Chemistry HL & SL

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Grade boundaries

Higher level overall

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 16	17 - 29	30 - 42	43 - 53	54 - 65	66 - 76	77 - 100

Standard level overall

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 14	15 - 26	27 - 40	41 - 52	53 - 61	62 - 73	74 - 100

Higher level internal assessment

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 3	4 - 6	7 - 10	11 - 13	14 - 16	17 - 19	20 - 24

Standard level internal assessment

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 3	4 - 6	7 - 10	11 - 13	14 - 16	17 - 19	20 - 24

Higher level paper one

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 10	11 - 14	15 - 18	19 - 23	24 - 28	29 - 33	34 - 40

Standard level paper one

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 7	8 - 10	11 - 14	15 - 17	18 - 19	20 - 22	23 - 30

Higher level paper two

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 12	13 - 25	26 - 37	38 - 47	48 - 57	58 - 67	68 - 95

Standard level paper two

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 6	7 - 12	13 - 19	20 - 25	26 - 30	31 - 36	37 - 50

Higher level paper three

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 7	8 - 15	16 - 20	21 - 25	26 - 30	31 - 35	36 - 45

Standard level paper three

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 4	5 - 9	10 - 13	14 - 17	18 - 20	21 - 24	25 - 35

Higher level and standard level internal assessment

The range and suitability of the work submitted

The range of work in terms of suitability for the assessment by the IA criteria was as usual varied although in the English-speaking section feedback to schools seems to have been effective and very few schools presented work that was inappropriate. In Spanish there has been some improvement over previous sessions but some schools continue to present investigations below expected level and at times unsuitable to mark according to criteria. Many teachers delivering the course in English provided plentiful comments and annotations that assisted the moderators. However this was far less common in the Spanish section meaning that frequently examiners didn't have the information that would allow them to understand rationale behind the marking. Note that general, rather than specific, comments are also of limited help.

Investigations using secondary data and hybrids continue to be uncommon. In this regard is important to underline that databased investigations are expected to use a selection from a significant number of data and this requirement isn't met when simply using some tables from texts and/or the internet. The use of closed simulations was not found in this session and this is appreciated as their use isn't suitable to meet the requirements of the IA.

Food chemistry and kinetics continue to be highly favoured themes. Investigations on Vitamin C, caffeine and vinegar are commonly found while those focused on wines and lipids seem to have become less common. In Spanish biodiesels continue to be popular. Weaker investigations included those iron determination, antacids and poor simulations of acid rain effects. Investigations based on electrochemistry are now far less common than in the past. Only a small number of low attaining candidates presented material where only qualitative data were recorded.

There were less reported cases where school submitted samples in which a large number of students had studied the same topic and overwhelmingly schools submitted a diverse sample of investigations.

Candidate performance against each criterion

Personal Engagement

The overwhelming majority of students managed to achieve at least one point for Personal Engagement and teachers had mainly been sensible in their assessments. The weakness where the student's justification of their choice of research question and topic spilling over into overlong and contrived personal narratives is still prevalent although less common than in previous sessions. Happily it was far less frequent to see Personal Engagement as a formal section of the report with its own sub-heading. It is a holistic criterion assessed using evidence across the whole report and should not be considered a contrivance or a paragraph to write up before start the action phase.

The commonest limitation to achievement in the first aspect of the descriptor was where students failed to show genuine curiosity by presenting a very undemanding research question where the outcome too self -evident, such as determining how the mass of alcohol combusted affects the heat energy evolved or a trivial brand analysis such as comparing different antacids. Where students presented a research question that reflected a question that they genuinely appeared interested in answering and couldn't already be expected to know the answer then credit was easily given.

The second part of the descriptor regarding personal input and initiative is evidenced across the whole report and here the outcome was variable. Successful students often applied a known technique to an interesting real-world situation and then by fully using their time to carry out trials at plenty of values of independent variable as well as including repeats. Less highly achieving candidates showed themselves not to be fully engaged was when there were clear limitations in the initial methodology that could have been quickly and easily addressed during the process, but the student made no attempt to do so.

It is worth encouraging students to describe briefly in a paragraph the process of developing their methodology. This will help explain the amount of data collected and give insight into the decision making of the student.

Exploration

The achievement in Exploration was variable although most students were able to achieve at least middle band fulfillment of the assessment criterion.

In many cases a suitable topic was identified and a relevant research question was described with the research question often falling into the category of determining how a measurable independent variable effected an identified dependent variable. These research questions achieved well against the assessment descriptor and also frequently facilitated a successful fulfillment of Analysis and Evaluation criteria.

The weaker research questions were those which were ambiguous, often using such terms as "suitable" or "effective", or those which were quite superficial or simple which would at best lead to an outcome that would have been self-evident from the outset. Compared to previous sessions in both English and Spanish were less investigations that involved more than one independent variable which is often an unnecessary complication. It wasn't uncommon to have long introductions justifying personal interest to be followed by a research question totally unrelated to previous context which is something that reduces how well focused the research question is considered to be.

Background information showed a wide variety of relevance and depth. Many candidates clearly focused on system under study and provided relevant equations and even structures when pertinent. In other cases, background was general rather than specific with lengthy section including such material as health concerns totally unrelated to introduction and research question.

The methodologies described by students were of varying standards and appropriateness. Some schools used surveys as methodology: this isn't suitable for assessment according to criteria. Several schools focused on Arrhenius theory rather than Bronsted- Lowry when covering acid-base topics. Material in this language limited the background to core contents that while correct added no value to the investigation. There were many investigations that simply determined pH of fruits, preparing solutions, establishing a reactivity list or topics equally simplistic. Investigations that are prescribed practicals do not meet the requirements of the IA.

Quite a few candidates presented a methodology that didn't allow to answer the research question due to the failure to collect relevant and sufficient data: this failing then impacted also both this criterion, Analysis and Evaluation. Reasons for the methodology to be considered inappropriate were failure to measure the relevant dependent variable (on rare occasion), failure to collect data related to sufficient values of the independent variable (more common) and failure to control, or at least monitor, relevant control variables that clearly would impact the finding. This was the most common of the methodological weaknesses.

Specific common examples of methodological errors were

- Assuming reaction temperature to be that of room temperature or to assume room temperature stays constant in investigations involving prolonged storage.
- Incorrect calculations of reactant masses in particular ignoring the mass of water when working with hydrates resulting in the wrong concentrations of ions.
- The use of the Beer-Lambert in suspensions as opposed to solutions.
- Poor consideration of drying when a mass of a product is being determined such as in electroplating. Repeat drying and massing to constant mass should be encouraged.
- Not calibrating pH probes. Some investigations based on pH used universal or litmus paper. Unfortunately, these lack the precision needed for many acid-base investigations.
- Poor choice of volumetric glassware such as using beakers instead of volumetric flasks.
- Citing uncertainties in the apparatus list to unlikely values which do not reflect the correct precision.

Safety issues continue to be fairly well addressed although often instructions were general rather than specific. IB World School laboratories should to have adequate fumes hood and certain reagents or products require their use rather than a simple 'ventilated area'. Due attention to environmental problems and correct disposal of left-overs have improved since May 2016.

Analysis

Most students were able to secure credit for presenting raw data. With regards to qualitative observations it was good that less students used pictures instead of recording their observation. Interpretation of images is subjective and as already observed in previous reports this should be discouraged.

As in previous sessions few candidates recorded important variables such as temperature, pressure when relevant or volumes, masses or concentrations of reagents. In titration experiments quite a few students report added volume -which is processed- rather than initial and final volumes with teacher making no observation.

Weaker candidates showed raw data together with processed in a way that made assessment quite challenging. Some very weak candidates only showed a graph as the only processing, while others reduced the processing to simple additions or subtractions. The inclusion of uncertainties in the data tables is required even if these have already been stated in materials. At times students introduced values whose origin was totally unclear or inexistent.

As usual a common approach to processing was simply to average the dependent variable data and then plot a graph against the independent variable to see the nature of the relationship. Often this was done well enough to award good credit. Other common data processing approaches were quantitative determinations based on titrations and calorimetry calculations. It was a positive feature that on less occasions than previously calculations had been awarded the highest level by the teacher but when spot checked by the examiners revealed themselves to contain major errors that significantly affected the conclusions drawn.

It was still a common area of weakness that in rate of reaction investigations some students didn't actually calculate a rate at all and contented themselves with comparative comments on reaction time and many occasions where students presented inappropriate bar charts rather than a properly constructed scatter graph with line of best fit.

The propagation of uncertainties resulting from preparing solutions/dilutions was often missing. Weaker candidates added up all uncertainties even those not impacting final result. It wasn't uncommon to find very dispersed values or outliers and student ignoring them. Students are expected to identify outlying data and to critically decide how to deal with them in the processing of data. One common weakness is that some students failed to realize the collected data were within the uncertainty range and could hence not support the later interpretation.

Simple comparative qualitative comments on curves in investigations on rate of reaction received little credit while on other occasions scatter graphs were presented for independent variables not continuous in nature. This is an erroneous practice and should be discouraged.

The consideration of uncertainties was variable. Where students did score credit for consideration of uncertainties was most often in numerical calculations related to stoichiometry or energetics when the followed a sensible protocol to propagate the uncertainty. Within graphical analysis the fulfilment of this aspect was less strong. Lines of best fit using Excel were often poor and error bars where included often didn't match the uncertainty or the student failed to appreciate the significance on the trend being identified. There seemed to be less cases of students undertaking standard deviation analysis which was good because often its significance is poorly understood.

Interpretation continues to be a challenging part of this criterion and more often than not candidates presented descriptions instead. It was unfortunate that when a satisfactory graphical analysis had been produced with the corresponding equation, only stronger candidates would successfully use it to reach a conclusion.

There seemed to be less occasions where students had been awarded high marks for correct but quite superficial analyses of a limited amount of data. Teachers appear to have a better appreciation of the level of expectation behind this criterion as illuminated in the teacher Support Material in My IB.

Evaluation

This criterion continues to be the most challenging for most students.

Although many students presented a conclusion that had some validity with the results, fully justified conclusions were not often found. The Spanish language moderating team reported that frequently conclusions were presented where no results were referred to and only offered a general description that poorly- if at all - answered the research question.

Many students failed to correctly describe or justify their conclusion through relevant comparison to the accepted scientific context. For this part of the descriptor students should either be making the comparison of their experimentally determined quantities to readily available literature values or referring to whether any trends and relationships identified were in line with accepted theory, ideally by referring back to their original background information.

