Chemistry Time Zone 1

Overall grade boundaries

Higher level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 17	18 - 31	32 - 43	44 - 54	55 - 66	67 - 77	78 - 100

Standard level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 16	17 - 30	31 - 41	42 - 52	53 - 62	63 - 73	74 - 100

Time zone variants of examination papers

To protect the integrity of the examinations, increasing use is being made of time zone variants of examination papers. By using variants of the same examination paper candidates in one part of the world will not always be taking the same examination paper as candidates in other parts of the world. A rigorous process is applied to ensure that the papers are comparable in terms of difficulty and syllabus coverage, and measures are taken to guarantee that the same grading standards are applied to candidates' scripts for the different versions of the examination papers. For the May 2014 examination session the IB has produced time zone variants of Chemistry HL/SL papers.

Higher level and standard level practical work

HL and SL component grade boundaries

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

The range and suitability of the work submitted

As the current internal assessment model nears the end of its cycle, with May and November 2015 being its last assessment sessions, it is probably not surprising that moderators reported that the range and suitability of the work submitted was not greatly different to the previous few sessions. Most schools and teachers have gained significant experience in implementing an appropriate practical scheme of work and generally the work submitted was appropriate to be assessed by the criteria although the quality of the individual students' work was as varied as ever.

There were some trends which seem to be regionalised which maybe is a reflection of different customary practises in host countries. One such area is in the proportion of schools which were submitting Design assessments which were purely theoretical exercises and there had been no follow up experimental phase. A number of moderators commented that there was a significant rise in the number of schools adopting this strategy although one or two described the opposite. This approach to Design is not really best practise and although acceptable for one more year we will then move to an Internal Assessment model where the follow up data gathering phase will be a compulsory element.

Another issue regarding the assessment of Design was that once again a significant minority of schools provided very narrow Design assessment tasks and the students subsequently responded in a very similar manner to each other. This is poor practise that in some cases led to moderators feeling that malpractice had occurred, something which can have very serious consequences for the students involved and should be avoided at all costs.
Most schools submitted investigations that effectively facilitated the assessment of DCP and CE and only minority of schools provided the students with instructions that gave too much support in terms of how to record or process the data. However, a disappointingly small proportion of schools challenged students with tasks that required the determination of a quantity from a graph such as determining an activation energy.

Some schools submitted samples where the same essential skills assessed twice such two DCP/CE assessments on two similar titrations or two similar enthalpy determinations. This is not in the spirit of thorough and fair assessment.
Although most teachers gave feedback using c, p, n or 2,1,0 notation with a good proportion giving at least a few written comments to explain how the marks were awarded in some schools there were still a number of schools who sent in work with no marking evidenced on the report at all. This does not help the moderator support the teacher's grading.

Candidate performance against each criterion

Design

Generally achievement in the first aspect was good with many students were able to secure “complete” for phrasing a research question and identifying relevant variables. However there were several recurring weaknesses identified.

Often the research question did not identify a suitable independent variable that could be fully manipulated. A good general guideline is that when choosing a research question if the independent variable is a readily changeable and numerically quantifiable factor (e.g. mole fraction, concentration, temperature, pressure, ionic radius, molar mass, etc) then it is almost certainly going to be an acceptable research question that will hopefully generate some meaningful graphical analysis. If the only outcome is going to be a comparison of randomly selected brands of household cleaner, type of nut, etc, then it is quite probably going to be below expectation. Similarly surface area is best used as an independent variable if it is actually measured; many students just make the distinction between large, medium and small particle sizes, which makes concluding only a general qualitative trend possible

Another weakness in a significant number of research questions was that the chosen independent variable could not be reasonably expected to have any affect the chosen dependent variable. In particular investigations into voltaic cells generated a number of very weak researches that revealed the often recurring confusion between potential difference and current. Why should salt bridge length or electrode surface area affect the cell potential?

There was often an ambiguity in language in the research question or identified variables with students using the ambiguous term “amount” when they should be specific as to whether they are referring to moles, mass, volume of solution, etc. Another linguistic confusing was in the use of the terms “dissolving” and “reacting” with students discussing the dissolving of magnesium ribbon in acid or similar. Also a number of designs looking at factors affecting the dissolving of salts revealed a confusion between rate of dissolution rather than amount solute dissolved. After comment in previous Subject Reports there was an apparent improvement in the number of students identifying the actual measurable dependant variable rather than the derived quantity such as reaction rate or enthalpy of reaction.

Aspect 2 continued to be the most challenging of the Design aspects and partial was a common award. The two main weaknesses identified in previous Subject Reports continue to be applicable. One is that students failed to identify any procedural methods to control or at least monitor the control variables that they had earlier identified as needing controlling. Unfortunately air conditioners continue to be a popular suggestion for controlling reaction temperature when this is not appropriate.
The second frequent failing for this aspect is that students simply did not include enough detail in their designed method. Not including details on how standard solutions were to be made up, what volumetric glassware is to be used, not stating how to make up a salt bridge in an electrochemical cell or forgetting to think about drying an electrode in an electroplating investigation were the commonest weaknesses. The guiding principle to relate to students is that their design should be communicated in sufficient detail to allow the reader to reproduce their experiment if desired.

Aspect 3 regarding sufficiency of data was often well fulfilled with 5 values of independent variable being planned for with often a suitable number of repeats. There were a small number of examples where students submitted unrealistic designs where method clearly would not work such as where a student required 10 cm solid gold electrodes! Where students had been given chance to follow up with an action phase these unrealistic plans were not apparent of course.

Data collection and processing

Achievement against this criterion was often high and where achievement was low it was often linked to the set or designed task not lending itself to full assessment of DCP. Often students had been over-rewarded for simply determining a simple mean, plotting the raw data on axes with no further quantitative processing (often just presenting the raw data logger output) and increasingly often for presenting an inappropriate bar chart.

Aspect 1 saw the highest fulfilment with most students able to clearly present raw data with uncertainties and relevant qualitative data included.

Aspect 2 also saw a high proportion of good responses where candidates had satisfactorily worked through of numerical calculations or a simple graphical treatment. However there were few insightful contributions where candidates evidenced higher order skills by determining a numerical quantity from a graph or taking account of calorimeter heat capacity in an enthalpy calculation.

Achievement in Aspect 3 was in line with previous sessions with the propagation through a calculation of the uncertainties in the raw data attempted with varying degrees of success by most candidates. Please note that the reward for the successful propagation of uncertainties is confined to DCP Aspect 3 as a discriminator between the partial and complete descriptors. Some teachers were also assessing the success of the uncertainty propagation in Aspect 2 and students were getting penalised twice. Quoting final calculated quantities to a reasonable number of significant figures proved difficult for many candidates. Most candidates who attempted graphical analysis could construct a best fit line should be drawn across the scattered points although we still saw some improper uses of Excel's polynomial trend-line function and even the joining of points with straight segments.

Conclusion and evaluation

Conclusion and Evaluation continues to be the most challenging of the criteria and few candidates achieved the top level across all three aspects.

In Aspect 1 it was common for candidates to compare their results to literature values where appropriate but not many candidates were then able to identify whether the difference indicated the presence of system error or could be explained by random error alone. Although it does really affect the marking under the current criteria only a small proportion of candidates presented any justification of their conclusions in terms of whether it was coherent with accepted theory with most focussing on a simple comparison with reference. This is an area that will have to change when the new Subject Guide comes in to effect.

An issue for teachers is how to assess this aspect when the investigation does not involve the determination of a quantity that can be compared to literature and a percentage error calculated but instead involves the determination of a trend such as is commonly seen for example in many kinetics investigations. In such cases the student should try and describe the nature of trend. For example even a SL student can conclude whether the rate of a reaction increases in direct proportion with concentration of one of the reactants or not. This can then be compared to the literature expectation and the likely impact of systematic or random errors discussed.

For Aspect 2 many candidates identified a good number of relevant procedural limitations or weaknesses. However, only a small proportion of candidates were able to insightfully comment on the direction and relative significance of the sources of error.

Most candidates achieved at least partial in Aspect 3 with some relevant suggestions as to how to improve the investigation although as is usually seen a significant minority were only able to propose superficial or simplistic modifications such as simply suggesting more repetitions to be carried out or for unspecified more precise apparatus to be used.

Manipulative skills and personal skills

All schools entered marks for these criteria.

Application of ICT

Most schools had checked the five ICT requirements at least once on the 4PSOW.

Recommendations for the teaching and guidance of future candidates

- Teachers should set open-ended questions to facilitate the assessment of Design and should strive to ensure that as an outcome there is a diversity of Designs produced.
- Encourage students to choose a research question where the independent variable is a readily changeable and numerically quantifiable factor e.g. mole fraction, concentration, temperature, pressure, ionic radius, etc.
- Teachers should endeavour to give their students the opportunity to carry out the practical phase associated with their Design investigations.
- All investigations for the assessment of DCP must include the recording and processing of quantitative data. Solely qualitative investigations do not give the students opportunity to fulfil this criterion completely.
- All candidates need to record, consider during processing (by propagating through calculations or most simply constructing a best fit line in graphical analysis) and evaluate the

significance of errors and uncertainties.

