkylation mechanism.

Question 4

Strong candidates could state an equation for the reaction between methylbenzene with ethanoyl chloride in the presence of a Lewis acid but very few candidates had a good understanding of the products formed during this reaction.

Question 5

Most candidates were able to correctly identify the reaction type but often struggled with the structural formula of acetylsalicylic acid.

Recommendations and guidance for the teaching of future candidates

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

Standard level paper one

Component grade boundaries

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

General comments

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

Teachers' impressions of this paper were conveyed by the 12 G2 forms that were returned. In comparison with last year's paper, 70% of respondents considered the paper of a similar standard; the remainder considered the paper slightly easier. 92% thought the level of difficulty was appropriate and only 8% considered the paper too easy.

Syllabus coverage was considered good by 58%, satisfactory by 25% and poor by 17%. Clarity of wording was considered either good (42%) or satisfactory (58%). Presentation of the paper was also considered mainly good (75%) with the remainder considering the paper satisfactory.

Overall, this paper appeared to be reasonably accessible and fair as borne out by the more general G2 comments received.

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

The difficulty index (the percentage of candidates achieving each correct answer) ranged from 96% to 33% and the discrimination index, an indication of the extent to which questions discriminated between high- and low-scoring candidates, ranged from 0.60 to 0.07. (The higher the value, the better the discrimination).

Comments were made on the following questions.

Question 4

A number of respondents felt that this question was off-syllabus. This was discussed at length during GA and it was felt that the question itself is clearly on-syllabus as it relates to AS 1.4.4 which states that candidates should be able to apply Avogadro's law to calculate reacting volumes of gases. In order to apply Avogadro's law candidates should be able to understand the underlying principle of the law itself. The question was asked within the confines of P1 and a formal definition was not asked, such as could be asked in P2, which in such a case then would be deemed off-syllabus.

The correct answer, D, with $V/n = \text{constant}$, was given by 40% of candidates and hence it was felt that the question although tough could be answered with a clear understanding of the nature of Avogadro's law as cited in AS 1.4.4. Some respondents did comment that the law is only valid if P and T are constant, which is a fair comment and it would have been better if for each of the answers A-D that the variables for the other constants had been put in brackets.

In the case of the correct answer D, it was assumed that P and T are constant and hence as D is the best answer of those given it was decided to keep this question, as 40% of candidates gave D as the correct answer.

Question 14

One respondent stated that the terminology covalent macromolecular was unfamiliar. All candidates should be familiar with covalent and an alternative to macromolecular is giant which was given in brackets in the question. The question itself was answered correctly by 60% of candidates.

Question 26

One respondent commented that a full cell representation should have been given in the question so that candidates could ascertain the direction of electron flow. This question is based on AS 9.4.2 which states that candidates should know that reduction takes place at the cathode and oxidation takes place at the anode. In this question, the correct answer is A, corresponding to I. and II., as in I. zinc changes from a +2 oxidation state in $\text{Zn}^{2+}(\text{aq})$ to 0 in $\text{Zn}(\text{s})$, which is reduction and in II. Chlorine changes from a 0 oxidation state in $\text{Cl}_2(\text{g})$ to a -1 oxidation state in $\text{Cl}^{-}(\text{aq})$. III. is ruled out as magnesium is in a 0 oxidation state in $\text{Mg}(\text{s})$ and changes to a +2 oxidation state in $\text{Mg}^{2+}(\text{aq})$ which is oxidation. Hence, it was not necessary to know the direction of electron flow from a representation of the voltaic cell to answer this question. The question was also well answered by candidates with 70% giving A as the correct answer.

Question 29

One G2 comment stated that there was an overlap between this question and a similar question in P2, which is correct.

Standard level paper two

Component grade boundaries

| | | | | | | | |
|--------------------|-------|--------|---------|---------|---------|---------|---------|
| Grade: | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Mark range: | 0 - 6 | 7 - 13 | 14 - 18 | 19 - 24 | 25 - 31 | 32 - 37 | 38 - 50 |

General comments

The range of marks awarded was very wide; the best candidates showed a thorough command of the material and a high level of preparation, although this session there were many candidates who scored poorly in either Section A or in their chosen Section B question.