Most students did succeed in identifying weaknesses and limitations although these were usually procedural (why the planned method was not properly implemented) and few were methodological (why the designed method itself was flawed or limited). The number of students identifying systematic and random error continues to be low and quite a few did this wrongly. The same applies to the terms precision and accuracy.

Very few candidates offered relevant and realistic extension(s). The use of instruments not available at school is not realistic. Simply replacing one metal by another if working on catalysts, one fruit for another if investigating Vitamin C or replace tea by coffee if working on caffeine are too limited to fully meet the expectation.

Communication

Most candidates scored at least 3 points and teachers showed good alignment when marking this criterion.

Not including enough information to allow for reproducing the method was a common mistake. Yet another was not presenting one example of calculations with actual values. Including general formulas/equations doesn’t provide enough clarity or specificity.

The use of titles for graphs and tables has steadily improved. Many students paid due attention to sf but it wasn’t uncommon to find inconsistent sf in the axis of graphs or a number not consistent with those in tables. Within data tables units and uncertainties (unless the latter change) should be in the column heading rather than in each box.

Many candidates included superfluous pictures, e.g. that of reagent or student working. In some cases, the latter actually raised concerns as they showed students working with hazardous chemicals and not wearing proper safety equipment. Pictures should only be included if they add value to the report. This also applies to diagrams, e.g. the diagram of a burette with the corresponding conical flask used for a titration adds no value and effect the report’s conciseness. Some students, especially in the introduction, used superfluous comments and verbose terms that aren't appropriate to a concise scientific communication.

In spite of a number of communications to the contrary (such as previous Subject Reports and FAQ) many students still include appendixes. Examiners aren't expected to read them and if these include relevant information, e.g. raw data unnecessary then points are lost. Also advise students to avoid cover pages and indexes since they limit the number of pages for actual report.

Most reports did include citations and/or bibliography. However, under closer scrutiny some included very long lists that contained many references that weren't used in the investigation. Note that proper referencing is necessary to establish the academic honesty of the work. It is not though a part of the Communication criterion so does not impinge on the mark.

Recommendations and guidance for the teaching of future candidates

- Students should develop investigations that seek to answer genuine research questions related to chemical principles and to avoid research questions whose answer is known beforehand.
- Encourage students to only use background information that is specific to their research question.
- Encourage students to reflect on data while collecting it so they have the chance to adapt or extend their procedural phase if the data are proving insufficient or erroneous.
- It is good practice for students to give a safety and environmental evaluation in any investigation involving hands on practical work even if it is to show that safety and eco-friendly disposal have been evaluated but no special precaution is then required.
- Encourage procedures to use lower quantities of chemicals to preserve the environment.
- Ensure students record all relevant associated data and not just the independent and dependent variable data.
- Address topics 11.1 and 11.2 of Measurement and Data Processing before students embark on their Individual Investigations.
- When evaluating methodology encourage a consideration of underlying factors affecting the validity of the method such as range, sample size, use of an alternative reaction system to study the same phenomenon, etc.
- Methodologies should be written in sufficient detail so that the reader could in principle repeat the investigation and also so that an idea of the associated uncertainties can be gained.
- Where relevant to the analysis students should present at least one worked example calculation so the reader could understand how the data was processed.
- Encourage students to interpret results quantitatively wherever possible. This will also provide a sound foundation for high quality conclusions.
- Students should consider suggestions for improvements that are related to previously identified limitations and that should be realistic and specific to their investigation.
- Title pages, indexes, content pages and appendices are unnecessary and should be discouraged.

When assessing the students work teachers should:

- Carefully check methodology for any missing key variables that would invalidate the conclusions being drawn.

- Carefully check calculations for errors that would affect the conclusions being drawn.
- Apply the model of best fit marking of the criteria evenly and not prioritizing some descriptors over others when awarding marks.
- Leave evidence of their assessment decisions for the moderator to understand the thinking behind the marks. Hand written annotations on the report scripts are fine for this purpose.
- If more than one teacher is involved in assessing the cohort then it is expected that school-based internal standardization of marks will take place before submission through IBIS.
- The only identifying information on the report should be the candidate alphanumeric code. The anonymity of the e-marking system means that the school code, candidate session number, candidate name and teacher name should NOT feature on the report or any attached mark sheets.

Higher level paper one

General comments

The number of candidates who sat this paper was 2460, and the average mark scored was 28.13 out of 40 which was slightly lower than the average mark in November 2017 (29.45 out of 40). This is not necessarily a reflection of the difficulty of the paper, as the drop in the mean score could be due to the increase in the number of re-take candidates registered in November. The marks ranged from 7 to 40 with only 34 candidates scoring 10 or less. The majority of candidates showed a very good understanding of chemical concepts and were able to apply them in a variety of unfamiliar situations. There were no major difficulties in this paper.

Many thanks to the 27 teachers who took the time to review the paper and send us feedback after the examination. All teachers who sent feedback found the paper appropriate. They commented that the paper stressed analysis and that the distractors in each question were interesting.

Teachers also sent the following feedback:

The best description of the difficulty of the paper in comparison with last year's paper

Much easier	A little easier	Of a similar standard	A little more difficult	Much more difficult	N/A
0%	11.11%	74.07%	11.11%	0%	3.70%

Clarity of wording

Very poor	Poor	Fair	Good	Very good	Excellent
0%	0%	18.52%	22.22%	29.63%	29.63%

Presentation

Very poor	Poor	Fair	Good	Very good	Excellent
0%	0%	11.11%	18.52%	33.33%	37.04%

In terms of accessibility and bias, all teachers thought the paper was accessible to candidates of different belief systems and genders, 96% thought the paper was accessible to candidates of different ethnicities, and 88% thought the paper was accessible to candidates who have special education needs.

The table below lists the questions from least to most difficult where the difficulty index is the percentage of candidates giving the correct answer. It shows the numbers of candidates who selected each of the options A-D and the discrimination index for each question (how well the question discriminated between high-scoring and low-scoring candidates).

In comparison, the difficulty index ranged from 40.91% to 96.46% in November 2017 and the discrimination index ranged from 0.09 to 0.63.

Question	A	B	C	D	Blank	Difficulty Index	Discrimination Index
19	50	2218	62	19		94.42	0.12
3	105	2150	24	70		91.53	0.18
22	2038	201	75	34	1	86.76	0.31
24	107	143	109	1989	1	84.67	0.35
10	169	62	160	1957	1	83.31	0.36
40	1927	117	239	65	1	82.03	0.40
18	224	1917	108	100		81.61	0.33
13	268	66	99	1912	4	81.40	0.35
29	227	1884	107	131		80.20	0.38
1	1879	181	151	134	4	79.99	0.37
4	1872	107	118	252		79.69	0.33
26	174	1837	93	243	2	78.20	0.45
31	92	176	272	1805	4	76.84	0.40
36	442	1771	109	22	5	75.39	0.50
37	157	212	1768	210	2	75.27	0.48
15	123	187	1762	277		75.01	0.50
12	1750	182	162	255		74.50	0.55
14	1746	317	123	160	3	74.33	0.47
21	204	148	1715	277	5	73.01	0.50
30	119	236	1710	279	5	72.80	0.49
8	104	357	179	1706	3	72.63	0.60
20	1696	354	155	143	1	72.20	0.41
39	148	1678	128	392	3	71.43	0.49
5	361	1654	97	232	5	70.41	0.39
34	159	158	397	1627	8	69.26	0.59
17	164	189	375	1620	1	68.97	0.56
16	255	329	1611	152	2	68.58	0.62
6	117	165	1610	452	5	68.54	0.35
9	309	106	1470	456	8	62.58	0.49
11	439	324	131	1452	3	61.81	0.46
32	519	272	118	1436	4	61.13	0.60
23	439	1383	127	396	4	58.88	0.50
7	577	1370	180	219	3	58.32	0.41
35	200	296	484	1357	12	57.77	0.65
38	1326	268	174	573	8	56.45	0.51
25	294	424	1308	320	3	55.68	0.61
27	1293	416	358	276	6	55.04	0.60
33	190	594	366	1193	6	50.79	0.57
28	252	598	337	1160	2	49.38	0.65
2	819	1114	365	47	4	34.87	0.61

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

- Using the Kelvin scale when dealing with the gas laws
- Comparing the ionization energies of ions
- Entropy and free energy values at equilibrium
- Salt hydrolysis
- Relating the colour of an indicator to pH and its pKa
- Identifying oxidizing and reducing agents in a disproportionation reaction
- Oxidation of alcohols
- The structure of benzene
- Comparing the rate of hydrolysis of different halogenoalkanes

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

- Stoichiometry
- Calculating molar concentration
- Identifying the numbers of bonding pairs and lone pairs surrounding an atom
- Hybridization
- Factors affecting rate of reaction
- The effect of temperature on the equilibrium constant
- Identifying Brønsted-Lowry acids
- Conduction in a voltaic cell
- The use of X-ray crystallography

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

Question 1

The majority of candidates were able to use the stoichiometric ratio to determine amount of reactant.

Question 2

This question had the lowest difficulty index on the paper. It is the only question on the paper where the most commonly chosen answer was not the correct one. The majority of candidates selected a lower temperature to give a lower volume for the sample of gas at constant pressure. However, more candidates selected the incorrect value (distractor B) obtained without converting the temperature to Kelvins.

Question 3

This was a very straightforward question. The majority of candidates knew how to calculate the molar concentration including the conversion of the volume to dm^3.

Question 4

The majority of candidates answered correctly showing an understanding of the characteristics of the emission spectrum of hydrogen.

Question 5

70% of the candidates deduced that element X belonged in Group 1 and element Y belonged in a group higher than group 2 based on their first three ionization energies.

Question 6

68% of candidates selected the correct answer. The most commonly chosen distractor was D which included Al_2O_3 and SiO_2 as oxides that produced acidic solutions when added to water. The amphoteric nature of Al_2O_3 and the fact that the oxides are insoluble were missed by candidates who selected D.

Question 7

This was a challenging question as candidates had to compare second, third and fourth ionization energies of different ions. It is pleasing to see that over half of the candidates were able to select the ion with the lowest ionization energy. The most commonly chosen distractor, A, would be the correct answer if the ionization energies of the atoms were compared.