- Teachers are encouraged to set some DCP tasks, especially to HL students, which will generate a graph that will require further processing of the data such as finding a gradient or intercept through extrapolation.
- Instruction of appropriate use of graphing software especially the construction of best-fit lines would benefit many candidates.
- Candidates should compare their results to literature values when relevant and include the appropriate referencing of the literature source.
- Students should evaluate sources of error as random or systematic and should be able to show an awareness of the direction and significance of the error.
- Suggested modifications should realistically address the identified sources of error.
- The two highest marks per criterion for each student should come from two different types of task. Students should not receive double reward for two very similar designs or data processing tasks or evaluations.
- Teachers should ensure that they act on specific feedback given by the moderator in the 4IAF feedback that is released through IBIS shortly after the results release.
- Teachers should provide feedback to candidates in terms of the separate aspect awards and any further brief comments on the reports explaining the mark awarded is equally useful to the moderator and student.

Higher level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 10	11 - 15	16 - 21	22 - 25	26 - 29	30 - 33	34 - 39

General comments

The number of candidates who answered the paper was 5407. The paper consisted of 40 multiple choice questions of the Subject Specific Core and the Additional Higher Level. The exam was done without calculator or data booklet. Some candidates did not answer every question.

Only 64 teachers gave feedback on the G4 format. The comparison with last year was given as following:

Much easier	A little easier	Of similar standard	A little more difficult	Much more difficult
0	6	40	13	1

As to difficulty and presentation the following answers were given:

	Too easy	Appropriate	Too difficult
Level of difficulty	0	62	2

	Very poor	Poor	Fair	Good	Very good	Excellent
Clarity of wording	0	3	10	21	21	9
Presentation of the paper	0	0	4	17	28	15

Respondents commented that the paper had a mix of fairly hard questions and easy one, having a good spread on all topics. Teachers seemed in general to respond favourable to the paper, a few individual questions were strongly commented though. The distribution of the marks was similar to last year.

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

The difficulty index (percent of candidates responding the correct answer) ranged from 15.46% to 88.42%. The discrimination index (indication of the extent to which questions discriminated between high and low-scoring candidates) ranged from 0.19 and 0.65.

The following comments are made on individual questions:

Question 1
Some teachers were worried about the use of a skeletal formula for the benzene ring. Certainly skeletal formulas are not on the syllabus but the benzene ring is.

Question 2
This appeared to be the hardest question of the paper as it tested the ideal gas law and unit conversion for temperature. Only 15.5 % of the students answered it correctly.

Question 5
Many G2s and OCC forum comments were made by teachers as reference had been made to the Aufbau principle instead of just Hund´s rule. This was however no problem for the students as 88% recognised that options II and III are incorrect electron configurations.

Question 9
Some teachers commented that two answers were acceptable as the difference of electronegativity between W and X and between Y and Z were both small, which could indicate a covalent bond. Although the students did not have access to the data booklet, the values of electronegativity of W and X were much smaller than those for Y and Z, indicating that they were metals. However, in fairness to the candidates it was decided to accept both answers B and D.

Question 19
The initial wording of the question was thought by a few to be complicated, though it was clear that a catalyst had been added (only possible answer here).

Question 21
This question could be answered if students knew that the relationship between K and T is exponential (as stated in A.S. 16.3.1), but it was not necessary that students recalled the Arrhenius equation. Candidates found the question difficult, having only 46% correct answers.

Question 31
Many justified comments were made on this question, as there was indeed an unfortunate mistake in the answer D of the question, where dichromate became chromate. This question was therefore not taken into account and will be corrected for publication.

Question 36
There were concerns that the conditions were not specified in the question, but the only possible answer was A. Many students chose C, as reaction of 2-bromobutane with alcoholic sodium hydroxide can produce both elimination and substitution, but the question was which reaction produces **only** butan-2-ol.

Question 40
This was the second most difficult question of the paper. Many candidates answered C and D, not realizing that, if correct, repeats would then increase the uncertainty.

Standard level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 7	8 - 11	12 - 15	16 - 18	19 - 20	21 - 23	24 - 29

General comments

The number of candidates who answered the paper was 7363. The paper consisted of 30 multiple choice questions of the Subject Specific Core. The exam was done without calculator or data booklet. Some candidates did not answer every question.
Only 65 teachers gave feedback on the G2 forms. The comparison with last year was given as following:

Much easier	A little easier	Of similar standard	A little more difficult	Much more difficult
1	5	44	9	1

As to difficulty and presentation the following answers were given:

	Too easy	Appropriate	Too difficult
Level of difficulty	1	58	6

	Very poor	Poor	Fair	Good	Very good	Excellent
Clarity of wording	0	1	14	23	18	8
Presentation of the paper	0	0	6	28	20	10

Respondents found in general the paper had several hard questions. The unusual chemicals such as dioxins in the questions were perceived as difficult. One comment made by teachers was that it would be helpful that volume units would be given in litres and not in cubic measurements. Though the IB does not object the use of these units in practical work, its international aspect makes it use the SI units. The distribution of the marks was similar to last year.

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

The difficulty index (percent of candidates responding the correct answer) ranged from 25.63% to 86.83%. The discrimination index (indication of the extent to which questions discriminated between high and low-scoring candidates) ranged from 0.12 and 0.57.

The following comments are made on individual questions:

Question 1
Students found this question one of the most difficult ones, with only 28.8% correct answers. Most candidates answered B, as they calculated the amount of molecules of NH_3, not the atoms. Worryingly this type of question is very frequent and the result clearly indicates that candidates do not carefully read the questions.

Question 2
Some teachers were worried about the use of a skeletal formula for the benzene ring. Certainly skeletal formulas are not on the syllabus but the benzene ring is.

Question 9
Some teachers commented that two answers were acceptable as the difference of electronegativity between W and X and between Y and Z were both small, which could indicate a covalent bond. Although the students did not have access to the data booklet, the values of electronegativity of W

and X were much smaller than those for Y and Z, indicating that they were metals. However, in fairness to the candidates it was decided to accept both answers B and D.

Question 18
The initial wording of the question was thought to be complicated, though it was clear that a catalyst had been added (only possible answer here).

Question 24
Many justified comments were made on this question, as there was indeed an unfortunate mistake in the answer D of the question, where dichromate became chromate. This question was therefore not taken into account and will be corrected for publication.

Question 30
This was the second most difficult question of the paper. Most candidates answered C or D, not realizing that, if correct, repeats would then increase the uncertainty.

Higher level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 12	13 - 24	25 - 35	36 - 46	47 - 57	58 - 68	69 - 90

General comments

The following are some statistical data based on 69 respondents.

Comparison with last year's paper

Much easier	A little easier	Similar standard	A little more difficult	Much more difficult
0%	0%	52%	28%	13%

Level of difficulty

Too easy	Appropriate	Too difficult
0%	74%	26%

Suitability of question paper in terms of:

	Very poor	Poor	Fair	Good	Very Good	Excellent
Clarity of wording	0%	3%	17%	39%	29%	12%
Presentation of paper	0%	1%	15%	35%	36%	13%

Candidates, in general found this paper a little more challenging than recent examinations. Most were well prepared, but there were considerably more candidates who obtained a score of less than 10, suggesting that some were less ready to attempt the component, it may be that some centres should review their entry policies with regard to the higher level paper. It is unfair for the candidates to sit an examination where they do not have the opportunity to show what they know, as opposed to what they do not.

Comments from the centres were generally positive, but some respondents questioned the validity of including three cells in series for question 6d. They stated that students would not be familiar with this set up and they would be disconcerted. This falls into the category of application of knowledge to an unfamiliar situation, which is a skill fundamental to Chemistry. Of the six marks available in question 6b, four of them were not dependent on the fact that there were three cells in series; they involved comparison of two cells.

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

- What value to use for mass in $Q=mc\Delta T$
- Calculation of Ea from experimental data
- Construction and balancing symbolic equations
- The nature of particles in ionic and covalent substances
- Commenting on observational changes during a reaction
- Half equations, particularly those involving organic compounds.
- Electrolysis
- Calculation of pH of solutions.
- Mechanisms
- Representing stereoisomers

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

- Calculations involving moles, A_r, entropy, Gibbs free energy and K_c values
- Nature of ligands
- Intermolecular bonding
- Determination of limiting reagents
- Definition and description of the role of buffers

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

Section A

Question 1

The use of 3.01 for the mass in the expression in $Q=mc\Delta T$ was common, candidates were able to score in the subsequent parts and many did so, although there was often a confusion between the value Q and the required answer for ΔH. In part c) most candidates understood the error due to heat loss, but few scored the second mark, usually quoting an answer involving an error generally that was far too vague. The inability to construct a balanced equation was disappointing, many lost credit for giving H_2CO_3 as a product. The score for the structure of the carbonate ion was often lost due to the failure to show that a charge is present on the ion, however, the shape and bond angle were known well, as was delocalisation and hybridisation.

Question 2

The interpretation of orders of rate from experimental data was well understood, and explained. Calculations of both the value and units of K_c were also done well. Very few candidates produced an acceptable equation for the rate determining step, many did not realise the importance of balancing both the number of atoms and charge on both sides. The required careful explanation of how E_a is determined from experimental data was lacking, too often a vague description of using gradient and *R* without context was considered sufficient by many candidates.

Question 3

This question generally scored well. The processes involved in a mass spectrometer were well understood; except for the importance of forming a cation. The calculation of A_r and the requirement to give an answer to two decimal places was performed very well.