Generally the paper was found to be accessible with a balance between straight-forward questions and some more challenging parts which allowed candidates to demonstrate an excellent depth of understanding of chemistry. Some candidates struggled however with basic concepts giving answers which lacked precision in wording or vague explanations.

Teachers' impressions of this paper were conveyed by the 26 G2 forms in English and Spanish from approximately 620 Time Zone 2 schools (<5% return). In comparison with last year's paper, 45% thought the paper to be of a similar standard, with the remainder evenly split between considering it more difficult or easier.

85% of the respondents thought the level of difficulty was appropriate and the remaining 15% found it more difficult. 84% felt that the syllabus coverage was good or satisfactory. Clarity of wording was considered good by 46% and satisfactory by an equal number of respondents. Two respondents considered it poor. The presentation of the paper was thought to be good by 56%, satisfactory by 40% with one respondent considering it poor.

Candidate's performance was on average equally balanced between Section A and B. Questions 1 and 4 were answered most successfully in Section A. Question 7, although the least popular, was generally the best answered question in Section B. This is significant as some candidates have the perceptions that organic chemistry is an inaccessible area of the course.

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

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

- Volumetric chemistry specifically back titration calculations.
- Line emission spectrum for hydrogen.
- Bonding, structure and intermolecular forces.
- Lewis structures.
- Deducing redox half equations.
- Reaction conditions and pathways in organic chemistry.

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

Once again there were some excellent scripts seen from some candidates, whose answers indicated detailed knowledge and understanding across the syllabus.

Topics generally well answered included:

- Writing correct formulas and balancing simple equations.
- Treatment of significant figures.
- Calculation of enthalpy changes from average bond enthalpy values.
- Definitions of electronegativity and first ionization energy.
- Explaining trends in electronegativity in the periodic table.
- Determining Equilibrium constant expressions.
- Application of Le Chatelier's principle.
- Drawing structures of organic compounds including the deduction of the repeating units of an addition polymer.

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

Section A

Question 1

Responses to this question were mixed. Many candidates were able to calculate the amount of HCl given its volume and concentration; however some failed to convert the volume from cm^3 to dm^3 . Some calculated the amount of acid which had reacted rather than the excess asked for. A significant number of candidates gave carbonic acid as a product of the reaction and some were not able to write the formula of calcium carbonate. Although candidates correctly determined the amount and percentage of CaCO_3 in the egg sample; many struggled with the assumption made. Only a small number realising that one had to assume that only the CaCO_3 reacted with the acid, nothing else in the sample would react. Some of the incorrect answers were: "it contained no contaminants", "it is 100% calcium carbonate" or "the eggshell was pure". There were a significant number of candidates however who received 0 marks for the whole question. Clearly, as was pointed out in the most recent November 2009 subject report, it appears that many schools are not covering core laboratory areas such as volumetric chemistry.

Question 2

Although this generally proved to be the second most difficult question in Section A there were some excellent diagrams with some even linking a correct energy level diagram with a correct line emission spectrum. Candidates in some schools, however, appeared not to have encountered these ideas at all. Common errors were to label the first energy level as $n = 0$ rather than $n = 1$ and to only include one transition for each series. Sometimes the arrows showed the absorption rather than the required emission transition.