Question 8

This question had a high discrimination index. It is pleasing that 72% of candidates were able to deduce the oxidation state of the iron and the charge of the complex ion.

Question 9

62% of candidates identified PF_3 as the species with the same molecular geometry as SO_3^{2-}. The most commonly chosen distractor was CO_3^{2-} which had a similar formula to SO_3^{2-}.

Question 10

Well answered by 83% of candidates who were able to deduce the number of lone pairs and bonding pairs of electrons in ClF_2^+.

Question 11

61% of candidates identified ethyl amine as having the highest boiling point. The distractors contained the elements O and F.

Question 12

Three-quarters of the candidates counted the correct numbers of sigma and pi bonds in the molecule.

Question 13

It is indeed pleasing that this question about hybridization was correctly answered by 81% of the candidates.

Question 14

Three-quarters of the candidates were able to use a Hess's law cycle to deduce the enthalpy change of reaction. The most commonly chosen distractor, B, omitted multiplying the enthalpy change of the second reaction by two.

Question 15

Three-quarters of the candidates understood the implications of a positive enthalpy change of reaction on the temperature change, relative enthalpy and relative stability of reactants and products.

Question 16

69% of candidates deduced the signs of the enthalpy and entropy changes for the reaction based on its spontaneity at different temperatures.

Question 17

A question with a high discrimination index. Stronger candidates identified the first electron affinity of chlorine as an exothermic process.

Question 18

A well-answered question about rate of reaction and stoichiometry.

Question 19

This was the most straightforward question on the paper. 94% of candidates knew that adding a catalyst decreased the activation energy of a reaction.

Question 20

72% of candidates were able to deduce the order of a reaction with respect to different reactants from experimental data.

Question 21

73% of candidates were able to deduce the reaction mechanism that contradicted the rate equation given.

Question 22

This was a very well answered question. Data about the value of K_c at different temperatures was used to deduce that the forward reaction was favoured at higher temperatures.

Question 23

This was a challenging question. Only 59% of candidates selected the appropriate entropy and free energy values (maximum or minimum) at equilibrium.

Question 24

The majority of candidates identified the Brønsted-Lowry acids in the forward and reverse reactions.

Question 25

This was one of the most challenging question on the paper and had a high discrimination index. 56% of candidates were able to arrange a group of four salt solutions in order of increasing pH.

Question 26

78% of candidates recognized that NH_4^+ cannot act as a Lewis base.

Question 27

This was one of the most challenging questions on the paper, relating the colour of an indicator to pH and its pK_a. 55% of candidates obtained the correct answer.

Question 28

This was a challenging question and had the highest discrimination index on the paper. About half of the candidates identified that P_4 was the oxidizing and reducing agent.

Question 29

80% of candidates knew the direction and location of electron flow in a voltaic cell.

Question 30

73% of candidates were able to connect the sign of electrode potential to the sign of ΔG and the value of K.

Question 31

Three-quarters of the candidates were able to calculate the correct cell potential from the standard electrode potentials.

Question 32

61% of the candidates were able to identify which of the alcohols were oxidized by acidified $KMnO_4$. The most commonly chosen distractor was A which only included the primary alcohols.

Question 33

This question about benzene was one of the most challenging question on the paper. The most commonly chosen distractor was B (contains alternate single and double C-C bonds and is planar).

Question 34

A discriminating question requiring candidates to select the reactants needed to form a branched ester. A pleasing 69% of candidates answered it correctly.

Question 35

This was a challenging question about rate of hydrolysis of halogenoalkanes. 58% of candidates recognized that a tertiary bromoalkane is hydrolyzed at a faster rate than a primary bromoalkane.

Some teachers were concerned that this question was too demanding, however, factors affecting rate of hydrolysis of halogenalkanes is mentioned in Topic 20 of the syllabus ("explanation of how the rate depends on the identity of halogen, whether the halogenoalkane is primary, secondary or tertiary and the choice of solvent"). Moreover, it was possible to obtain the correct answer by eliminating the incorrect answers.

Question 36

Three-quarter of the candidates chose the correct major product of the reaction of HBr with but-1-ene. The most commonly chosen distractor was the anti-Markovnikov addition product.

Question 37

75% of the candidates identified the correct number of chiral carbon atoms in the molecule.

Question 38

This was one of the more challenging questions. The most commonly chosen distractor was D where the identical chemical environment of the two methyl groups was missed.

Question 39

71% of candidates calculated the absolute and percentage uncertainties in the change in mass correctly.

Question 40

A well-answered question by 82% of the candidates who recognized X-ray crystallography as the technique used to find the bond lengths and bond angles within a molecule.

Recommendations and guidance for the teaching of future candidates

- Continue to challenge students to apply concepts in new situations.
- Practice problem solving so that students are confident and can apply concepts with accuracy and speed.
- Encourage students to give their reasoning for their choices in multiple choice questions.
- Candidates should be encouraged to answer all questions. If they are not sure of the answer, they should eliminate incorrect answers and then guess one of the remaining answers, as there is no penalty for incorrect answers.
- Candidates should be made aware that the questions appear in the order of the topics in the syllabus, and that they should not spend more than 90 seconds for each question to come back to the unanswered ones if necessary when they finish.
- Please remember that candidates with special education needs can apply for special accommodation through the IB DP Coordinator.

Standard level paper one

General comments

The number of candidates who sat this paper was 2670, 51% in English, 48% in Spanish and 1% in Japanese. The average mark scored was 14.97 out of 30 which was slightly lower than the average mark in November 2017 (15.57 out of 30). The English and Spanish mark distributions were very different as there was a weak cohort among some of the Spanish-speaking schools.

Many thanks to the 24 teachers who took the time to review the paper and send us feedback after the examination. Teachers commented that the paper was fair and had a good coverage of topics. Some teachers gave positive comments about the level of critical thinking that the paper demanded, and others commented that the paper required more processing time as it contained a few challenging questions that required working out. Candidates did seem to find a few questions challenging as the most commonly chosen answer was not the correct answer on five occasions. There was a concern that there was an excessive focus on NMR spectroscopy in the paper which is a fair point.

Teachers sent the following feedback:

The best description of the difficulty of the paper

Too easy	Appropriate	Too difficult
4.17%	83.33%	12.50%

The best description of the difficulty of the paper in comparison with last year's paper

Much easier	A little easier	Of a similar standard	A little more difficult	Much more difficult	N/A
0%	8.33%	58.33%	25.00%	4.17%	4.17%

Clarity of wording

Very poor	Poor	Fair	Good	Very good	Excellent
0%	0%	4.17%	25.00%	45.83%	25.00%

Presentation

Very poor	Poor	Fair	Good	Very good	Excellent
0%	0%	0%	16.67%	54.17%	29.17%

In terms of accessibility and bias, all teachers who responded thought the paper was accessible to candidates of different belief systems, genders and ethnicities, as well as to candidates who have special education needs.

The table below lists the questions from least to most difficult where the difficulty index is the percentage of candidates giving the correct answer. It shows the numbers of candidates who selected each of the options A-D and the discrimination index for each question (how well the question discriminated between high-scoring and low-scoring candidates).

Question	A	B	C	D	Blank	Difficulty Index	Discrimination Index
17	170	1968	272	171	11	75.93	0.52
4	338	1901	143	196	14	73.34	0.48
6	161	1831	403	186	11	70.64	0.60
10	505	172	345	1558	12	60.11	0.55
18	1536	357	402	271	26	59.26	0.65
19	247	556	247	1527	15	58.91	0.64
7	235	381	1518	431	27	58.56	0.33
22	452	1506	362	259	13	58.10	0.59
20	424	210	1500	433	25	57.87	0.66
16	595	1497	222	256	22	57.75	0.56
5	1473	393	401	308	17	56.83	0.64
15	242	427	1427	483	13	55.05	0.51
1	1426	484	300	367	15	55.02	0.58
13	1404	539	416	215	18	54.17	0.69
3	188	810	1327	234	33	51.20	0.30
23	454	552	1314	258	14	50.69	0.50
28	284	631	328	1305	44	50.35	0.50
12	577	448	1277	279	11	49.27	0.50
30	304	1262	349	636	41	48.69	0.52
14	334	351	1218	674	15	46.99	0.64
11	560	475	323	1211	23	46.72	0.44
25	740	1201	420	185	46	46.33	0.47
27	367	422	705	1057	41	40.78	0.41
29	1016	541	329	652	54	39.20	0.44
24	645	567	376	963	41	37.15	0.44
9	370	310	854	1037	21	32.95	0.49
26	339	984	544	701	24	27.04	0.40
8	1133	695	219	539	6	26.81	0.34
21	443	911	539	667	32	25.73	0.47
2	420	1566	528	64	14	16.20	0.18

Number of candidates : 2592

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

- Using the Kelvin scale when dealing with the gas laws
- Comparing the ionization energies of ions
- Identifying oxidizing and reducing agents in a disproportionation reaction
- Deducing the molecular geometries of polyatomic ions
- Oxidation of alcohols
- The structure of benzene
- ^{1}H-NMR spectroscopy
- Esterification

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

- Calculating molar concentration
- Finding the numbers of subatomic particles in ions
- Identifying the numbers of bonding pairs and lone pairs surrounding an atom

- Factors affecting rate of reaction
- The effect of temperature on the equilibrium constant
- Identifying Brønsted-Lowry acids
- Identifying oxides that form acidic solutions
- Conduction in a voltaic cell

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

Question 1

This question had a high discrimination index. 55% of candidates were able to use the stoichiometric ratio to determine the amount of reactant.

Question 2

This question had the lowest difficulty index on the paper. The majority of candidates selected distractor B which is obtained without converting the temperature to Kelvins.

Question 3

Half of the candidates were able to calculate the relative atomic mass of the metal from the masses of the two elements and the formula of the compound (MBr_2). The most commonly chosen distractor was B which had the same number of moles of the metal and the bromine.

Question 4

This was a very straightforward question. 73% of the candidates knew how to calculate the molar concentration including the conversion of the volume to dm^3.

Question 5

Over half of the candidates answered correctly showing an understanding of the characteristics of the emission spectrum of hydrogen. The three distractors were chosen by nearly equal numbers of candidates. The question discriminated well.

Question 6

A very well answered question. 71% of the candidates deduced the correct numbers of subatomic particles in the ions of the iron isotopes.