Question 4

Conditions for the reaction even though the mark scheme accepted fairly vague answers, were not well known. The calculations of enthalpy, entropy and Gibbs free energy scored well; it was pleasing to note that many realised the importance of conversion of units in part d(v). The link between the changes in temperature and the effect on spontaneity was understood, but many lost credit on part d(ii) for failing to mention the change in the number of gaseous moles. In d(v) most candidates missed the fact that 2 moles of hydrogen were present in the equation.

Section B

Question 5

There appeared to be some significant gaps in knowledge within this question, the various parts either scored very well or not at all.

In a(ii) there was a poor understanding of the nature of bonding in aluminium chloride and aluminium oxide. Candidates are still confusing electrical conductivity in compounds with that in metals, and often refer to the inability to conduct being down to a lack of mobile electrons in compounds.

Balancing equations both, full, as in part a(i) and a(iii), and half equations as in b(ii) showed poor knowledge both of the reactants and products and in the ability to balance them in both atoms and charge. It should be expected that higher level candidates would be comfortable with these processes. The ability to deduce and predict what they would see during a reaction is a skill required of all chemists, it was missing in the attempts to answer b(ii). Parts c) and d(i), ii) and iii) showed good knowledge, but in part d(iv) the understanding of the acid nature of some d block complex ions was lacking. Part e) was rarely given credit, as many appeared to misread the question, and discussed the changes in first ionisation energies across Period 3.

Question 6

Most candidates attempted writing half reactions, but few got them correct in a(i), a(ii), b(ii), c(i) and d(iii). The structure and conditions for the standard hydrogen electrode produced a range of marks, and there was a significant minority who drew two half cells. The importance of the nature of the electrodes was hardly ever explained, if comments about the inert nature of aluminium due to its oxide coating were mentioned they would have been given credit. Once again the inability to describe and then explain the processes happening during the electrolysis of copper sulphate was apparent.

Question 7

The construction and use of equilibrium expressions for K_c showed good understanding. The prediction of the effect of increasing pressure on the position of equilibria by applying Le Chatelier's principle was good, but the fact that K_c remains constant at fixed temperatures was less well known.

pH calculations in c(i), c(ii) and c(v) tended to be very good or completely incorrect.

Question 8

Poorly constructed symbolic equations on what should be relatively simple reactions once again impeded candidates from credit. The use of $pV=nRT$ often scored for error carried forward even when they lost the first mark from incorrect use of units for pressure. The attempts at the S_N2 mechanisms were generally poor, with errors both in the attacking nucleophile, and the sloppy use of curly arrows which indicate that many students have a basic lack of understanding about what they represent. While candidates could score the first two marks, the third mark was almost never awarded. Conditions and reagents in d(ii) and d(iii) were rarely known, and definitions of stereoisomers and the representation of 3D structures was disappointing.

Recommendations and guidance for the teaching of future candidates

- Teachers need to emphasise careful organised working, many candidates lost marks due to carelessness.
- Make greater connections need to be made between practical work and the teaching of theory. There is evidence of a disconnect in Q 1, 4 and 7.
- Greater practice with reaction mechanisms
- Practice pH and buffer calculations.
- Ensure definitions are well known by the candidates.

Students should:

- In explanations students must be very specific and use correct terminology.
- In questions involving properties dependant on intermolecular bonding that they do not imply intramolecular forces.
- Read the questions carefully and understand the action verbs used.
- Be familiar with the general contents of the data book, as it will often enable students to maximise their scores.
- Ensure that they read all the optional questions carefully before attempting them. Although it is not recommended, if they do more than 2 questions in Section B, it may be advantageous not to cross them out, as they will then be marked.

Standard level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 6	7 - 12	13 - 17	18 - 23	24 - 29	30 - 35	36 - 50

General comments

The range of marks awarded was very wide and there were many papers of a very low standard. These candidates often gave the impression that they had never studied chemistry at any level or only studied specific part of the syllabus. On the other hand, some candidates were clearly very well prepared for this examination and scored highly for very good responses which demonstrated their in-depth chemistry knowledge.

Teachers' impressions of the paper were conveyed by the 69 G2 forms that were returned. In comparison with last year's paper, 78.26% considered the level of difficulty of the question paper appropriate, 1.45% too easy and 20.29% too difficult. 50.73% felt that it was of a similar standard, 5.8% thought that it was a little easier, 1.45% felt it was much easier, 27.54% a little more difficult and 5.8% were of the view that the paper was much more difficult. Clarity of wording was considered excellent by 7.25%, very good by 36.23%, good by 30.44%, fair by 23.19%, poor by 1.45% and very poor by 1.45% of respondents. The presentation of the paper was thought to be excellent by 10.15%, very good by 34.78%, good by 34.78%, fair by 13.04% and poor by 7.25%.

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

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

- recognizing suitable experimental techniques for measuring rates of reaction

- calculating enthalpy change from given data
- applying Hess's law
- calculating percentage difference
- drawing Lewis structure of carbonate ion
- defining relative atomic mass
- explaining solubility of compounds in water
- stating observations of changes in common chemical reactions
- writing half-equations
- explaining trends in boiling points
- explaining why a chloride ion has a larger radius than a chlorine atom
- explaining electrical conductivity
- writing and balancing chemical equations
- drawing an S_N2 mechanism

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

Topics generally well answered included:

- mole calculations
- operation of mass spectrometer
- calculations of relative atomic mass
- equilibrium expressions
- effect of SO_3 pollution on environment
- defining oxidation in terms of electron transfer
- deducing oxidation numbers
- drawing a section of a polymer

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

Section A

Question 1

Many candidates could sketch correct curves in (a)(i), though many did not realize that the same final volume of hydrogen is formed. Lines were generally poorly drawn with several lines for one curve, and curve I often did not join smoothly with the given curve, but dropped near the end or overshot the final volume and then fell back down. Candidates are advised to draw graphs in pencil first. In (a)(ii), very few students indicated that because the mass of hydrogen is very small it is better to measure reaction rate using gas volume; most indicated that it is not precise because the mass of a mixture is measured. It seems that very few candidates are aware that measuring loss of mass per unit time is a valid tool for determining the rate of a reaction when CO_2 is produced. The moles of magnesium sulfate were mostly calculated correctly in (b)(i), but in (b)(ii) most candidates had problems calculating the enthalpy change, working with the mass of magnesium sulfate instead of water or solution and not giving the enthalpy change a negative sign. Several candidates only found the temperature change and called this the enthalpy change, or found the energy change and ignored the number of moles. Few candidates correctly applied Hess's law in (c)(i). Some respondents felt that this was not on the SL course, but it is clearly stated in 5.3.1. Some candidates had no idea how to calculate the percentage difference in (c)(ii) and several left this blank despite a value being given for the experimental results for candidates to use if they had not found a value themselves. Quite a few others determined the percentage difference correctly. In (d) most candidates stated heat loss to the surroundings as an error, mentioning further irrelevant errors. Only the better candidates also referred to the partial hydration of the anhydrous salt. The equation for the reaction between sulfuric acid and magnesium carbonate was generally done well in (e)(i) but H_2CO_3 was frequently (incorrectly) given as a product. A few candidates did not know the formulas for sulfuric acid and magnesium carbonate. Very few candidates could give a correct Lewis structure for the carbonate ion in (ii). Some almost scored but failed to include brackets and charge. Some decided that the carbonate ion was a synonym for carbon dioxide and drew that. The formula for the carbonate ion should be known (assessment statement 4.1.7) and only one Lewis structure was required so students did not need to know about resonance structures. Shape and bond angle were also done poorly but there were a few candidates who knew the shape and bond angle of the carbonate ion even though they couldn't draw the Lewis structure.

Question 2

In 2(a) the processes in the spectrometer were generally well described although many candidates did not mention that positive ions are formed. Relative atomic mass was defined poorly in (b)(i) but the atomic mass was generally calculated correctly. Most candidates gave their answers to the required two decimal places. Even though relative atomic mass was asked for, most candidates stated units for A_r.

Question 3

The equilibrium constant expression for the equilibrium between NO_2 and N_2O_4 was well done by most candidates in 3(a) although a few had the expression upside down and several separated the molecules into atoms. Students generally could state and explain the shift in equilibrium position but had more trouble with the effect on the equilibrium constant in both (b)(i) and (b)(ii). It was rare to find a response that stated the changes and explained them for both the equilibrium position and the equilibrium constant. Candidates should take care to answer all parts of the question.

Question 4

The order of solubility of butane, propanal and ethanoic acid in water was generally correctly given in (a), but candidates had trouble explaining it, often just discussing functional groups or polarity, without referring to interactions with water in (b). Many referred to the length of the carbon chain. It was apparent that the concept of solubility was poorly understood. Responses were often not an explanation but merely a repetition of the order stated in (a).