Question 3

This proved to be the most difficult question in Section A. There was a general failure to recognize the relationship between different types of bonding with the melting points of period 3 elements. Many candidates did not appear to understand metallic bonding with much confusion between ionisation energy and melting points of metals. Many gave vague explanations or contradictory answers and there was some confusion of metallic bonding with covalent bonds or intermolecular forces. References to atoms instead of ions were more plentiful than expected with few candidates mentioning the increase in positive charge for the cations from Na to Al. There was also little mention of the increase in delocalized electrons from Na to Al or the decrease in ionic radii. Trying to explain why S_8 has a higher melting point than P_4 caused many problems for candidates. There was a failure to appreciate that both S_8 and P_4 are simple molecular substances with van der Waals' forces between their molecules. Some answers lacked the precision necessary for the marks with many candidates stating that S_8 has a greater mass rather than molar or relative molecular mass. Although the better candidates were able to state that Si has a giant structure some did not mention covalent bonding and a large number of candidates stated incorrectly that there were no intermolecular forces between argon atoms. In summary, intermolecular forces and structure and bonding were poorly understood.

Question 4

This question was generally the best answered of all the questions in Section A. A number of candidates however could not write the formula for HF and strange compounds such as H_2F_4 and H_2F were often cited. In (b) the most common mistakes for the Lewis structures involved double and triple NN bonds in hydrazine or candidates omitting the lone pairs on nitrogen. There were many correct calculations to determine the enthalpy change with ECF applied in cases, when candidates showed their correct working despite giving incorrect equations or Lewis structures in earlier answers. A worrying number of schools used the previous edition of the Data Booklet with different bond enthalpies. Most candidates were able to suggest which mixture was a better fuel based on the enthalpy changes, but few referred to differences in the amounts of gaseous products.

Section B

Question 6 was the most popular choice for candidates. Although question 7 was the least popular it was generally well answered. Performance in question 5 and 6 was approximately the same.

Question 5

Parts (a) and (b) were reasonably well answered. Generally the understanding of electronegativity was good, but some made the error of stating that it was the attraction of one electron only; others did not clarify that it is the ability of an atom to attract a shared electron pair in a covalent bond. The reason for the increase in electronegativity across period 3 was sometimes incomplete with candidates not mentioning both the increase in number of protons and the decrease of atomic size. Although the definition of first ionisation energy was generally well known quite a few candidates only gave one reason for the increase across a period and some referred to the number of electrons in the outer shell as a reason for the general increase. Many candidates did not refer to delocalized electrons when explaining the difference in electrical conductivity between sodium and phosphorus. The oxidation numbers of lead in Pb, PbO_2 and PbSO_4 were given correctly by many candidates; however, incorrect responses included 0, II and IV or as 4^+ and 2^+ .

A common mistake was to give +10 for the oxidation state for lead in lead(IV) sulfate presumably as candidates mistakenly assigned an oxidation number of -2 to sulfur. The half reactions for the lead-acid storage battery proved to be difficult with few being able to deduce the half-equation at the cathode, although $\text{Pb}^{4+} + 2\text{e}^- \rightarrow \text{Pb}^{2+}$ was accepted. The number of candidates providing the more accurate version of the reaction at the cathode, namely: $\text{PbO}_2 + 4\text{H}^+ + 2\text{e}^- \rightarrow \text{Pb}^{2+} + 2\text{H}_2\text{O}$ was very small. In addition, many candidates interchanged the oxidizing and reducing agents. Most candidates were able to place Ag, Cu and Pb in the correct order of reactivity although equations were often unbalanced or included incorrect ionic charges with species such as Ag^{2+} or Cu^+ . Many could not explain the position of metals in the reactivity series clearly with statements such as "Pb is the strongest reducing agent because it reduces Cu and Ag" instead of Cu^{2+} and Ag^+ .

Question 6

This was the most popular question in Section B but responses were mixed. Part (a) was generally well dealt with but some candidates confused K_w with K_c or forgot to include charges on the ions in the equilibrium constant expression. Few received the mark for question (ii) although some mentioned equilibrium which was sufficient.