Question 7

A well answered question about acidic oxides. 59% of the candidates selected the correct answer. The most commonly chosen distractor was D which included Al_2O_3 and SiO_2 as oxides that produced acidic solutions when added to water. The amphoteric nature of Al_2O_3 and the fact that the oxides are insoluble were missed by candidates who selected D.

Question 8

One of the most challenging questions on the paper in which the most commonly chosen answer was a distractor. Candidates had to compare second, third and fourth ionization energies of different ions. 27% of the candidates were able to select the ion with the lowest ionization energy. The most commonly chosen distractor, A, would be the correct answer if the ionization energies of the atoms were compared. Several teachers commented that this question was tricky.

Question 9

One of the challenging questions on the paper where a distractor was the most common answer. The question required candidates to deduce the molecular geometry, and hence also the Lewis structure, for several species which could be time consuming for weaker candidates. A third of the candidates identified PF_3 as the species with the same molecular geometry as SO_3^{2-}. The most commonly chosen distractor was CO_3^{2-} which had a similar formula to SO_3^{2-}.

Question 10

Well answered by 60% of candidates who were able to deduce the number of lone pairs and bonding pairs of electrons in ClF_2^+.

Question 11

47% of candidates identified ethyl amine as having the highest boiling point. The most commonly chosen distractor (A) was CH_3CHO.

Question 12

A straightforward question about selecting the polar molecule. Only half of the candidates selected NCl_3 as the polar molecule, while $BeCl_2$ and BCl_3 were frequently selected.

Question 13

This question had the highest discrimination index on the paper. 54% of the candidates were able to use a Hess's law cycle to deduce the enthalpy change of reaction. The most commonly chosen distractor, B, omitted multiplying the enthalpy change of the second reaction by two.

Question 14

47% of the candidates understood the implications of a positive enthalpy change of reaction on the temperature change, relative enthalpy and relative stability of reactants and products. This question discriminated well between high-scoring and low-scoring candidates.

Question 15

A straightforward question on using bond enthalpies to calculate the enthalpy change of reaction. 55% of the candidates answered it correctly. Some candidates reversed the signs for bonds broken and bonds formed (distractor D) and others missed the fact that there are three N-H bonds in NH_3 (distractor B).

Question 16

A relatively well-answered question about rate of reaction and stoichiometry. 58% of candidates answered correctly. It was surprising that A, which stated that the initial rate was the same, was the most commonly chosen distractor even though the concentrations of the acids were different.

Question 17

This was the most straightforward question on the paper. 76% of candidates knew that adding a catalyst provide an alternative pathway with a lower activation energy for the reaction.

Question 18

This was a well answered question with a high discrimination index. Data about the value of K_c at different temperatures was used to deduce that the forward reaction was favoured at higher temperatures by 59% of candidates.

Question 19

Well answered - 59% of the candidates identified the Brønsted-Lowry acids in the forward and reverse reactions. The question had a high discrimination index.

Question 20

A straightforward question. 59% of the candidates ordered the strong and weak acids and bases in order of increasing pH. This question also had a high discrimination index.

Question 21

This redox question was one of the most challenging questions on the paper as it involved disproportionation of P_4. Some teachers commented that it was a very challenging question particularly for standard level candidates. A quarter of the candidates selected the correct answer.

Question 22

A well answered question. 58% of candidates knew the direction and location of electron flow in a voltaic cell.

Question 23

Half of the candidates selected H_2O_2 to OH^- as the reduction.

Question 24

37% of the candidates selected both primary and secondary alcohols for changing the colour of acidified $KMnO_4$ from purple to colourless. The most commonly chosen distractor (A) included only the two primary alcohols.

Question 25

47% of the candidates ordered the isomers in the order of increasing boiling point. The most commonly chosen distractor (A) had the reversed order.

Question 26

This question about the structure of benzene was not well answered. The most commonly chosen answer was the distractor B (it contains alternate single and double C-C bonds and is planar). Only 27% of the candidates deduced that the ^{1}H NMR spectrum of benzene would contain one signal only. Those whose who selected distractor C (six signals in the ^{1}H NMR spectrum and readily undergoes substitution) were fewer than that.

Question 27

41% of the candidates deduced the alcohol and carboxylic acid needed to form the branched ester. The most commonly chosen distractor (C) had the correct carboxylic acid but would have formed a straight chain ester.

Question 28

Half of the candidates chose the correct statement about spectroscopy (mass spectroscopy provides information about the structure). The most commonly chosen distractor (B) was that ^{1}H NMR spectroscopy provides the values of C-H bond lengths.

Question 29

It is pleasing that the most commonly chosen answer was the correct one for the ratio of the areas under each signal in the ^{1}H NMR spectrum of 2-methylbutane. Distractors B and D were popular. Both distractors had the two methyl groups give separate signals, and distractor B also had the ethyl group hydrogens give one signal only.

Question 30

This question about uncertainties was answered correctly by nearly half of the candidates.

Recommendations and guidance for the teaching of future candidates

- Provide plenty of opportunities for students to apply concepts in new situations and using a variety of species as examples. Students need to work quickly and accurately in paper one. The more practice they have during the course the more confidently they will tackle the exam.
- Encourage students to re-read the question after answering to ensure they have paid attention to every requirement in the question.
- Make sure to cover spectroscopy. Students should know how to obtain information from each type of spectrum.
- Remind students to use absolute temperature when conducting calculations using the gas laws.

- It is helpful for students to know some commonly used strong and weak acids and bases such as HCl, CH_3COOH, NaOH and NH_3.
- In general Organic Chemistry seems to need more instruction time as candidates seem less confident in this area.
- Candidates should be made aware that the questions appear in the order of the topics in the syllabus, and that the average time allocated for each question is 1.5 minutes.

Higher level paper two

General comments

This was deemed to be a somewhat more difficult paper than November 2017 by both examiners and teachers. There was also evidence to suggest that the November 2018 cohort of students was a strong one. As a result of this combination, the grade boundaries are slightly lower than previous years and there is a higher percentage of top achieving marks.

Some candidates were clearly competent yet missing entire topics. It is vital that the entire syllabus be taught as top scoring candidates need to demonstrate competency across the entire range of topics.

25 teachers gave feedback from a total of 400 schools. The approximate percent comparison with last year's paper is as follows:

Much easier	A little easier	Of similar standard	A little more difficult	Much more difficult	N/A
0	8	32	44	12	4

As to the percent level of difficulty, the following answers were given:

	Too easy	Appropriate	Too difficult
Level of difficulty / %	0	72	28

Suitability of question paper in terms of clarity and presentation (approximate %):

	V poor	Poor	Fair	Good	V good	Excellent
Clarity of wording	0	8	12	28	44	8
Presentation of the paper	0	0	8	16	52	24

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

- Calorimetry calculations
- Reaction quotient meaning / interpretation
- Half equations for electrolysis in aqueous solutions
- NOS based questions. In particular application of accuracy to experiments and reflecting on chemical knowledge.
- Weak acid base titrations, acid/base equations (equilibria)

- Drawing Lewis diagrams of complex species
- Calculating formal charges on atoms
- Paramagnetism, diamagnetism, and differentiating between same electron spin/orientation and unpaired electrons.
- Factors affecting hydration enthalpies
- Delocalization application including showing how it occurs in a conjugate base ion.
- Calculating the mean oxidation number of an element in a species
- Knowing the difference between structural isomers and stereoisomers
- Clean, clear reaction mechanisms

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

- Empirical formula and stoichiometric calculations
- Simplifying assumptions made in calorimetric calculations
- Collision theory / rate curves
- Identifying the M_r from a mass spectrum and functional group from IR spectrum
- Deducing the electronic structure of an atom and representing this in an energy level diagram
- Explaining decrease in atomic radius across a period
- The meaning of "homogeneous"
- The dependence of entropy on the number of moles of gas
- Calculating $\Delta G^{\ominus}$ from the equilibrium constant
- pH calculations
- Knowing that $LiAlH_4$ reduces carboxylic acids to primary alcohols
- Identifying a primary halogenoalkane and explaining how they were able to do this
- Being able to explain why a species was acting as a Lewis base
- Rate law / mechanism relationship
- Organic reactions / conditions; nucleophilic mechanism was better than usual

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

Question 1

(a)(i) Generally done very well with most candidates identifying $CuSO_4$ as the limiting reagent.

(a)(ii) Generally done well. Some incorrectly used the mass of $CuSO_4$ instead of Cu to calculate the theoretical mass.

(b)(i) There were several teachers' comments here. We recognize that enthalpy of reaction is generally given in kJ mol^{-1} while we asked it to be given in kJ for this specific equation (as enthalpy is an extensive quantity). While some candidates used incorrect mass for M1, some were then not determining the enthalpy change for the reaction (in kJ or kJ mol^{-1}) by dividing their value for q by the number of moles. Many other forgot the negative sign for the exothermic reaction and missed M2.

(b)(ii) Most candidates could correctly identify an assumption made in the calculation, such as the specific heat of the solution is the same as water.

(b)(iii) Average performance. Many were able to score one mark by calculating the relative uncertainty (0.2°C/7.5°C) in the temperature but then did not multiply the relative uncertainty by the molar enthalpy calculated in part (b)(i).

(c)(i) Very well done with most candidates earning both, or at least 1 mark. The most common mistake being drawing an increasing, rather than decreasing curve.

(c)(ii) Easy marks for most, weaker candidates omitted the tangent. Some stated to calculate rate as [$FeSO_4$]/time rather than **change** in concentration.

(c)(iii) Most got surface area. Some did not include the required time factor for collisions for M2.

(d) Mediocre performance. Most candidates earned 1 mark. Very few used reduction and oxidation of water as both electrode reactions but instead used Fe^{2+} reactions, often confusing anode and cathode reactions.

Question 2

(a) Generally very well done with few students rounding off the moles calculated to arrive at $C_5H_{10}O_2$ instead of dividing by the smallest number of moles and coming up with the correct answer, C_3H_6O.

(b) Generally very well done with some candidates naming a class of compound, such as ketone or aldehyde, rather the functional group.

(c) Generally very well done. Some candidates added the masses from 2a and stated 58.09 as the M_r rather than reading it from the mass spectrum.

(d) Generally well done. Some candidates drew structural formulas of a substance which could be oxidized, such as propanal.

Question 3

(a)(i) Generally well done with no real common error amongst the minority of candidates missing this mark.

(a)(ii) Generally well done; some provided lower shells while it was clearly stated that they should not.