Section B

Question 5

Question 5 was a popular choice in Section B. There were many candidates who stated a correct equation for the reaction of sodium with water, but many gave Na_2O instead of NaOH as a product in (a)(i). Candidates could frequently state one observation of this reaction in (a)(ii) and most candidates correctly predicted relative reaction rates for lithium, sodium and potassium with water in (a)(iii). Question (b)(i) required candidates to predict changes which may be observed when chlorine gas is bubbled through separate solutions of aqueous bromine and potassium bromide. Very few candidates correctly predicted both of the changes observed and there was some confusion between observations and statements of the expected reactions. In (b)(ii) many candidates gave the complete equation between chlorine and bromide ions and not the half-equations as requested. Part (c) referred to the periodicity of boiling points of hydrogen halides. Most candidates referred to the hydrogen bonding between HF molecules as the reason for the high boiling point of HF in (c)(i) although some said that the bond in H-F is a hydrogen bond and so hard to break, indicating a lack of understanding of what is happening on a molecular level when boiling occurs. Many had difficulties explaining the trend of the boiling points of the hydrogen halides, often referring to the elements themselves in (c)(ii). Only the better candidates referred to the strength of van der Waals' forces increasing with increasing electrons or molecular mass. In part (d) very few candidates could explain why the ionic radius of a chloride ion is greater than the atomic radius of a chlorine atom, forgetting the extra repulsion between the electrons. Some answered in terms of the nuclear charge. Many simply stated that non-metal ions are larger than the non-metal atom, suggesting that the command terms are not well understood. Many candidates did not mention that Na_2O has an ionic bond and SO_3 a covalent one in (e)(i) and many candidates also had problems explaining why Na_2O conducts electricity when molten, referring to free moving electrons instead of ions. A surprising number of candidates seemed to think that as Na_2O melts, the sodium reverts to its metallic structure and hence is an electrical conductor. Several others referred to electrons being able to move through the ions which were no longer fixed in position. Several candidates could not state the acid-base nature of Na_2O and SO_3, although many could state their equations with water in (e)(iii). Many candidates correctly identified a source of SO_3 in (e)(iv) and those who did not often had a vague answer such as engine or factory. Most candidates correctly named acid rain as the environmental effect of sulfur trioxide pollution. Some respondents felt that this was beyond the scope of the syllabus but there is clear reference to these effects in 3.3.2 and 8.3.1.

Question 6

This was another popular choice of question in Section B. In part (a) almost all candidates defined oxidation correctly. The oxidation number of chromium was mostly determined correctly in (b)(i), but only the better candidates could write the half-equation for the oxidation of the alcohol C_4H_9OH in (b)(ii), even though the product was identified in the question as C_4H_8O. Subsequently the overall equation of the redox reaction in (b)(iii) was poorly answered. One respondent stated that balanced redox equations are not required. This is stated in 9.2.2. In (b)(iv), candidates who realized the product with molecular formula $C_4H_8O_2$ was an acid, deduced correct formulas of the two primary alcohols, though some did not read the question and gave the formulae for the acid and not the alcohol. Commonly, candidates drew isomers of C_4H_9OH giving one primary structure and one secondary structure. Incorrect structures frequently had oxygen atoms connected to the molecule with single bonds but nothing else attached. Part (v) required candidates to identify the isomer which cannot be oxidized by acidified potassium dichromate solution. Many candidates correctly gave the formula and name of the tertiary alcohol. In (b)(vi) several candidates gave a correct equation for the combustion of alcohols but more usually one mark was scored for correct reactants and products and the mark for correct balancing was missed. Part (c) was on electrolysis. There were several poorly drawn electrolytic cells in (c)(i), sometimes even with the electrodes outside of the electrolyte, but most candidates managed a few marks and many candidates scored full marks. A significant number of candidates drew a voltaic cell with a salt bridge and a small minority had the battery terminals incorrectly connected or drew a voltmeter. The half-equations for electrode reactions were poorly done in (c)(ii) with several candidates again writing whole equations. The reduction of the potassium ion was often given at the anode and the oxidation of the bromide ion was seldom done well with many candidates writing a reduction half-equation for Br_2. In (c)(iii) candidates described poorly how current is conducted in a molten electrolyte. The common response was that electrons are forced through the solution from the cathode to the anode. Many candidates deduced a correct order of reactivity for the metals listed in (d)(i) but the overall equation for the reaction occurring in a voltaic cell made from two of the metals was either done well or was completely wrong in (d)(ii).

Question 7

Question 7 was answered by relatively few candidates, and those who chose this question were usually not well-prepared. In (a) very few candidates indicated that HCl is a strong acid and CH_3COOH a weak one. Many candidates seemed unfamiliar with the distinction between state and outline and simply said that HCl would be a better conductor. In (b)(i) very few candidates could state a correct equation for the reaction between ethanoic acid and sodium hydrogencarbonate, even when the formulas were provided, but most could calculate the limiting reagent in (b)(ii) and the mass of CO_2 produced in (b)(iii). Part (c) gave details of a volatile organic liquid. Most candidates could calculate the moles of gas present in (c)(i), although the conversion to the correct units for pressure and volume gave many problems. The calculation of the molar mass of the gas, especially with ECF applied, was generally done well by the candidates. Part (d) referred to the substitution reaction of bromoethane to form ethanol. Identifying the reagent in (d)(i) for this reaction caused problems, with many stating OH^- as the reagent instead of NaOH or KOH. Only the best candidates could draw the mechanism for this substitution reaction in (d)(ii). Many candidates seemed to have very little idea of how to represent an S_N2 mechanism. Although most candidates identified HBr as the reagent which could produce bromoethane from ethene, they often gave UV as the required condition in (e)(i). Teachers should note that assessment statement 10.6.1 indicates that reagents, conditions and equations should be included for all reaction types listed in the syllabus. Calculation of the enthalpy change using bond enthalpies did not give problems to the good candidates in (e)(ii) but many of the weaker candidates failed to identify all the bonds broken and formed, and only scored the final mark through the application of ECF. Drawing a section of a polymer produced from bromoethene in (e)(iii) presented few problems for most candidates.

Recommendations and guidance for the teaching of future candidates

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

- Learn the common definitions on the syllabus
- Discuss the observations and errors in experiments and evaluate experimental information
- Practise converting units during calculations
- Show clear working in calculations so that ECF marks can be awarded
- Practise writing half-equations
- Practise writing balanced equations
- Practise explanations of chemical phenomena
- Practise drawing reaction mechanisms

Higher level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 7	8 - 14	15 - 19	20 - 24	25 - 30	31 - 35	36 - 50

General comments

There was a greater number of candidates who took HL in TZ1 in May 2014 compared to May 2013, increasing from 5154 to 5781, reflecting 12% growth which is very encouraging to see at HL for TZ1. The percentage of candidates in new schools increased from 6.05% in May 2013 to 8.10% in May 2014.

Candidate performance this session on this particular component in TZ1 appeared to be solid with a number of candidates doing better at the top end compared to May 2013. Overall it was generally felt that the paper holistically across all options was quite accessible with a number of easy marks that could be gained in each option. In each option however there were also a number of more challenging questions and these proved to be excellent discriminators when looking across grade boundaries. Although candidates seemed well prepared there were a noticeably large proportion of candidates who appeared as if they had not studied either any option or at best one option only. These candidates typically chose either Option D on Medicines and Drugs or Option E on Environmental Chemistry but did exceptionally poorly on both as the depth of chemical understanding was lacking by such candidates having not studied the options. This contrasted greatly with candidates who did study these options, especially Option D where the difference in performance was marked.

All options were attempted though fewer candidates chose Options C, F and G. Many of the stronger candidates chose Options A and G. Option A was generally very well answered and there were some excellent answers evident here. Option G in contrast was not done well this session with many candidates struggling with organic reaction mechanisms and providing succinct explanations to key chemical concepts such as the inductive effect, inherent stability of a tertiary carbocation, etc. Option B was very popular but often candidates appeared to answer some of the questions from a biological perspective instead of answering the questions based on chemical principles as stipulated in the questions themselves. **It is imperative that candidates who take options such as B, D and F are fully prepared for the chemical basis of questions and do not overly rely on biological perspectives**. Option C was poorly answered this session but some excellent answers were seen on Option D. Option E tended to be a safe-haven for candidates who had not studied an option in depth and hence many performed dreadfully here resorting to journalistic type answers. In Option F, performance was mixed.

It was quite disappointing to see the number of candidates who struggled with core skills such as deducing ionic formulas, working with units, balancing chemical equations and writing in calculations at HL.

The following is the statistical analysis of the paper based on feedback received from 69 respondents and their associated G2 comments.

Difficulty of the paper

Too easy	Appropriate	Too difficult
0%	89.96%	10.15%

Difficulty of the paper in comparison with May 2013 TZ1

Much easier	A little easier	Of a similar standard	A little more difficult	Much more difficult	NA
0%	4.35%	72.46%	10.15%	5.8%	7.25%

Suitability of the paper in terms of clarity and presentation

	Very poor	Poor	Fair	Good	Very good	Excellent
Clarity of wording	0%	2.9%	10.15%	43.48%	31.88%	11.59%
Presentation	0%	1.45%	10.15%	34.78%	39.13%	14.49%

Teachers in general appeared to be very satisfied with the nature of this paper and several commented on the fact that there was much greater parity across all seven options this session compared to previous years. The paper authors do make every attempt to establish parity across the options so it is encouraging to see this positive feedback from teachers this year in TZ1.

Options D and E in particular were well received. Some commented that Options A and G were challenging and that the syllabus coverage could have been better on Option C, with perhaps a higher proportion of marks allocated to liquid crystals than the number of hours allocated (18% of the total time) on the syllabus. This is a valid point though candidates in the options can expect to be assessed on any part of the syllabus and not all sub-sections will be covered in each option on each examination paper. However in this case the G2 comment is well-founded. Another respondent commented not on the questions themselves in Option B, but on the range of topics covered on the current syllabus in Human Biochemistry and stated that the range of topics is highly limited. In the new IB Chemistry curriculum attempts have been made to address this and Biochemistry has been expanded greatly in terms of the topics covered and also with a greater emphasis on chemical principles compared to the current programme. Another respondent stated that such an important topic such as nanochemistry did not feature this session and the topic is rarely asked on IB papers. The topic has been assessed in previous examinations.