Candidates recognised that increasing the temperature shifts the equilibrium to the right, but most did not explain why, namely to use up some of the heat supplied. The calculation in (iv) was quite well done although some only gave a qualitative answer. The equilibrium of carbonated drinks was well understood. In part (c) (i) candidates frequently described the shape of the curve instead of offering an explanation using collisions theory. Candidates did state, for example, that the curve flattens but did not refer to consumption of $\text{HCl}(\text{aq})$, the limiting reagent. Only the better candidates were only able to link slope with rate and some still consider the rate to increase after the reaction has started. In (ii) most realised that the curve would be less steep but few drew a curve with the same maximum volume produced at a later time. Even fewer candidates were able to explain why the number of moles of carbon dioxide remained the same. Although some candidates chose mass loss / pH / pressure as the dependant variable in c(iii), some were penalised for imprecise answers such as mass of reactants without referring to mass of flask. Others misunderstood the question and described experiments that they had done with catalysis or described changes with temperature as the dependant variable. (c)(iv) was generally well answered, but again some responses lacked precision; the activation energy is the minimum energy needed for a reaction to occur.

Question 7

Although this was the least popular question it was generally accessible with candidates often scoring high marks. The colour change when bromine water is added to an alkene was well answered by most candidates although some either did not state the colour of bromine or stated that it becomes clear, rather than colourless. Most candidates deduced the correct Lewis structure of chloroethene although some did not include the lone electron pairs on the Cl atom. The formula of the repeating unit of the polymer poly(chloroethene) was generally done well. In (a) (iii), although many got a mark for margarine few received a second mark as their answers did not refer to specific process or chemical. The structural formula of but-2-ene and butanone were well known but (a) (ii) was poorly answered. Many did not specify that concentrated sulfuric acid is needed as the catalyst for the hydration of but-2-ene and the equation for the oxidations of butan-2-ol proved to be beyond most candidates although it is securely on the syllabus and simplified equations using the symbol [O] to represent oxygen supplied by the oxidizing agent are acceptable. (c) was generally well answered.

The most common error in (c) (i) was just giving 'propanol' with no reference to the position of the OH group. The structures of the organic products were well known although the experimental conditions needed to extract the products were less familiar.

Recommendations and guidance for the teaching of future candidates

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

- Have a good knowledge of laboratory based experiments such as of back titrations.
- Practise ion-electron half-equations paying careful attention to balancing and the inclusion of charges and electrons.
- Stress the difference between metallic and covalent bonding and intermolecular forces.
- Show the working for all calculations so that the chance of obtaining error carried forward (ECF) marks is maximised.

- Practise deducing Lewis structures and make sure that all lone pairs are included.
- Better treatment of the link between line emission spectra and electron transitions.
- Pay more attention to reaction conditions in organic chemistry.
- Use mark schemes more to show the level of focus and chemistry language needed.
- Use the latest Data Booklet for all teaching and examinations.

Standard level paper three

Component grade boundaries

| | | | | | | | |
|--------------------|-------|--------|---------|---------|---------|---------|---------|
| Grade: | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Mark range: | 0 - 6 | 7 - 13 | 14 - 17 | 18 - 21 | 22 - 26 | 27 - 30 | 31 - 40 |

General comments

A very wide range of performance was seen - there were some excellent responses and also there were a number of candidates who were insufficiently prepared for the paper. The major problem continues to be that candidates do not consider carefully enough what the question is asking and/or do not answer it in sufficient detail taking into account the number of marks allocated to the question. The answers to questions were often couched in non-specific terms rather than the more precise language one might expect from candidates who have completed a two year course in chemistry. Almost all candidates followed the rubric and answered two options, though the varied choice of options answered by candidates from some schools raised the question of whether they had actually been taught such a wide range of options.

Of the 17 G2 forms received 58% felt that the paper was a similar standard to last year, while the number thinking it slightly easier and slightly more difficult were both 18% with 6% considering it was much easier. The vast majority (82%) of the teachers who responded felt the level of difficulty was appropriate, 13% felt it was too difficult and 5% too easy. For clarity of wording 36% felt it was good, 59% satisfactory and 5% poor.