(b)(i) This was poorly done with many incorrect structures, non-showing of electrons on oxygen, and structures which wouldn’t work for either case (e.g. 14 electrons on Br).

(b)(ii) Good candidates scored both, some did not get M1 but managed ECF. Others lost M2 by saying “lower” instead of closer to 0.

(c) Candidates struggled to earn all 3 marks here. Some would get ECF from their structures in 3 (b)(ii). Others made reference to the presence of the lone electron pair without listing three bonded pairs as the complete answer for their reasoning.

(d)(i) Mediocre to poor performance with many candidates not including H^+ or not writing a reduction half-equation. Some had difficulties balancing charges in the equation.

(d)(ii) This was surprisingly poor even with generous ECF from 3 d(i)

(d)(iii) Many candidates could not calculate the E_{cell}, had incorrect number of electrons, and omitted the negative sign on the energy released.

(e) Generally poor performance with candidates stating the ions being ferromagnetic instead of both being paramagnetic. Many missed the explanation stating that the ions had their electron spin in alignment but not these were unpaired electrons.

Question 4

(a) Fairly well answered with many lower scoring candidates earning 1 or both marks. Missed marks was often due to lack of clarity in responses regarding increasing nuclear charge or similar shielding.

(b) Answered more poorly than 4(a). Candidates missed isoelectronic point or commented on sodium ion having more protons than electrons and the reverse for the oxide ion but did not compare number of protons/electrons within the sodium ion to oxide ion.

(c) Generally well done with most identifying increasing ionization energies with a large jump between 3rd and 4th IEs. Some showed the large jump elsewhere and a few showed a graph where the values were decreasing or increasing and then decreasing.

(d) Very poorly done. Some did not identify charge density or ionic radius as significant or had the Mn^{2+} ion listed as smaller size. Most candidates did not explain the stronger interaction with polar water molecules as the reason for its more exothermic enthalpy of hydration.

Question 5

(a) Generally done very well although few candidates did not read the question carefully and wrote about equilibrium rather than why it is considered homogeneous.

(b) Generally well done with some candidates not mentioning the sign of the entropy change.

(c) Well done by the broad spectrum of candidates with a few omitting the negative sign on the ΔG. Very few arithmetic errors.

(d) Good performance by higher scoring candidates and has shown to be a discriminating question. Where candidates had made an error in part 5 (b) and predicted sign of $\Delta S^\ominus$ as positive, they were unable to deduce that in that $\Delta H^\ominus$ could be positive or negative depending on the temperature. There were no/few candidates who earned this ECF mark.

(e) The question was done poorly with many candidates unaware of the concept of the equilibrium quotient, Q_c. Some calculated its value but referred to it as K_c and others had no idea what to do next.

Quite a few candidates who correctly calculated the value of Q_c (= 20.8) and recognized it as less than K_c (= 280) were not able to outline how this influenced the direction of the reaction.

Question 6

(a)(i) Many 1 out of 2 marks earned here. Common mistakes were: not including equilibrium arrows, omitting the charge on the conjugate acid/base ion, or not writing the reaction with water and simply writing a dissociation equation.

(a)(ii) poorly done; many had two Lewis structures or missed out the charge

(a)(iii) One teacher commented “Students are unfamiliar with the term "average oxidation state" as this is not commonly used in the syllabus.” This is taken from the syllabus: “Deduction of the oxidation states of an atom in an ion or a compound.” This is a skill which should be practiced more regularly and has actually been assessed in recent sessions.

Common wrong answers were 4 , 0, and +1

(b)(i) Very well done with only few students not being able to calculate hydroxide ion concentration from hydrogen ion concentration.

(b)(ii) Generally well done with a variety of approaches. Some candidates used the Ka expression.

(c) Most candidates scored at least one but few earned all three. Candidates struggled with a WB/WA curve, showing buffering regions or large pH drops at equivalence. Some did not identify 25cm^3 as the equivalence point and/or had a wrong pH at that volume.

(d) Many only scored one for comparing only one type of IMF. Most failed to realize that both molecules had components of all 3 IMF´s and a comparison between at least 2 of the types was needed.

(e)(i) Mediocre performance. There were a variety of incorrect reducing agents mentioned.

(e)(ii) A significant number lost the mark with butanol, not butan-1-ol.

Question 7

(a) Very well done. A few candidates mentioned hydration instead of hydrogenation.

(b) Mediocre performance with many candidates incorrectly stating the standard enthalpy of combustion of ethane (-1411) as the answer.

(c) Much better performance than 7b with many of the candidates earning ECF by obtaining +150 from the answer -1411 of 7b.

(d) The NOS questions in paper 2 were not well answered. Very few gave specific examples and attempted too broad an answer. The idea of experimental uncertainty was not well understood. Candidates did not recognize that values experimentally determined have uncertainties or different sources have (slightly) different values amongst other possibilities.

Question 8

(a) Poorly done. Few candidates use the VSEPR theory and could mention bond or ring strain or identify the bond angle in a 3-membered ring.

(b)(i) Poorly done; many re-drew the original molecule in different orientations.

(b)(ii) Mediocre performance. Common reference was to absence of C=C double bond as a requirement for cis-trans isomers instead of restriction of rotation which methyloxirane has but with only one (axial) CH_3 substituent at the ring rather than two substituents that would be required for cis-trans isomerism.

(c) Chemical shifts were often incorrectly identified with 1.3 – 1.4 being the more common one. Splitting pattern was generally done well.

Question 9

(a)(i) Mediocre performance. Many candidates referred to polarity and some to bond strength. However a number of candidates mentioned electronegativity without further comparison.

(b) Generally well done. Most candidates identified it as primary and then went on to give a good reason. A few failed to clearly explain why.

(c) Generally quite well done. Some consistent negligent errors such as sloppy drawing, incorrect start and finish of arrows, OH-C bonding, incorrect transition state/charge missing, Br- missing as product.

(d) Generally done well with the typical error being donating an electron or electrons rather than a pair of electrons.

(e) Mixed performance on this NOS question. Most earned a mark for synthesis examples. Some very good alternatives given but a distinct lack of specific examples which fit any of the categories.

Question 10

(a) Generally done well. Some candidates listed catalyst as either B or D.

(b) Most candidates had the correct rate equation with some having [A] in the denominator of the equation

(c) Very good performance, however few candidates earned ECF from an incorrect rate equation in 10b

Recommendations and guidance for the teaching of future candidates

- Emphasize clarity of language and drawing.
- Practice atypical scenarios to generate understanding of concepts.
- Emphasize the need for clarity when drawing structures, curves, etc. In view of the difficulties from scanning erased information, insist on candidates using extra pages.

- Training candidates to read the question carefully with regard to what exactly it is asking, the command term used and the implications of this, taking into account the number of marks available
- For each area of the syllabus where an explanation is needed it would be beneficial to give an exemplar answer for the students with emphasis on the key words or phrases.
- Teachers need to give students more experiences in problems which are challenging or unfamiliar.
- Candidates should perform and evaluate a variety of experiments. Students should develop an understanding of ***the purpose*** of each step in a procedure and evaluate results including uncertainties and their implications.

Standard level paper two

General comments

The number of candidates who sat this paper was 2670, divided almost equally between English and Spanish, with a small number of Japanese candidates. There was a variety of performance levels on this paper with the candidates answering in English outperforming the candidates answering in Spanish, as there was a weak cohort in some of the Spanish-speaking schools. Some candidates were well prepared and tackled the paper with confidence, while others, possibly retake candidates, were unsure of concepts and did not demonstrate understanding.

There were no problematic questions on the paper, although students seemed to struggle when questions were presented in a new format, such as sketching the orbital diagram of the valence shell of a bromine atom on an energy axis or predicting the salt formed from an acid-base reaction. The nature of science question which invited candidates to comment on the accuracy of the value they obtained using Hess's Law was particularly challenging but was tackled with some success by over a third of the candidates.

Thirty teachers sent feedback about the paper. They thought the paper was well presented and had a good coverage of topics. They thought the questions were clear and liked the fact that candidates often had to provide reasons for their answers. Some teachers felt that the paper included more "unseen" questions and unusual substances than the November 2017 paper make it slightly more challenging. Specific comments about questions are covered in the section on individual questions. There was no evidence that candidates did not have enough time to complete the paper as all questions were attempted by most candidates, and the mean mark in English (23.75 out of 50) was slightly higher than November 2017 (23.32 out of 50) indicating the paper was not necessarily more challenging.

Teachers also sent the following feedback:

The best description of the difficulty of the paper

Too easy	Appropriate	Too difficult
0.00%	86.67%	13.33%

The best description of the difficulty of the paper in comparison with last year's paper

Much easier	A little easier	Of a similar standard	A little more difficult	Much more difficult	N/A
0.00%	10.00%	56.67%	26.67%	3.33%	3.33%

Clarity of wording

Very poor	Poor	Fair	Good	Very good	Excellent
0.00%	0.00%	10.00%	23.33%	50.00%	16.67%

Presentation

Very poor	Poor	Fair	Good	Very good	Excellent
0.00%	0.00%	0.00%	20.00%	60.00%	20.00%

In terms of accessibility and bias, all teachers who sent feedback agreed that the paper was accessible to candidates of different genders, ethnicities and belief systems, and that it was accessible to candidates with learning support.

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

- Determination of enthalpy change of reaction from experimental data
- Sketching orbital diagrams
- Balancing redox half-equations and full equations
- Using the reaction quotient to predict direction of reaction
- Equations for the reactions of weak acids and bases with water
- Comparing the strength of the same type of intermolecular forces in different substances
- Deducing the formula of a salt formed from an acid-base reaction
- Using a Hess's law cycle
- Commenting on the accuracy of enthalpy change values

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

- Determination of the limiting reactant
- Calculation of percentage yield
- Sketching concentration-time graphs
- Explaining effect of surface area on rate of reaction
- Classification of alcohols
- Oxidation of alcohols
- Deducing oxidation states
- Electron configuration
- VSEPR theory
- Explaining trend in atomic radius
- Identifying an addition reaction

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

Question 1

(a)(i) Most candidates calculated the amounts of the two reactants and determined the limiting reactant correctly. Mistakes included not rounding numbers correctly and power of ten errors in the answer (for example 0.160 instead of 0.0160).

(a)(ii) The majority of candidates were able to calculate the theoretical and percentage yield of copper.