Overall however teachers stated that the majority of questions focused on the assessment statements, with no major surprises on P3.

Two respondents did feel that in some of the text-boxes provided on the paper more space could have been given to candidates. Candidates should not have to use continuation sheets in examinations and typically each question has an ample amount of space for candidates to write their answers. If the amount of space is increased it sometimes gives the impression that longer answers are required than is necessary, based on the number of marks allocated to the individual question.
Lastly, many examiners this session commented on the poor hand-writing of a higher proportion of candidates compared to previous session. In some cases the hand-writing was almost illegible. This is an area which might be highlighted to candidates by teachers also as part of the final examination preparations.

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

Many of the weaker candidates had difficulty setting out and performing calculations, writing chemical equations, showing organic reaction mechanisms and providing coherent suggestions and explanations. In Option B in particular some candidates appeared to be overly relying on biological concepts instead of chemical principles. During this session especially many candidates simply failed to answer what was asked specifically of them in questions (*e.g*. redox processes, state symbols, reaction conditions *etc*.) and teachers need to highlight these points to candidates as part of the preparation of candidates for IB Chemistry examinations. Some candidates still are not prepared for more challenging Objective 3 type questions, especially at HL, where chemical principles are often probed. Such questions are often the hallmark of IB HL Chemistry. Many of these questions typically involve the suggest command term (in many cases, especially in P2 and sometimes in P3, these questions are hypothesis type questions). In several of the options in May 2014 there were questions of this nature (typically 1-2 marks). Candidates need to be totally familiar with the various IB command terms, found on Pages 11 and 12 of the guide.

The following are some of the specific areas of the programme and examination which appeared difficult for candidates this year:

- Descriptions and use of 1H NMR was often vague and poorly understood.
- Knowledge of the fingerprint region of an IR spectrum and associated libraries.
- Colour and crystal field energy splitting.
- Nucleotides and DNA – chemical concepts – structures, hydrogen bonding in particular.
- Redox processes governing aerobic and anaerobic respiration.
- Half-equations in a hydrogen-oxygen fuel cell with an alkaline electrolyte.
- Liquid crystal behaviour – chemical principles associated with this.
- Half-equations for mercury cells.
- Identification of functional groups and difference between class and functional group name.
- Basic formulae of salts.
- Enantiomers, chiral auxiliaries and identification of chiral centres.
- Balancing of chemical equations.
- PANs.
- Solubility product expression.
- Advantages and disadvantages of saturated fats compared to unsaturated fats or oils.
- Additives and shelf life of food.
- Organic reaction mechanisms – in particular use of curly arrows.
- Explanations pertaining to inductive effects and stability of a tertiary carbocation.

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

There were a number of areas where candidates showed a solid understanding of chemical principles this session:

- Empirical formula.
- Analysis of spectra, in particular IR.
- Calculation of R_f.
- Action of drugs.
- Polarity.
- DNA profiling.
- Hydrogen-oxygen fuel cell.
- Toxic nature of mercury.
- Mild and strong analgesics.
- Two-step mechanism of photochemical decomposition of ozone in the Earth's stratosphere.
- Lewis structures and bond order.
- Influence of conjugation on colour.

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

Option A – modern analytical chemistry
A number of the better candidates attempted this Option and performance in general was strong here, with the exception of comprehensive discussion of ^{1}H NMR spectra in Question 2 (b) and part (b) in Question 4 on paper chromatography. It was encouraging to see candidates tackling a real chemistry spectroscopy type question with conviction in Question 3, even though for many candidates and teachers first sight of a question carrying 11 marks on an IB paper might have appeared daunting! The layout of the question however assisted candidates in focussing their answers.

Question 1
Most candidates were able to describe the essential difference between the emission spectrum of sodium and its absorption spectrum. The question related to differences in the spectra rather than the differences between the two processes and candidates should ensure that when answering questions the wording of the question should be carefully considered. Credit was given for a description of the two processes though even here some candidates did not mention electronic transitions. Part (b) was generally well answered though bond was often omitted for bond vibrations. In M4, a common mistake was stating mass spectroscopy instead of visible/UV/AA. Part (c) was very well answered though some candidates stated just concentration without stating the concentration of the element present.

Question 2
The question on empirical formula in (a) posed no difficulty and even the weaker candidates scored the mark. In the spectroscopy question in (b), some of the better candidates managed to score all 11 marks assigned to this extended response type question. In the MS, + was often omitted. Many students could not distinguish between observed ions and lost fragments. Only one candidate mentioned the "fingerprint" region of IR but did not refer to the need to compare with library spectral data. For the IR the majority of candidates scored all three marks, though the weaker candidates frequently suggested NH bonds and CF bonds even though neither nitrogen nor fluorine are part of the empirical formula given in the stem of the question. Discussion of the ^{1}H NMR spectrum proved the most challenging and many candidates did not relate the splitting pattern to the specific carbon fragments. It was disappointing at HL seeing a number of candidates not including hydrogens in their final answer for the structural formula of 2-methylbutan-2-ol.

Question 3
The extinction coefficient in part (a) was calculated correctly, with correct units, by the better candidates. In (b), reference to d orbitals was often ignored and splitting was frequently not mentioned for M1 and M2.

Question 4
Calculation of the two R_f values posed little difficulty though a number of candidates incorrectly included units in their answers. In some cases the R_f values for spot 1 and spot 2 were reversed and hence the mark was not given. On respondent stated that it was odd having the measurements included – it is true that in previous examinations typically students had to measure the distances directly so giving the candidates the distances here certainly made the calculation routine, albeit atypical for this type of question. Part (b) turned out to be almost a dead mark in Option A as virtually no student stated that the two amino acids have the same R_f value which is the exact reason why only two spots are present. In (c) the majority of candidates suggested using a different solvent.

Option B – human biochemistry
This was a popular option and although there were a number of accessible parts, it was surprising how badly many candidates did on the DNA question, particularly in (b) and (c) (i). In addition in Question 8 (a), candidates often failed to answer the question in terms of redox processes and energy release. It suggests that far too many candidates are overly relying on their knowledge of biology as opposed to chemistry when answering these types of questions and teachers need to emphasise the chemical concepts here to students when teaching this option. One respondent also stated that some of the structural representations were difficult. This was discussed at GA and it was felt that this was not the case.

Question 5
(a) (i) was well answered and many candidates also scored full marks in part (ii). In (b) (i), the better candidates identified correctly the named functional groups, namely carboxyl and hydroxyl. Some cited classes, which were allowed in the markscheme. The most common mistakes involved stating glycerol or hydroxide for Y, or reversing the functional groups for X and Y. In (ii), most candidates scored one mark. Often double bonds were stated instead of C=C, and reference to the carbon chain was often omitted. In (c), the majority of candidates knew that fats are less oxidized. In (d), terminology and chemical understanding often tripped up candidates. For example, the omega 6 and omega 3 notations refer to the first C=C to the right of the terminal methyl group. In both linoleic acid and linolenic acid the first C=C is on C9 however. Once more in (d) C=C was required and not just double bonds as both acids also contain C=O from the –COOH group. This however was penalized once only in parts (b) and (d) in Question 5.

Question 6
(a) and (b) were well answered. In (b) (i) the weaker students incorrectly stated rickets. In this question the disease caused by a deficiency of vitamin A in the body was explicitly asked for and not the condition although answers such as dry eyes and night blindness were accepted. (b) (ii) was a hypothesis type question. The better candidates related the explanation to the fat solubility of vitamin A thereby scoring the mark. Weaker candidates skirted around the answer and strange explanations based on micronutrients were common.

Question 7
Parts of this question proved very difficult for candidates, in particular part (b) (most got water however) and (c) (i). In Question 7, only a tiny number of candidates were able to draw a correct structure of the nucleoside. Many students knew how many hydrogen bonds were between adenine and thymine but couldn't draw these bonds and often had no idea what hydrogen bonds were. In (d), most candidates suggested forensic and paternity cases as to possible uses of DNA profiling.

Question 8
In this question, candidates often did not read the question carefully where they were asked to refer explicitly to the processes of oxidation/reduction and energy release. Poor explanations such as glucose broken down, producing 36 ATP, etc. and misconceptions such as glucose reduced to

lactate, etc. were frequently seen. The overall chemical equation in (b) was usually written correctly, though some candidates forgot to balance.

Option C – chemistry in industry and technology

Possibly the least popular option overall but nevertheless a number of schools did prepare candidates for this option and candidate performance was satisfactory. There were two G2 comments on the limited syllabus coverage for this Option, both of which are valid points and have been referred to previously under the General Comments section of this report.

Question 9

(a) was well answered. In (b), many candidates missed the fact that the fuel cell was with an alkaline electrolyte, even though alkaline was marked clearly in bold on the examination paper. Parts (iii), (iv) and (v) were very well answered and many candidates scored all three marks.