Finally, for presentation of the paper, 50% considered it to be good, 45% satisfactory and 5% poor. The comments on the syllabus coverage were a little more worrying with only 28% considering it to be good, whilst the number considering it to be satisfactory and poor were both 36% and there were many comments on the G2 forms relating to this. With typically only three or four questions on each option compared to about seven topics in each option it is difficult to ensure comprehensive coverage, though the paper setters try to ensure that over a period of a two to three years all assessment statements are examined and also that a variety of question types are employed. Another comment that appeared on many G2 forms was that many of the questions relied on recall rather than application of knowledge. This could perhaps reflect the fact that many options contain a great deal of factual material and, indeed, candidates generally seem to perform better on questions of this type.

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

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

- Lack of understanding of atomic absorption spectroscopy and its application
- Calculating energy content of food from calorimetric measurements
- The tertiary structure of proteins
- The nature of and importance of dietary fibre
- Nanotechnology techniques
- Iron ores and their reduction in the blast furnace
- Factors affecting the properties of addition polymers
- Identifying and naming functional groups
- The problems of treating viral infections and the functioning of antiviral drugs
- The greenhouse effect
- Equations relating to the ozone layer
- The definition of shelf life
- Fatty acids, their hydrogenation and issues associated with this
- Grignard reagents
- The use of curly arrows to describe mechanisms
- The hydrolysis of chlorinated aliphatic and aromatic compounds

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

This was an accessible paper and the candidates were familiar with the material. Some of the candidates gave very good answers and were obviously well prepared. Most candidates seemed able to complete the paper in the space given.

The areas which seemed well understood were:

- Paper chromatography
- Changes leading to the absorption of infrared radiation
- The formation of peptides
- The bonding in the primary and secondary structures of proteins
- The role of hormones and uses/abuses of steroids
- The difference between lyotropic and thermotropic liquid crystals
- Strong and weak analgesics
- Identifying depressants and being aware of their effects
- Identifying greenhouse gases

- Factors affecting shelf life
- The difference between pigments and dyes
- Deducing the steps of a reaction pathway proceeding via an alkene

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

Option A - Modern analytical chemistry

Question 1

This was generally well answered.

Question 2

Very few candidates seemed to have a good grasp of the essentials of atomic absorption spectroscopy and many seemed to confuse it with UV-VIS spectroscopy. In part (d) only a handful realized the significance of the standard solution, going on to describe how to obtain and use a calibration curve. Many simply explained the technique.

Question 3

This was generally well done with most candidates displaying a good comprehension of the R_f concept. In Part (c) many candidates correctly suggested comparing the R_f value to that of standard samples, but very few pointed out that these must be obtained under identical conditions.

Question 4

Generally well done, though in part (a) many candidates discussed the polarity of the molecule rather than whether the dipole moment would change when it vibrated; indeed many seemed to think that because it was non-polar it could not vibrate! The various bending and stretching modes of the water molecule appeared to be well known.

Option B - Human biochemistry

Question 1

Generally well done, though a number of candidates confused which mass they should be using in the calorimetry, though if they set out their calculation clearly most gained a number of ECF marks. A disappointing number of candidates lost a mark for not giving their final answer to an appropriate number of significant figures.

Question 2

Often quite well done. In part (a), whilst proteins can be used as an energy source, energy storage would not be considered a major function as the body usually stores energy in other forms. In Part (e), few candidates pointed out that the tertiary structure is a folding of the primary and secondary structures that gives the protein its three-dimensional shape.

Question 3

Most candidates managed to explain what dietary fibre was, but explaining its importance was less well attempted. Many candidates knew of the health risks associated with low fibre diets.

Question 4

Generally well done, though a number of candidates appeared a little confused about where hormones were produced and the fact that they are released directly into the bloodstream. In Part (b) a number of candidates failed to point out that many steroid uses and its abuse are associated with muscle development.

Option C - Chemistry in industry and technology**Question 1**

As a relatively new topic, nanotechnology still seems to present a significant challenge to the small proportion of candidates studying Option C and whilst many knew the scale upon which it operated and a few could gain credit for implications, usually related to health concerns, hardly any could distinguish between physical and chemical techniques.