(b)(i) This question was found challenging by the majority of candidates. M1 was obtained by about 40% of the candidates. The main mistake in M1 was using an incorrect value of mass in $q=mc\Delta T$. M2 was only obtained by a minority of candidates. Most candidates did not divide q by the number of moles of limiting reactant. Those who did, still had to remember to include the negative sign of the enthalpy change in order to score the mark. One issue in this question was that the question asked for ΔH in kJ which can be used as the unit of the enthalpy change of a given reaction. If kJ mol-1 were used as the units of ΔH in the question it might have reminded candidates to divide q by the number of moles.

(b)(ii) Candidates were generally aware of the assumptions when calculating enthalpy change of a reaction occurring in aqueous solution from experimental data. The most common answer was assuming the specific heat capacity of the solution was the same as pure water.

(b)(iii) About half of the candidates calculated the percentage uncertainty in the temperature change and many of them continued to determine the absolute uncertainty in the calculated enthalpy change. ECF was applied for the answer obtained in (b)(i).

(c)(i) A very well answered question. The majority of candidates sketched the curve for the concentration of product against time as the reaction proceeded obtaining both marks. Mistakes included a straight line for part of the graph and sloppy curves that were excessively bumpy and included a drop in the concentration at some point.

(c)(ii) More than 50% of the candidates recognized that the initial rate is equal to the gradient at time = 0. Fewer candidates also recognized the need to draw a tangent to the curve at time = 0 and measure its gradient.

(c)(iii) A very well answered question. The majority of candidates explained the change with correct references to surface area and frequency of collisions. There was a minority of candidate who said "less collisions" without reference to time, failing to score M2.

Question 2

(a) The majority of candidates drew the structural formula of propan-2-ol correctly. However, some candidates were not careful in connecting the O of the OH to the carbon.

(b) About 60% of the candidates calculated the number of hydrogen atoms in 1.00 g of propan-2-ol correctly. Some candidates only obtained one out of the two available marks by forgetting to multiply by the number of H atoms in the molecule or making a calculation error.

(c) The majority of candidates classified propan-2-ol as a secondary alcohol giving clear and accurate reasoning. Some candidates lost the mark because of lack of accuracy in the reasoning.

(d)(i) The majority of candidates suggested a suitable oxidizing agent. Dichromate(VI) was the most common answer.

(d)(ii) The majority of candidates deduced the average oxidation state of carbon and expressed it in the correct format. Some teachers who sent feedback were worried that the term "average oxidation state" would be unfamiliar. The term was used in previous papers, for example in November 2016, and the question was well answered indicating this was not an issue for candidates.

(d)(iii) About half of the candidates deduced that the product of the oxidation was propanone. The most common incorrect answer was propanoic acid.

Question 3

(a)(i) 70% of candidates gave the correct electron configuration of Br. Some candidates promoted an electron from 4s to 4p to give [Ar] $4s^1\ 3d^{10}\ 4p^6$. Others had fewer electrons than 35.

(a)(ii) The answers were rather disappointing for this question probably because it was an "unseen question". Some candidates did not limit the diagram to the valence shell, and others included the 4p subshell only, failing to read the question carefully. Some candidates did not have the subshells at the correct energy relative to each other. 30% of candidates scored the mark.

(b) 40% of the candidates drew a Lewis structure for BrO_3^- that obeyed the octet rule. Mistakes included Lewis structures with an expanded octet and missing or incorrect numbers of lone pairs. The majority of candidates did not include the charge of the ion, which was not penalized this time but should have been included. Some teachers were concerned that BrO_3^- was a challenging species for SL students.

(c) The majority of the candidates predicted the molecular geometry and O-Br-O bond angle correctly. Most of them also gave good reasoning in terms of the VSEPR theory. ECF was awarded for Lewis structure drawn in (b).

(d)(i) This was a challenging question and only about 20% of the candidates deduced the half-equation. Some candidates had the wrong reactants and products even though they were given the information in the question. Some teachers commented that this was a challenging question for SL students, however, such questions are needed to discriminate between stronger candidates.

(d)(ii) 30% of the candidates deduced the redox equation, including those who had an ECF from their answer in (d)(i).

Question 4

(a) The question was well answered by the majority of the candidates. However, a significant proportion of candidates only obtained one of the two marks by discussing the increase in the number of protons without reference to shielding or the number of shells.

(b)(i) Only about a third of the candidates recognized that Na^+ had more protons than O^{2-} and about a quarter of the candidates recognized that the two ions were isoelectronic. Many candidates did not answer the question and simply compared the radius of Na^+ with Na and O^{2-} with O.

(b)(ii) 40% of candidates stated a correct physical property of Na_2O. Mistakes included giving a chemical property or a physical property of a metal.

Question 5

(a) Half of the candidates knew what homogeneous meant.

(b) About a third of the candidates used the reaction quotient to determine the direction the equilibrium proceeds. Incorrect answers often failed to compare Q with K_c but rather they stated Q > 1. About half of the candidates were able to score M1 by at least giving the expression for Q, although there were many attempts that had incorrect powers in the expression.

Question 6

(a) It was disappointing that less than 40% of the candidates stated equations for the reactions of butanoic acid and ethylamine with water, even though the question stated that they were a weak acid and a weak base respectively. Some candidates gave the correct reactions but lost a mark for not including a reversible arrow.

(b) The answers to this question were usually incomplete. About 50% of candidates obtained a mark for the stronger London dispersion forces between butanoic acid molecules but very few gained the second mark. Many candidates thought ethylamine did not have hydrogen bonding between its molecules. Some candidates stated that both substances had hydrogen bonding but did not attempt to compare the H-bonds formed by each substance. The question had a good discrimination index.

(c) This question was the most challenging question on the paper. Only 10% of candidates deduced the formula of the salt formed. Some teachers who sent feedback wondered whether this question went beyond the scope of the syllabus. It is a borderline case but some candidates were able to deduce the products of the reaction and hence the ions in the salt using BrØnsted-Lowry theory.

Question 7

(a) A very well answered question. The majority of candidates identified the reaction in step 1 as an addition or hydrogenation reaction.

(b) Only 30% of the candidates calculated the standard enthalpy change of step 2. The majority gave the enthalpy of combustion of ethene without adding the enthalpy of combustion of hydrogen. Some teachers who gave feedback commented that the cycle was quite challenging.

(c) 40% of the candidates used the cycle to obtain the standard enthalpy change of step 1. Many candidates obtained the mark as ECF. Mistakes were mainly in the signs of the enthalpies of combustion.

(d) This nature of science question was one of the most challenging questions on the paper. Some candidates scored marks by saying the values were specific to the compounds rather than average values, and others recognized that the values of enthalpy of combustion in the data booklet were experimentally determined and hence had uncertainties. Teachers who sent us feedback commented that the majority of candidates found this question confusing. It is pleasing that 40% of the candidates were able to give valid suggestions and score one mark on the question.

Recommendations and guidance for the teaching of future candidates

- A conceptual approach to teaching helps the students to apply the concepts in different situations.
- Provide plenty of opportunities for students to apply the concepts and write explanations.
- Practice determination of enthalpy change of reaction using experimental data, paying attention to the sign of the enthalpy change of reaction.
- Discuss the relative strength of each type of intermolecular forces in different substances.
- It is better to use a variety of weak acids and bases when practicing BrØnsted-Lowry acid-base reactions and not limit examples to ethanoic acid and ammonia.
- Student should work accurately and avoid early rounding of numbers during a calculation which leads to final answers that are far from the expected answer.
- Please remind students to pay attention to bonds connecting to the correct atoms when drawing structural formulas.
- Encourage students to explicitly respond to the prompts in the question (e.g. Lewis structures that obey the octet rule, energy diagrams for the valence shell).
- Incorporate discussions on the nature of science and TOK links within the coverage of the course.

Higher level paper three

General comments

Based on the 25 G2 comments received, 100%, of teachers found the examination paper to be of an appropriate standard in terms of level of difficulty. 72% of the teachers stated that the paper was of a similar standard to N17. 12% considered it to be slightly more difficult. Only 9% considered the paper slightly easier.

Few G2 comments were given by teachers for this session which seems to suggest that the paper was very well received.

Based on feedback received from examiners, general consensus was that the overall paper was highly accessible with a good spread of easy and challenging questions throughout each Section and Option. Most examiners deemed the paper to be slightly less challenging than in N17. The biggest difference for most examiners appeared to be a very accessible Section A and overall a much stronger performance by candidates on this Section. In addition, there appeared to be a number of questions, particularly in Option D which appeared on recent papers and hence candidates were well prepared for these stock, off-the shelf answers. Performance was strong across a number of general areas such as interpretation of graphical data and numerical calculations in general. NOS based questions still appear problematic for candidates however. Overall the cohort appears to be slightly better in N18.

As regards the clarity of wording on the paper, the following were the approximate statistics, based on G2 feedback: excellent – 20%, very good - 60%, good - 16%, fair – 4%. The corresponding approximate statistical data for the overall presentation of the paper was as follows: excellent – 32%, very good - 52%, good - 12%, fair – 4%.

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

- Serial dilutions
- NOS based questions
- Titration involving iodine-thiosulfate
- Lewis structures
- Solid-state chemistry

Section A

- Serial dilutions
- NOS based questions
- Titration involving iodine-thiosulfate
- Significant figures

Option A – Materials

- Solid-state chemistry calculations

Option B – Biochemistry

- Iodine number calculation
- Structural components of amino acid sequence responsible for hydrogen bonding
- How O_2 affects hemoglobin shape

Option C – Energy

- Idea of a breeder inn breeder reactors
- Lewis structure of superoxide
- Conversion of coal and steam to methane
- Importance of carbon dioxide and methane as greenhouse gases
- Equations at electrode for discharge process of a lithium-ion battery

Option D – Medicinal Chemistry

- Solvent extraction
- Explanation of targeted alpha therapy (TAT)

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

There was good evidence that candidates demonstrated multiple skills and conveyed competency in several core areas of the programme:

- Numerical calculations –well executed this session compared to previous years
- There was a marked improvement in the overall performance in Section A, especially for the data-based question. Interpretation of graphical and tabular data was very good
- Addressing significant figures in numerical problems

Section A

- Interpretation of data in graphical question
- Idea of complementary colour
- Calculation of percentage of copper in the alloy

Option A – Materials

- Functional groups
- RIC
- Electrochemistry calculation

Option B – Biochemistry

- Enzymes

- Proteins

Option C – Energy

- Nuclear reactions
- Half-life calculations
- Specific energy
- Transesterification
- The relationship between conjugation and absorption of light

Option D – Medicinal Chemistry

- Penicillin
- Opiates
- Chiral auxiliaries
- Buffer calculations
- Half-life calculations

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

Section A

Section A in N18 was found to be highly accessible to candidates with most gaining a high percentage of the allocated marks. This was a welcome change to previous sessions and shows that performance on the data-response question appears to be improving. 1(g) proved to be a good discriminating question.