Question 10

In (a) most candidates scored one mark. Some did not mention crystals and reference to solids alone was not enough. In (ii), candidates often struggled with the fundamentals of LC behaviour. In many cases inadequate explanations were suggested such as lacking a long chain instead of a long axis etc. (iii), which was a hypothesis type question also proved very challenging and candidates did not link the fact that as there is rotation about the carbon-carbon single bonds in octane the molecules are not rod-shaped. One respondent stated that in Option C there is no reference to liquid-behaviour of ions on the syllabus. In C11 in AS C.11.1, the guide states explicitly that the identification of molecules likely to show LC properties should be known and explanations of LC behaviour on a molecular level. This is based on a clear Objective 3 assessment statement. HL candidates should realise that since LC behaviour is associated with molecules, this automatically rules out an ionic species such as substance I. HL candidates are expected to show this level of chemical understanding in relation to the different types of chemical bonding. This question ultimately became a good discriminator separating the better candidates at the top end from the weaker candidates. Part (b) (i) however was well answered. In (ii), Y again is ruled out since it is ionic. Although there are charges on Z, it is molecular overall as the + charge is on nitrogen and the –ve charge is on oxygen. One G2 comment stated that according to the TN in C.11.1 only biphenyl nitriles will be assessed. This is valid for X. In the case of Z, the question was essentially relating to AS C.6.2 where the TN states that biphenyl nitriles are common examples of substances which display thermotropic LC behaviour. The respondent makes a point that the TN on C.11.1 may also be interpreted for AS C.6.2 and it would have been better if a more appropriate example was chosen for Z. The better candidates however often deduced that Z appears to have the properties of typical LC behaviour and scored the mark. In (c) (i), continuation bonds were frequently omitted and H_2O was often stated incorrectly instead of HCl. In (ii) although some candidates mentioned the hydrogen bonding network in Kevlar® often they did not state that these intermolecular forces are between the C=O and NH groups. (iii) was generally answered correctly.

Question 11

In part (a), state symbols were frequently omitted and few gave the correct half-equation for the negative electrode (cathode). Most mentioned mercury poisoning in part (b).

Option D – medicines and drugs

By far the most popular option on the paper and some very good answers were seen. One respondent suggested that there was little focus on antibiotics and antivirals in Option D. As mentioned previously in this report, candidates must be prepared for Option-based questions which do not necessarily cover all sub-topics in the particular Option – some sub-topics may be assessed in detail and this may vary from session to session depending on the nature of the questions posed.

Question 12

(a) proved to be an easy two marks for most candidates, though some did not refer to the fact that paracetamol blocks transmission specifically *at the source*. In (b), very few candidates scored all three marks. Virtually no candidates mentioned the fact that codeine contains a methoxy group or two ether groups or that there was an additional ether group. Once more many candidates did not answer this question in terms of functional group differences and instead gave class names, which although accepted are technically incorrect. Hydroxide was suggested by many candidates instead of hydroxyl for codeine. In (c), although well answered, some candidates gave imprecise answers such as aspirin is not suitable for children instead of referring to Reye's syndrome. In (e), many candidates stated that aspirin "dilates blood vessels" or "lowers blood pressure" which is incorrect – it reduces the ability of the blood to clot. In (e), the addictive property of codeine was often missed.

Question 13
In part (a) it was hugely disappointing that so many HL candidates could not write correct formulas for magnesium chloride, aluminium chloride or calcium chloride. The better candidates of course scored all three marks here. In (b) (i), some candidates just took one hydroxide into account instead of both. Others managed to score M1 for the two amounts but then struggled with the volumes in M2. One respondent stated that more marks should have been allocated to (b) (i), which is probably a fair point in isolation but this would have increased the net number of marks to five for the two sets of calculations which on balance would appear to be too high for this Option. However a number of candidates did well on the calculations and scored all four marks even though another respondent expressed concern on the amount of math seen in this Option. In the past many teachers have criticised this Option which often can appear to have a largely biological focus and hence in this session, the chemical principles underpinning a lot of Option D served as a response to this earlier concern from some teachers. In (c), the majority of candidates stated the fact that simethicone is an anti-foaming agent or reduces bloating gaining the one mark. Some candidates also expressed their answers in an alternative fashion, namely the simethicone causes small bubbles of gas to form into larger bubbles and be released as flatulence. All three are perfectly valid answers to this question.

Question 14
In (a), enantiomers typically were not referred to and few stated that since drugs can pass from mother to foetus all drugs must be tested for their effect on pregnant women. In (b) (i) most candidates got one chiral centre but surprisingly at HL only the better students got all three. In (b) (ii) although M2 was generally scored, few scored M1 *i.e.* the fact that a chiral auxiliary attaches to a non-chiral molecule. In (iii) few candidates scored both marks. Many stated that doxorubicin can react with an acid but did not mention the fact that it contains an amino group *etc.*

Option E – environmental chemistry
Fewer candidates answered this option compared to previous sessions. Many of the weaker candidates attempted this option, often at their pearl, appearing not to have studied the option at all, based on the poor standard of responses evident. Journalistic type, non-scientific answers were wide-spread. There were some excellent responses however though PANs proved to be the most challenging topic for even grade 7 candidates.
One respondent stated that there was an over-emphasis on memorization in this Option. Even if this is true, this certainly did not help candidates and chemical equations, simple questions such as the advantages and disadvantages of landfill and incineration were incredibly poorly answered. Options C and E often tend to be more descriptive than Options A and G, so this may be a valid comment in general, though hopefully in the new curriculum this point should be addressed to a greater extent, with greater parity across all four options.

Question 15
In (a), there were several truly vague answers. Many candidates simply stated what was already given in the question stem i.e. the fact that methane is produced from landfill. (b) was poorly answered. In (c) (i) most candidates mentioned either swamps or manure which scored one mark. In (ii), many stated carbon dioxide instead of carbon monoxide though most scored full marks here. Some candidates omitted state symbols and some candidates did not balance the equation. In the question it would have been better if pollutant was stated instead of primary pollutant as although in most IB textbooks CO is classified as a primary pollutant, in the context of this question it is actually a secondary pollutant. This did not appear to be an issue at all for candidates, as they zoned in on the *toxic* nature of CO. However, in the MS we were very open to this and accepted other pollutants such as methanal.

Question 16

(a) and (b) were well answered though the weaker students in (b) simply stated that C_2F_6 contains no chlorine – no credit was awarded for this. (c) (i) was generally well done though temperature inversion often was not correctly described. Part (ii) was very poorly answered and most only scored one mark. PANs continue to be a real challenge for candidates and similar to previous examination papers candidate performance here was very poor. In (d) the most common mistake was the sight of two lone pairs instead of one on the central oxygen in ozone. (e) was well done however, though some inconsistency of radical symbols was common.

Question 17

There were two G2 comments on this question stating essentially based on the wording of the stem of the question a precise value of the concentration of copper(II) ions can only be deduced if the concentration of hydroxide ions is in addition known. The comments made are valid. This was discussed at length during standardization and grade award and several scripts were examined to see how candidates handled this question. Nearly every candidate who managed to get the K_{sp} expression correct in (a) took this to read as a saturated solution and calculated $[Cu^{2+}(aq)] = 2.3 \times 10^{-7}$ mol dm^{-3}, which was the original intention of the MS. However, the MS took into account a number of possibilities here – for example if (b) was attempted any solution was accepted where the product of the concentrations of Cu^{2+}(aq) and OH^{-}(aq) matched the K_{sp} value or if it was stated that one value was unknown, as long as candidate got an answer in (a). Hence candidates were not penalized in any way in the marking of this question as all candidates getting a K_{sp} expression did actually score in (b) in a way or another. Overall the problem was typically more one of candidates not even getting started on the K_{sp} expression in part (a) and all sorts of strange, totally incorrect K_{sp} expressions were suggested (e.g. using water instead of hydroxide). The question will be rewritten prior to publication.

Option F – food chemistry

This was not a popular option this session and candidates often struggled with many parts such as Question 18 (e) and all of Question 19.

Question 18

In (a), many candidates were unable to construct a correct structural formula of the triglyceride. Most identified water as the answer to (b). In (c) although many candidates stated that unsaturation was involved few progressed to link this to packing and London forces. Many candidates scored full marks on (d). In (e), some candidates stated that saturated fats "deposit in blood vessels" instead of “increases LDL-cholesterol levels”. Overall (e) was very poorly answered.

Question 19

Candidate performance on this question was possibly the poorest on the paper with virtually no candidate scoring full marks.

Question 20

In (a), there were several excellent answers. In (b), many candidates also scored full marks in part (i) and one mark in part (ii). Inconsistency of radical symbols was common.

Question 21

Most candidates acquired two marks on this question on GM-foods. One G2 comment referred to the fact that in the TN corresponding to the Aim 8 AS F.5.2, only two potential concerns are listed. It should be noted that TNs are for guidance only and the MS facilitated several difference answers in addition to the ones stated in the guide i.e. links to increase allergies and the risk of changing the composition of a balanced diet by altering the natural nutritional quality of foods.

Option G – further organic chemistry

This was not a popular option but many of the better candidates did attempt it and generally did quite well except for Question 25, parts (b) and (c). However the weaker candidates struggled here and were unable to show sufficient correct detail or provide suitable explanations. There was an obvious lack of ability in showing organic reaction mechanisms.

Question 22
(a) (i) was answered correctly. In (ii) the most common mistake was stating nucleophilic substitution instead of nucleophilic addition. In this question the mechanism in part (iii) was poorly done. Many candidates did not take due care with the starting and finishing parts of curly arrows. Few gained full marks in (iv). In (b), many candidates forgot to include water as a product.