Question 2

Even though the production of iron has been in the course for many years, a large number of candidates failed to gain any marks for this question. It is disappointing how many candidates displayed their inability to balance a simple chemical equation.

Question 3

The way in which the properties of addition polymers depend on their structure and methods for modifying this appeared to be very poorly understood, with only a handful of candidates scoring well on any parts of this question. In Part (b) many candidates discussed the difference between isotactic and atactic polymers rather than the effects of branching.

Question 4

This was probably the best answered question in this option with many candidates being able to state the difference between the two types of liquid crystals, as well as give an example of a substance that can have a lyotropic liquid crystal state.

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

Many candidates were able to identify the differences in the structures of morphine and diamorphine, but in the second part of the question quite a number of candidates gave the formula of the functional groups rather than their names, as required by the question.

Question 2

This was probably the question in this option that candidates found most difficult and whilst many could give correct differences between viruses and bacteria they seemed to have little knowledge about the action of antiviral drugs or the reasons why viral infections are more difficult to treat.

Question 3

Many candidates displayed good knowledge about the differences in the mode of action of weak and strong analgesics, as well as the advantages and disadvantages of the latter.

Question 4

Again very well done with most candidates being able to recall other depressants and describe an effect they have.

Option E - Environmental chemistry**Question 1**

Whilst most candidates could identify greenhouse gases correctly, many were distracted by gases associated with acid rain such as SO_x and NO_x , a disappointingly small percentage could correctly explain how they affected the temperature of the earth with many confusing it with ozone depletion. Many candidates managed to score some marks on the effects of global warming, though often they failed to relate the change they were discussing to food production.

Question 2

This question was generally well answered, though on occasion candidates failed to be specific enough about the sources of nuclear waste. In the second part, many confused the preferred techniques of disposal for high level wastes with long and short half-lives.

Question 3

Only a small proportion of candidates could correctly quote the two equations for the photochemical decomposition of ozone, though many could correctly identify alternatives to CFCs.

Question 4

Many candidates were capable of discussing different types of soil degradation, though on occasion the answers they gave lacked the required precision.

Option F - Food chemistry**Question 1**

Whilst many candidates could successfully discuss factors that affect shelf life, many lost marks in the first part of this question by relating shelf life to food spoilage rather than to consumer expectations.

Question 2

This was generally not well done, with many candidates in the first part failing to note the degree of unsaturation as well as not specifying it was carbon-carbon bonds they were referring to. In Part (b) the conditions for hydrogenation reactions appeared not to be well known, though many candidates gained some marks on the advantages and disadvantages of hydrogenated fats, though the latter often lacked the required precision.

Question 3

This was generally quite well answered, though many candidates lost marks through stating that antioxidants prevented oxidation, rather than merely delaying or slowing it.

Question 4

Almost all candidates could correctly distinguish between a pigment and a dye.

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

Most candidates were aware of the products of the addition reaction and some could correctly draw the mechanism and account for the distribution of products in terms of carbocation stability. A few candidates appeared to have encountered the reactions forming Grignard reagents, but hardly any could give the correct formulas of the products of their reactions.

Question 2

The difference in the ease with which aliphatic and aromatic halides hydrolyse was poorly understood.

Question 3

Many candidates were aware of the reactions involved in this two-stage reaction pathway that proceeded through an unsaturated intermediate and could write equations for them.

Question 4

An encouraging number of candidates could interpret values in the data booklet with regard to the strength of halogenated carboxylic acids, explain these correctly and predict the implications of this.

Recommendations and guidance for the teaching of future candidates

- Candidates need to study each option in depth and ensure they know any definitions involved as well as the equations relating to the processes they study
- Candidates need to read questions carefully ensure they answer exactly what has been asked precisely and from the perspective of a chemist, using appropriate terminology
- Candidates need to take note of the action verb and use this, along with the number of marks assigned, as a guide to the depth of answer required
- Candidates should prepare for the examination by practicing past paper questions and carefully studying the mark schemes provided