Question 1

(a) Most stated that the gases produced are toxic etc.

(b) This was very well answered and most scored the two marks for $y = 40\,x$.

(c) Most scored the two marks here.

(d) Knowledge of dilutions was poorly understood, especially in terms of the essential glassware required.

(e)(i) Many scored all three marks for 64%.

(e)(ii) The most common errors were 1 SF and 3 SFs.

(f)(i) Well answered.

(f)(ii) The most common answer was resistant to rusting.

(g) Poorly done – looks like not many candidates had actually done this titration in practice!

Option B – Biochemistry

This was the second most popular option taken by candidates. Candidates performed reasonably satisfactory on this Option but even the better candidates dropped marks on certain questions.

Question 6

(a) ATP was probably the most popular answer; respiration was given as frequently as glucose. Catabolism hardly seen.

(b) Most scored the mark here for not enough sunlight.

(c) M1 difficult for many - solubility in fat was the most popular answer. M2 vague in many cases - it was not stated that the concentration of the xenobiotic increased up the food chain.

Question 7

(a) Could have been much better answered. Many did not refer to the idea of the sequence of the bases.

(b) The most common answers were for long-term effects unknown or causing allergic reactions.

Question 8

(a) M1 scored well (as it should have been) but few candidates could accurately state that the H-bonds form between C=O and N-H groups. Many scripts discussed alpha helices and beta pleated sheets for M2.

(b) Well done on the whole - this topic is well-rehearsed.

(c) Again, many good answers. Errors centred around effects on V_{max} and K_m rather than action of the inhibitor.

Question 9

(a) Many correct answers. Errors largely due to incorrect number of C=C bonds identified.

(b) Very well done.

(c) Well answered.

Question 10

(a) Generally fine - most common error was 'ether'.

(b) Generally fine - most specified C-4.

(c)(i) Best answers given in terms of alpha and beta glucose. Where explanations of structures were given instead, candidates were much less secure.

(c)(ii) Some good responses.

Question 11

(a) Poorly done. Many simply described the shape of the curve. Some scored M2 for cooperative binding but rarely M1.

(b) Reasonably well done.

Option C – Energy

The third most popular option. Although it was deemed that the Option overall was accessible to candidates, few scored very high marks.

Question 12

(a) Not well-answered. M1 more successful than M2 - many wrote about the energy released.

(b)(i) Very few correct answers seen - if any. This topic is not known / understood.

(b)(ii) Reasonably answered but the most common error was to show the production of only 3 neutrons instead of 4.

(c) Good responses - even if equations were abandoned in favour of writing out the % remaining after each of the successive 8 half-lives!

(d)(i) Remarkably difficult -very few correct answers seen - either insufficient electrons were shown or the negative sign was omitted.

(d)(ii) Very few correct answers. M1 was frequently omitted and M2 saw vague responses- e.g. mutations (without specifying what).

Question 13

(a) Poorly answered - far too many responses gave O_2 as a product rather than CO_2.

(b) Good responses here – but nearly all gave 'H_2 higher specific energy' … which is the most obvious answer from the data given. Candidates did not have to extend themselves here at all!

(c) Many got 50.6 kg but not many scored M2 for 156 kg.

Question 14

(a) Good responses for both marking points - 'renewable' and 'weather dependent / not available a night' being the most popular responses.

(b)(i) Many just wrote viscosity, which scored the mark.

(b)(ii) Very good - 'transesterification' was the most common correct answer given.

(c) Not well-answered at all - either on relative abundance or relative effectiveness at absorbing IR radiation. GF or GWP were not mentioned at all.

(d) Overall, equations were poorly written both in the chemistry expressed and also not recognising that the reactions are equilibria. If M2 was scored, it was via the option given in the MS Notes. Many of the top end candidates recognized this from previous examination papers and scored both marks. Done better than previous sessions but still problematic for the weaker candidates.

Question 15

(a) Well answered.

(b) Poorly done. If any marks were scored then they were for M1 and very rarely for M2.

(c) Generally good but most frequent errors were to use n = 1 rather than n = 2 and/or not be able to convert the ln value into the answer. Calculator / mathematical skills lacking here.

(d)(i) Most got the idea of conjugation.

(d)(iii) Any correct answers were usually of the 'large surface area' variety.

(d)(iv) Surprisingly well done.

Option D – Medicinal Chemistry

This was the most popular option taken by candidates in Section B and in general the standard of responses was satisfactory across this Option with a lot of accessible parts. Some of the questions were broadly similar in nature to those asked on previous examination papers so many candidates were able to give stock, off-the shelf correct answers.

Question 16

(a) This question on the internal bond angles in the beta-lactam ring was typically well answered though some candidates mixed up the ideal angles for sp^2 and sp^3 hybridization.

(b) Most candidates had seen how this question was answered in the past and hence had no difficulty in gaining the two marks.

(c) Most candidate knew that the structure of penicillin can be modified to combat the effect of resistance caused by over prescription by modifying the side-chain.

(d) A high percentage of candidates stated correctly that cells in humans do not contain cell walls.

Question 17

(a) Generally fine with many candidates scoring both marks - the common error was to omit 'hydrophobic/non-polar/made of lipids' for M1.

(b) The most common mistake was candidates stating “amount” instead of “fraction”. Few gave the correct answer, but the majority gained the mark for stating that bioavailability is the fraction of the administered dosage that reaches the target.

Question 18

(a) Very good - the most common error was to invert the ratio resulting in [1 max].

(b) Very good but no ionic equations seen. A few incorrectly stated that the formula for calcium chloride is $CaCl$, and not $CaCl_2$.

(c) Very poor - and titration was the only technique in the MS that was seen. Mostly descriptions of what to do were given. On reflection although the original MS indicated that the name of the technique was required this might have been rather demanding. A common question with SL and maybe we could have been more open with the MS with respect to the acceptance of other possible answers.

Question 19

Reasonably well answered though many did not give entirely precise answers.

Question 20

Many scored the two marks here. Ozone depletion was the most common response. That chlorinated solvents are toxic was also frequently given. There were also the usual environmental concerns given.

Question 21

(a) Very well done in general though some did incorrectly circle more than two atoms.

(b) M2 usually scored but responses for M1 quite often omitted reference to stereochemical conditions / induction.

(c) Many answers were in terms of chiral auxiliaries! Some candidates have a working knowledge of solvent extraction but many others gave vague responses. Poorly answered in general and a good discriminating question for Option D at the upper 6/7 boundary.

Question 22

(a) Much better answered than in previous sessions and most were able to cite the correct answer, based on their knowledge of previous examination paper responses for TAT.

(b)(i) This calculation was very well done though a few gave 39% instead of 0.39%.

(b)(ii) Less than half gave the correct answer of (some form of) excretion - the rest wrote about radioactive decay.

Question 23

(a) GC was the most common and correct answer given.

(b) Colour change always correct (except when confused for manganate(VII)). 'Acidified' often omitted for M1. Some candidates mixed up the two methods and those who chose the fuel cell fared better than those who chose the 'original form' of the breathalyser.

Recommendations and guidance for the teaching of future candidates

- Legible handwriting should be encouraged – there was evidence again of a noticeable number of scripts this session where examiners struggled in trying to decipher what was written in several responses.

- It is critical that core chemical principles are brought to the fore in the Options, especially those which have often a twin biological focus e.g. Biochemistry and Medicinal chemistry. Core chemistry should always underpin applied topics. This is a major feature of the new curriculum.
- Candidates often struggle with questions that require explanations or multiple steps. Candidates need to fully understand the various command terms and teachers should take time to review with candidates the various command terms (across all three objectives) throughout the two years of the programme to ensure they understand how to answer questions.
- Candidates should prepare for the examination by working through past examination questions of the new syllabus (as they come on stream) and carefully study the markschemes provided. In addition, it is critical that candidates are continuously challenged throughout the delivery of the programme by NOS-based type questions. Candidates need exposure to data-based scientific problems involving unfamiliar situations, and should be capable of interpreting graphical representations, critique and interpret data and draw logical conclusions involving scientific methodologies.
- It is imperative that laboratory work lies at the heart of the IB chemistry programme. Ideally candidates should be exposed to a comprehensive experimental experience in the laboratory where suitable facilities are available. Where this is not the case other resources such as simulated experiments should be sourced. If an analytical technique is required by an Option and students are required to know the steps, then ideally the technique should be performed in class or via a simulation.
- Environmental chemistry should be integrated in linked topics throughout the delivery of the programme. This strand is also present across all four options and is of prime importance in the syllabus. Consideration of Aim 8 of the programme is worth emphasizing in this regard.
- Bond connectivities should be emphasized.

Standard level paper three

General comments

In general, we saw an improved performance on this paper for the November 18 marking session. More candidates were well prepared for the paper and a few had answers that were excellent. However, there were still a significant proportion of candidates who did not manage to achieve a satisfactory mark. Their answers were very weak indicating that the option may have not been covered during the course and/or their practical programmes were not fully supportive for developing much needed skills based on the prescribed laboratory curriculum. In Spanish, the number of students not receiving any mark was quite low and this is very encouraging. Performance in Section A once again improved from previous sessions even when some questions were still challenging for many students.

We received detailed feedback from very few teachers this session. The teachers responding found this paper to be of appropriate difficulty (90%) with 7% describing it as too difficult and 3% describing it as too easy. When compared to last year's paper 70% of the teachers felt it was of a similar standard, 10% felt it was a little easier, 13% felt it was a little more difficult, and 3% felt it was much more difficult. In terms of clarity of wording all the teachers felt that the paper was good to excellent. The presentation of the paper received similar comments all teachers describing the paper as good to excellent. The teachers responding agreed that the questions were somewhat to strongly accessible to all candidates with learning support and/or assessment access requirements and they felt the questions were accessible to all candidates irrespective of their religion, belief system, and/or gender and irrespective of their ethnicity. Teachers are reminded that special education students can apply for additional time or other examination accommodations as appropriate such as the use of molecular modelling kits when molecular diagrams are too challenging to visually interpret. Please discuss this with your IB Coordinator.