Question 23
Both these parts were poorly answered.

Question 24
In (a) it was surprising at HL that many candidates did not state that the lone pair of electrons was on the nitrogen. In (b), only the better candidates mentioned the greater hindrance associated with triethylamine.

Question 25
The mechanism in (a) was poorly drawn. Parts (b) and (c) were incredibly poorly answered and many vague answers such as just activating group were seen without providing further detail. In (c) virtually no student mentioned the inherent stability of the tertiary carbocation.

Recommendations and guidance for the teaching of future candidates

- Options should be covered in class and are an integral part of the teaching programme. It is critical that the recommended time is devoted to cover the two options thoroughly and in depth. Certainly this session there was very clear evidence that some subject areas were not covered by certain schools. Students who are left to learn material independently can struggle with the options.
- It is critical that core chemical principles are brought to the fore in the Options, especially those options which have often a twin biological focus e.g. Options B, D and F. In addition core chemistry should always underpin applied topics.
- Candidates should not use extra continuation sheets.
- Candidates need to fully understand the various command terms and should always look at the associated marks allocations in questions.
- Candidates should prepare for the examination by practising past examination questions and carefully studying the markschemes provided.
- Candidates should be fully au-fait with all the organic reaction mechanisms covered on the syllabus and understand the meaning of curly arrow notation.
- Greater care needs to be adhered to in drawing chemical structures. This session there was a very large number of candidates who either omitted hydrogens or gave incorrect bonding arrangements.
- Candidates should practise writing balanced chemical equations.

Standard level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 5	6 - 11	12 - 15	16 - 19	20 - 22	23 - 26	27 - 40

General comments

There was a large proportion the papers that were of poor quality, indicating that these candidates were poorly prepared for this examination. A surprising number scored only a handful of marks, some even 0. For quite a few candidates the whole examination proved difficult. However, many candidates demonstrated a good understanding of concepts and provided detailed answers with correct use of terminology. The options should be covered in detail during instruction time; 15 teaching hours for each option besides the time spent on related lab activities. Depth and a focus on chemical aspects are expected in the teaching of the options along with applying the concepts covered in the Core curriculum.

Option D was the most popular option among SL candidates this session, followed by options B, E and F. There were only a few candidates who attempted option G; stronger students were able to score well in this option. Option C was the least popular and proved to be challenging for those who did attempt it. There were several straight-forward knowledge based marks to be scored in each option, surprisingly many candidates missed scoring these points; many due to lack of specific support in their answers and some not reading the question carefully. Only a handful of marks were application questions that discriminated at the top end. Candidates generally scored better on Options B and D. The questions focused on the chemical applications in these options. However, the more general questions often missed the markscheme criteria.

Majority of the candidates were able to score part marks for questions involving calculations. Candidates had varying levels of skills when writing chemical equations. Often the products were missing or the equation was incorrectly balanced. Some missed providing the physical states when the question specifically asked for them to be included. Many students were able to balance the equations for the antacid reactions; many had difficulty providing the redox reaction equations. However, many students had a better understanding of the organic reactions. Candidates did not apply the command terms correctly with answers lacking in support for the claims and did not score the point.

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

Surprisingly many of the weaker candidates had difficulty writing equations, balancing equations particularly deducing two-step organic reaction mechanisms and providing coherent suggestions and explanations. In Option F in particular, most candidates appeared to have difficulty writing the structural formula of the triglyceride. Many candidates simply failed to read what was asked in questions (e.g. state symbols, correct significant figures, naming functional groups instead of writing structural formula etc.); most failed to state overcoming limitations of the same spectroscopic techniques for question 4. Teachers should emphasize these points to candidates during the course of their teaching and as part of examination preparation. Most of the options in this session had questions requiring synthesis, typically 1-2 marks. These questions used directive terms listed in the program of study. Candidates were not prepared these types of questions, requiring understanding of chemical principles based on their knowledge of the syllabus.

- Principles of Spectroscopy
- Condensation Reaction of Glycerol and Three Fatty Acids
- Comparing the Structure of Two Essential Fatty Acids
- Explain the Higher Energy Value of Fats Compared to Carbohydrates
- Liquid Crystals
- Hydrogen-Oxygen fuel cell
- Redox equations
- Different ways that Analgesics work
- Describing greenhouse effect
- Ozone depletion
- Compare the various methods for waste disposal
- Ways to prolong shelf life

- Compare aerobic and anaerobic respiration in terms of oxidation/reduction
- Explain the occurrence of colour in naturally occurring pigments
- Genetically modified foods
- Nucleophilic addition reactions
- Explain the relative basicity of amines
- Describing primary and tertiary amines

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

There are several areas of the program the candidates were well prepared for. Many attempted option B,D and E and were able to answer most questions partly correct.

- Mass spectrometry
- Paper chromatography
- Deducing R_f value
- Calculate energy value of food
- Importance of fibre in diet
- Providing examples of saturated/unsaturated fatty acids
- Deduce solubility of vitamins in water
- Effect of vitamin deficiency
- Distinguish between thermotropic and lyotropic liquid crystals
- Modes of actions of analgesics
- Comparing structure of codeine and diamorphine
- Antacids
- Hydrogenation process
- Identification of functional groups
- Addition-elimination reaction of ketone
- Addition hydrogen cyanide to an aldehyde
- Factors affecting shelf life of foods

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

Option A – modern analytical chemistry
Question 1
Students found it difficult to explain clearly the difference between emission and absorption spectra for part (a). Most candidates successful in gaining the mark, described the difference in terms of energy released or absorbed by the electrons. There was lack of understanding however for the difference in the coloured and the dark lines produced by the two spectra. Candidates who described the difference in terms of coloured lines or continuous spectrum had difficulty attaining the mark. Very few students achieved all 4 points for part (b). Most had difficulty completing the information for ^{1}H NMR. Many stated a number for what was measured instead of the atomic/molecular process e.g. chemical shift as opposed to nuclear spin. Candidates were well prepared for answering part (c) often, stating concentration of the element as the answer.

Question 2
Part (a), identification of the ions, was answered well by most candidates. Few missed charge or used incorrect charge on the ions e.g. I^-. For part (b), most scored the point for 29. Prominent peaks values

for bromine isotopes proved to be a little more challenging for the candidates, many gave average values of 109 and 80 as other answers.

Question 3

This question was generally well answered. In part (a) some candidates reversed the answers for the spots and lost the mark. Very few linked the R_f value in part (b) to the two amino acids on same spot; often the reason stated was that one amino acid did not dissolve. Part (c) was well answered. Students demonstrated a good understanding of how the nature of the solvent affects the R_f value.

Question 4

This question proved to be very challenging for most candidates as majority were unable to evaluate the two claims. Candidates appeared to have some general understanding but were often lacking depth in understanding of the two analytical techniques. The answers were often too general and most did not suggest ways to overcome limitations using the same spectroscopic techniques. Limited understanding of the directive term 'evaluate' along with missing the 'same' spectroscopic technique in the question stem, penalized the most students from scoring even part marks.

Option B – human biochemistry

Question 5

Candidates generally used the appropriate equations to solve for the energy value for part (a) however, many included 1.13g with the mass of water and on quite a few occasions, 22.4 dm^3 was used in the question for to calculate energy per gram. Several missed the final mark for not expressing the final value in 2 significant figures. Candidates were not able to apply the rules for addition and subtraction within the mathematical process. Surprisingly defining dietary fibre in part (b) scored poorly. Many omitted reference to plant material or cellulose; there appears to be a general misunderstanding that any food that is not digested is dietary fibre. Most candidates were able to name two health problems for (b)(ii).

Question 6

Almost all students were able to score the point for part (a). Many students lost the mark for part (b)(i) that required deducing the chemical equation for addition of iodine; this was frequently due to additional products such as water or hydrogen included as products. Some made errors in incorrectly adding iodine at the double bond. About half the candidates were able to score one mark for part (b)(ii). For part (c)(i), most were able to answer X correctly; the most frequent answer was fatty acids. A significant number of candidates gave "glycerol" for Y whilst a number of others gave formulas rather than names and were not successful in attaining the second mark. In (c)(ii), candidates rarely mentioned length of chain but were able to score a point for mentioning 'unsaturation' as one of the factors. For part (d) when students compared fats and carbohydrates as number of oxygen atoms present, the question was answered well. Several responses however, were in terms of total number of hydrogen bonds in large fat molecules. Part (e) proved to be the most challenging section of this question. Responses often lacked the necessary detail in terms of carbon-to-carbon double bonds and their specific locations. Most, lost mark for not specifying C=C double bonds. "Both have *cis*-configuration" was never mentioned.

Question 7

Most candidates were able to recognize that the molecule had polar groups present for part (a). Some referred to H bonds within the structure of the vitamin and lost the point. Part (b)(i) was answered well. Almost all students were able to score the point. For part (b)(ii) very few students were able to apply their knowledge in order to answer this question. Candidates were not able to make the connection between fat-soluble vitamin and accumulation in fat cell. Only a small number referred to the fat solubility of vitamin A as the reason for accumulation in the fat cell. Again the answer was often vague stating too much vitamin is harmful.