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

- Preparing dilutions in section A
- Stoichiometry problems in applied situations
- Errors in titrations
- Explanation of the plasma state
- Intermediate bonding
- IMF as applied to polymers
- Catabolism
- Conversion of units and use of logarithms in buffers
- Iodine number calculations
- Groups involved in hydrogen bonding in proteins
- Names of basic techniques suitable for given systems

- Discussion questions related to equilibrium in a different context

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

- In the Options, candidates performed better when questions were based on factual information rather than when an interpretation was required.
- Questions that could be answered using algorithms were typically well answered even by weak candidates.
- Many candidates showed satisfactory graphical skills especially when analysing and interpreting the data in Section A as well as answering questions concisely.

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

Section A

Question 1

(a) Many candidates scored here. Common mistakes were to vaguely state that the purpose of a fume hood was to contain gases. Some candidates also mentioned it was to avoid light interfering with reactions.

(b) A well answered question.

(c) This was rather disappointing and confirms findings in Internal Assessment. While many candidates obtained one of two marks resulting from correctly naming needed glassware, most answers showed poor or no understanding of correct techniques. Some answers were not referring to the correct ratio or referred to beakers or graduated cylinders instead of correct glassware.

(d)(i) Most candidates were able to identify the concentration of copper from the graph and achieved one mark. The number of candidates achieving full marks was much lower due to difficulty with the calculations.

(d)(ii) Many correct answers. However, many students lost this mark as they stated the significant figures they ended with for 1di.

(e)(i) Many good answers but sometimes candidates who had obtained an incorrect % below 60% provided the argument for 70% and as ECF lost the mark. Weaker candidates made no reference to reducing the presence of bacteria.

(e)(ii) In general, this was a well answered question. Those who failed to score usually mentioned vague, incorrect, or unrelated properties.

(f)(i) Many good answers, but not as many considering the level of challenge. Many students did not receive the mark because they left species in the equation that should have been cancelled out.

(f)(ii) Not well answered. Answers were general in character and failed to use information provided in stem. Students should be able to apply skills from lab and as described in the question to new situations if suitable data are provided.

Section B

Option A:

Very few candidates attempted this option with approximately 3% of papers containing student responses. Many of the responses were weak.

(a) Not well answered. Candidates showed a poor understanding of topic and those who scored were typically awarded the mark from M1.

(b)(i) This was poorly answered. The usual problem was making no mention of IMFs.

(b)(ii) There were some good answers here.

(c)(i) Not very well answered even when this type of question has often appeared in previous sessions.

(c)(ii) Poorly answered showing shallow understanding of topic.

(d) This question had many good answers.

Question 3

(a) Those who attempted a reply usually made no use of positively charged particles or ions.

(b) Stronger candidates fully scored here.

(c) Most candidates scored at least one mark. Lack of correct conversion of units was a common mistake.

Question 4

(a) This was very poorly answered. Perhaps the historical context confused students.

(b) Many candidates showed some understanding but not enough to provide answers that deserved a mark.

(c) Only stronger candidates answered this question correctly.

Option B

This was a very popular option with approximately 34% of candidates attempting Option B. Many students appeared well prepared for this option.

Question 5

(a) Many students received a mark for ATP rather than the expected answer of catabolism or cellular respiration. Most common answers included just 'food' or referred to sunlight.

(b) A well answered question but one that raised some concerns as many candidates consider that vitamin D is transported with light.

(c) Most candidates scored at least one mark, usually by correctly addressing accumulation in the food chain. Stronger students also obtained the first mark but not many acknowledged the accumulation in lipidic tissues.

Question 6

(a) Not very reassuring. Many candidates correctly identified the relevance of hydrogen bonding but not the functional groups involved. Most candidates referenced general protein secondary structures such as alpha helixes or beta sheets which did not receive a mark.

(b)(i) This was a well answered question. Most candidates scored at least two marks and many fully scored

(b)(ii) This question was not well answered. Arguments usually vague or referred to contents already presented in previous question (6bi).

Question 7

(a) A significant number of students scored one mark usually by stating glycerol, but the most common mistake was to suggest phosphate(s) as second product. Very few students were able to identify the second product.

(b)(i) A poorly answered question. Some candidates identified a wrong number of double bonds - ranging from one to five potentially including the carbonyl as a double C to C bond and obtained at least one mark through ECF.

(b)(ii) This was a very well answered question.

(c) Many candidates provided good answers to this question and received a mark.

Question 8

(a) A question well answered by many. However, many spelling mistakes were found.

(b) A relevant number of candidates evidenced having a good general idea but failed to convey it properly. A common mistake included mentioning both C1 and C4.

Option C

This was a reasonably popular option with approximately 23% of the candidates selecting Option C. Students appeared better prepared for Option C this session.

Question 9

(a) Many students fully scored here. References to 'atoms' rather than 'nuclei' was less often found than in previous sessions, but binding energy continues to challenge as many students referred to it as 'the energy released' (b)(i) This question was very poorly answered. Many students failed to convey the idea of converting non-fissile material into fissile material and simply repeated the material given in the question.

(b)(ii) This question had many correct answers.

(c) A well answered question but often through use of algorithms rather than of deep understanding. Integrating the option with kinetics could improve deeper understanding.

Question 10

(a) Many students responded correctly with both alternative answers seen during the session.

(b)(i) Many candidates answered correctly although weaker students used wrong values in the table.

(b)(ii) Many students scored here, even those who had lost the mark in previous question due to Error Carried Forward (ECF).

(c) A significant number of candidates scored the first mark, but only stronger candidates also obtained M2.

Question 11

(a) There were many good answers and most candidates received both marks.

(b) While many candidates correctly identified the correct molecule and reasons for absorbing visible light, they did not receive the mark as they failed to realize molecule B had a more extensive conjugated structure.

(c)(i) This was very well answered even by weaker candidates.

(c)(ii) This was well answered with 'transesterification' being the most popular response.

(d) This question was better answered than in previous session, but a deeper understanding of this concept continues to be an issue. A significant number of students scored one mark by stating that CO2 was more abundant but failed to score the second mark.

(e) This was not very well answered. Lack of correct symbols for the equilibrium arrows in the equation and states of matter resulted in many candidates losing M1. The use of equilibrium in the explanation was not often found or poorly conveyed. This reinforces the importance of integrating Options with core content.

Option D

This was a the most popular option for the November SL 2018 session with approximately 40% of the candidates selecting Option D. Students appeared reasonable prepared for this option although they struggled with the calculations.

Question 12

(a) A majority of students stated the first angle correctly and many also a second but not the required three. A common mistake was to suggest 107o.

(b) This was better answered than in previous sessions. However, even when replies showed some evidence of correct knowledge of content not many candidates obtained both marks.

(c) Bacteria developing resistance was by far the most common argument in a question where many achieved the mark. Weaker candidates used problems related to addiction.

(d) This question was well answered. Common mistakes in weaker candidates included replacing the beta lactam group or adding other functional groups. Both errors show shallow understanding of the topic.

(e) This was not as well answered as expected. However, many students provided correct answers.

Question 13

(a) More candidates made a good comparison between both compounds than in previous sessions and scored M1. Not as many identified the lipidic nature of the blood-brain barrier and lost M2.

(b) This question was better answered than in previous sessions. Weaker students failed to mention brain or CNS and hence lost the mark.

(c) This was generally, well answered. Weaker students refer to bioavailability as possibility of having access to the drug or used vague terms such as 'enters the body'.

Question 14

(a) Calculations of pH and buffers continues to be a challenge for many students. However, as ECF was applied a significant number of students achieved one mark. The lack of skills when working with logarithms or correct understanding of equation was commonly found.

(b) This was a well answered question although some students did not have correct formulas, did not balance the equation correctly, or did not have water and carbon dioxide as products (dissociated form of carbonic acid).

(c) This was very disappointing. Students read the question and responded incorrectly. It asked for a 'technique' and many students provided steps of a methodology instead which did not receive a mark without a correctly named technique.

Question 15

(a) This question continues to challenge students but more of them provided solid differences.

(b) Only stronger candidates fully scored both marks for this question.

Question 16

(a) Even weak candidates achieved at least one mark, usually by identifying that solvents were toxic and many relating them to ozone depletion.

Recommendations and guidance for the teaching of future candidates

- The experimental laboratory programme should be integrated with the rest of the course and students should be familiar with the application of lab techniques for all topics and the options taught. Titrations are very common techniques and their relevant sources of errors should be properly understood. Students should be familiar with the different types of glassware and how to prepare dilutions themselves (not just work with prepared solutions).
- It is critical that core chemical principles are taught along with the options. Core chemistry should always underpin applied topics and content that is directly related should be emphasized.
- Candidates continue to struggle with questions that require explanations, interpretations or multiple steps. Very often they address one part of the question while neglecting the others.
- The interpretation of command terms continues to be an issue. Students should be provided with a list of the command terms and their definitions, so they are familiar with expectations for each individual term and how they are applied in a variety of questions and responses.
- Candidates should always look at the associated mark allocations in each question. Together with the command terms the marks provide guidance on the depth expected by examiners for each answer.
- Teachers should provide training during the course in addressing question and producing concise arguments. Superfluous comments achieve no extra mark and may lead the student to lose focus.
- Students are not required to answer questions in complete sentences. They may focus their responses as bullet points or tables.
- Converse arguments are accepted. For ESL/EAL students this may facilitate producing their arguments.
- Handwriting continues to be a problem with some responses being illegible. The IB Coordinators should be made aware of specific situations with enough time so that special accommodations may be arranged. Students should consider the type of pen used as well since some can smear or bleed through the paper making marking more challenging when scripts are scanned.
- Concepts related to Chemical Bonding and Intermolecular Forces should be integrated with most topics.
- Please encourage candidates to use A_r values in section 6 of the data booklet, round numbers correctly, and state their answers to calculations to an appropriate number of significant figures. Discourage rounding after each step or prior to reporting their final value.
- Train students to be specific in their answers using scientific terms, e.g. 'atoms' aren't synonyms of 'nuclei' or 'ions'. Candidates need to read questions carefully to ensure that they answer every part of the question as asked.
- Throughout the course, draw your students' attention to the implications of concepts as they are related to the environment. Suggestions are provided in the right-hand column in the programme guide. This should dissuade students from producing journalistic or vague answers.