Question 8

Candidates struggled with this option. The few who attempted this option had difficulties with almost all the questions. For part (a) 'refined' was interpreted as impurities that needed to be removed. The idea of different fractions used as fuels in the crude oil was missed by majority of the candidates. Many did not provide a complete response by comparing crude oil as a fuel and as a feedstock; many only addressed one of these two. Candidates also had difficulty providing examples for crude oil components and feedstock. Students did not score well in this part. Part (b) was also challenging for the students. Most students performed poorly unable to provide examples for feedstock and crude oil fuel fractions. About half the candidates gave thermal cracking as the response for (c)(i), and were not able to score the point. Majority of the candidates gave the correct response for the uses of the products of cracking for (c)(ii).

Question 9

Although most candidates knew the energy conversion for the fuel cell in part (a), majority of the candidates were not able to identify the half reactions in part (b) correctly and scored poorly on (b)(i) and (ii). The function of the polymer membrane was well understood as were the disadvantages of the fuel cell. Most candidates were successful in scoring the mark for parts (b)(iii) and (iv).

Question 10

This proved to be the most challenging question in option C. Candidates were able to identify A as the molecules present in the liquid-crystalline phase but were unable to describe the state for part (a)(i). Majority of the candidates were not able to score more than two marks for part (ii). Most were unable to identify Substance **I** as ionic and substance **II** was often identified as 'yes' but without sound support. For (a)(iii), again students struggled with explicit sound reasoning. Response for (a)(iii) was poor with most stating non-polar as the reason for inability of octane to show liquid-crystalline behavior. Very few candidates were able to identify and explain if molecules will behave as a liquid crystal. Majority of the candidates were unable to score the point. Candidates were able to state the difference between the two liquid crystals in (b)(i) correctly but were not able to apply the information correctly in (b)(ii) to identify which substances shoe thermotropic liquid-crystalline behavior.

Question 11

Majority of the candidates were familiar with the mode of action of mild and strong analgesics in part (a) however, there was some inaccurate use of the terminology. There was some confusion about signal interception and transmitting signals. For example, some candidates talked about prostaglandins released at the source and reducing pain perception in the brain. Most candidates answered the part (b) correctly; a few did not use functional group names but used bonds or diagrams instead. Many candidates missed stating two ether groups and were not able to score the third mark. The majority of candidates stated correct advantages and disadvantages of paracetamol over aspirin in part (b). Part (c) was well answered by the majority of candidates; some gave the only reason as aspirin thins blood and lost the mark; almost all candidates were able to provide one reason for answer to part (d) correctly. Many candidates missed to identify both, codeine as a strong analgesic and addictive, and did not score the mark.

Question 12

Majority of the candidates were able to provide correct balanced equations for part (a) and score the three marks. Many were able to score one mark for completing the calculations in part (b)(i). The most common errors were using the incorrect value for the volume in step 2 or deducing the incorrect amount of HCl reacting. Most candidates performed well on part (b)(ii). For part (c) candidates lost the mark for stating it prevents flatulence.

Question 13

In part (a) most errors occurred because adjacent carbon was also circled. Several candidates lost the mark for including CH_3 in the circle. Almost all answered part (b) correctly. Many candidates had an idea about the different types of amines in part (c); few were able to express it in terms of nitrogen or alkyl groups. Most candidates could not distinguish between the terms primary and tertiary amines correctly. The answers were not specific and lacked clarity. Nitrogen attached to one carbon atom and three carbon atoms was a common response that did not score the point. Alkyl groups were rarely mentioned. About half the candidates gave incorrect structure for phenylethylamine. Often the bonding represented was incorrect or the number of hydrogen atoms was incorrect.

Question 14

Many candidates struggled with this question; they discussed the destruction of ozone instead of the greenhouse effect. Responses indicated poor understanding of the role of UV and IR and the terms trapped and reflected were often used to explain the role of greenhouse gases. Some candidates neglected to properly discuss how the energy (UV) enters the atmosphere through the gases and how the energy (IR) is absorbed from the Earth (not the sun) and re-radiated back to the Earth. Very few candidates scored 3 marks for part (a). Candidates also struggled with identifying other greenhouse gases for part (b). Many listed the gases in the stem that they were directed not to use; many incorrect gases were identified (CO, NO_2, SO_2, SO_3). Majority of the candidates failed to score the two marks. Candidates demonstrated a good understanding of the effects of global warming, scoring the mark for part (c).

Question 15

An important issue that was highlighted in part (a) was that many candidates did not deal correctly with the command term evaluate that requires assessing implications and limitations. Majority of the responses were too general lacking in support. Candidates also provided answers that gave the advantage for one as the disadvantage for the other which cannot receive both marks. Many candidates were able to provide another source for methane production in part (b)(i) correctly. Many candidates gave an incorrect balanced equation and several had incorrect products for part (b)(ii).

Question 16

Candidates performed poorly on this question and were not able to gain the mark for part (a). Many did not apply the terms oxidation and reduction correctly and some did not distinguish between the two terms, only one of the two terms was explained. Some incorrectly stated hydrogen used in anaerobic respiration instead of oxygen being absent. Several also missed reference to organic material. Several candidates were able to perform the calculations, for part (b), correctly; some used incorrect value for I^- moles (2 instead of 4) in part (ii) and did not gain the mark.

Question 17

Most of the candidates were able to score part marks for (a); marks were not gained either due to incorrectly balanced equations or incorrect Step 2 equation. In part (b) comparing C_2F_6 with CFCs was challenging with many not really knowing why C_2F_6 is used. Candidates demonstrated a poor understanding of reactivity and the strength of the fluorine to carbon bond. Many referred to CFCs as having longer lifetime and being more stable. Most candidates were able to score only one mark for this question.

Question 18

Generally candidates struggled with the details of the triglyceride structure; very few were able to gain the mark for part (a). Almost all the candidates were able to state water as the other product and gain the mark in part (b). Candidates often missed the specific details for the answer to part (c); they were able to identify the presence of double bonds or unsaturation but had difficulty expanding and linking the idea to how this changed packing and intermolecular forces. For part (d) many candidates stated hydrogenation as the answer and scored one point but many were not able to state the two reaction conditions correctly. Most responses on advantages and disadvantages of saturated fats, part (e), were too general for example, affects your health. A common statement was ‘better storage/ transport’ as an advantage for saturated fats. Most candidates only scored one or two points for this question.

Question 19

Surprisingly few candidates linked the action of sodium benzoate to microbial growth/activity, often referring to oxidation and prevention of free radicals in part (a)(i). Candidates performed well on part (a)(ii) and part (b).

Question 20

A fair number of candidates were able to identify C as the correct in part (a) but were not able to give a clear explanation; only a few justified C correctly without giving a wrong colour, often orange. Most candidates missed the visible spectrum range and were only able to score one mark. For part (b), almost all candidates were able to score two points.

Question 21
Most candidates scored part marks for this question. They had a general understanding with the most common response being increased risk for allergies; however it is surprising that even the stronger students were not able to articulate concise specific concerns for using GM foods. General statements such as ‘we don't know enough yet about their effect, effect health or other species’ were common responses. Depth of knowledge associated with application of the concept was missing in the answers.

Question 22
Most candidates performed well on parts (a)(i)(ii) and (iii). For part (a)(iii) some candidates are not aware that curly arrows must start from non-bonding pairs; correct direction is not sufficient. Also, candidates often drew the first arrow from the non-bonding pair of electrons on the nitrogen rather than the carbon of the nitrile group and did not score the first mark. Part (iv) was more challenging for many candidates with 2-hydroxypentanoic acid was a frequent response. Many candidates were able to write the correct reaction equation for part (b); however, many lost the mark due to incorrect placement of the double bond or missing water as the product.

Question 23
Strong candidates performed well on this question for both parts (a) and (b), often securing complete marks. Several marks here required more than one component and weaker candidates frequently did not have both parts of the answer for the mark. For part (b) many students confused the reaction mechanism with oxidation with acidified potassium dichromate solution and did not score any mark.

Question 24
Majority of the candidates scored the mark for part (a). Lack of reference to N and lone pairs in part (b) penalized many candidates in scoring the mark. Most candidates were unable to explain the stronger basic properties diethylamine in part (c). Responses indicated weak understanding of the inductive effect of the alkyl groups. Many candidates did not address it the increased inductive effect due to two alkyl groups.

Recommendations and guidance for the teaching of future candidates

- Pay attention to command terms; students should become familiar with what is required for each command term. Provide practice in applying command terms during class work.
- Candidates should give specific details and avoid general answers. For example, instead of writing “no water pollution”, students should expand the answer by stating source of underground water and soil pollution due to leaching of toxic chemicals. Another example is explicitly stating C=C or carbon-to-carbon double bond instead of just double bond.
- Candidates need to answer completely, constructed a well-sequenced response that goes all the way to the idea that needs explaining or describing.
- Candidates should practice writing organic reactions with drawing structural formula to avoid making bond connectivity errors. They should pay attention to the fact that curly arrows show transfers of electron pairs.
- Teachers should emphasize to the students that writing more than one answer for the same question often negates the correct response if it is followed by an incorrect response.
- The rules for significant figure should be made more explicit, with ample practice provided to the students to apply the guidelines correctly.
- Candidates must read the questions carefully for example question four required addressing limitations using the same instrument. Candidates selected different instruments in their answers.
- Candidates should be provided with opportunities to practice previous examination papers and mark schemes to enhance their understanding of meeting all the required points in the markscheme.
- Provide practice for writing organic reaction mechanisms with emphasis on curly arrows shown correctly. Students should be informed that missing hydrogen atoms is penalized when writing structural formula.