

## CHEMISTRY

### Overall grade boundaries

#### Higher level

<b>Grade:</b>	1	2	3	4	5	6	7
<b>Mark range:</b>	0 - 18	19 - 34	35 - 46	47 - 57	58 - 67	68 - 78	79 - 100

#### Standard level

<b>Grade:</b>	1	2	3	4	5	6	7
<b>Mark range:</b>	0 - 16	17 - 31	32 - 44	45 - 55	56 - 64	65 - 75	76 - 100

### Higher and standard level internal assessment

#### Component grade boundaries

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

### The range and suitability of the work submitted

The November 2010 session evidenced a similar standard to November 2009 with a good number of schools submitting challenging work which reinforced learning and provided a suitable opportunity for assessment, and a proportion of schools that did not undertake a suitable practical scheme. Considering that the previous November session had been the first time these schools had addressed the newly revised criteria it may have been expected to see a further improvement this second time around.

A large number of students produced work that was well presented, with data recorded and processed appropriately and the procedure evaluated to a satisfactory extent. However, in many cases, despite the work being extensive and achieving well against most of the aspects, some obvious misconceptions were frequently evidenced. Typical examples of these common errors or misconceptions were: the confusion of current with voltage in electrochemical cells; the idea that cutting a piece of magnesium ribbon in half significantly increases its surface area; and that in a rate of reaction experiment the temperature to be held constant is the room temperature and not that of the reaction mixture itself. Students make mistakes but, unfortunately, on many occasions no marking comment from the teacher had picked up on these errors for the students' benefit.

The most disappointing issue to arise, yet again, with a small number of schools was that the work of some candidates was clearly guided by teachers, fellow candidates or unreferenced sources to a level well beyond that shown in the instructions. It was unfortunately not uncommon in these schools for all candidates to choose exactly the same variables, carry out an identical procedure, or follow through with identical methods in complex calculations, while the instructions provided had indicated an independent, open-ended task. At best this could be considered poor practice for failing to ensure that candidates carry out the task legitimately for themselves and, in some cases, the moderators had to file Problem Report Forms (PRF) citing malpractice. Teachers should ensure that assessment is carried out in good faith and that an individual's skills are being assessed. There are many legitimate school-based strategies that can address at source the problem of work that is quite possibly plagiarised or a result of collusion. Teachers should make every effort to ensure that such work does not find its way into a student's I.A. portfolio, or contribute in any way to any student's I.A. mark. If a moderator has a well founded suspicion of malpractice then the reporting procedure leaves very little room for discretion and the outcome for the students will be serious.

### **Candidate performance against each criterion**

#### **Design**

Aspect 1: This was well addressed with most students being able to phrase a research question and identify most variables, thereby securing an award of at least Partial and in many cases Complete.

Aspect 2: This was the most challenging of the Design aspects and many students failed to identify any procedural methods to control or at least monitor the control variables that they had earlier identified as needing controlling

Candidates need to be explicit in stating how they intend to control the variables they have selected and exactly what data they will collect. For example, what equipment will be used at each stage (e.g. for measuring is it a 50 cm<sup>3</sup> measuring cylinder, or a cm<sup>3</sup> pipette, or a 50 cm<sup>3</sup> burette etc); the concentrations of vital solutions; they should address issues of 'limiting reagents' or if 'in excess'; the control and recording of temperatures; the measurement and recording of initial and final volumes. Another problem was the planned use of inadequate material, such as using litmus paper to establish pH.

Aspect 3: The clarification in the Subject Guide as to the minimum sufficiency of the data led to a good level of fulfilment of this aspect with most students able to design for the collection of data that would include repeats or would be sufficient to analyse graphically (enough to generate at least five data points in such a case).

#### **Data Collection and Processing**

Aspect 1: There was generally a good level of fulfilment with most candidates including uncertainties and relevant qualitative data.

Aspect 2: The level of fulfilment was encouraging. Most students made some attempt to process data appropriately, although following a calculation successfully through to its conclusion, or to plot a graph from which a quantity could be determined, remained demanding. Nearly all students secured at least Partial in both examples with many achieving Complete on at least one occasion.

Aspect 3: Many candidates tried to propagate uncertainties through a calculation although not always successfully. A significant number of candidates still could not construct a line of best fit on a graph and there were a significant number of inappropriate bar charts presented. Presentation of a final processed numerical quantity, which was cited to an inappropriately large number significant figures, was a common failing that prevented a significant proportion of candidates from achieving Complete.

### **Conclusion and Evaluation**

Aspect 1: Although most candidates could achieve some credit this was once again a demanding criterion. Generally only high-achieving candidates successfully placed numerical results in the context of a literature value and then identified whether the difference indicated the presence of systematic error, or could be explained by random error alone. Also only a small proportion of candidates presented any justification of their conclusions in terms of whether it was coherent with accepted theory.

Aspect 2: Partial was the most common award for this criterion with most students able to identify sensible sources of error but few being able to evaluate whether the source of error accounted for the direction of the deviation from a quoted literature value.

Aspect 3: This criterion showed wide variation, as it has in previous sessions, with many good responses but a similar number of very superficial or simplistic contributions. A common failing was for students to simply state that there should be 'more repetitions' and that unspecified 'more precise apparatus' be used.

### **Manipulative Skills and Personal Skills**

All schools entered marks for these criteria.

### **Application of ICT**

Most schools had checked the five ICT requirements at least once on the 4PSOW although the assessed work submitted rarely corresponded to these investigations, so it is hard to evaluate the appropriateness of the tasks.

## **Recommendations for the teaching of future candidates**

- Candidates should be made aware of the different aspects of the criteria by which they are being assessed and evaluation of investigations using a grid of criteria/aspects, with n, p and c indicated clearly, is strongly encouraged.
- It is essential to ensure that candidates are solely assessed on their individual contributions to any activity used for the assessment of the written criteria.
- Teachers must ensure that candidates have the opportunity to fulfil criteria and, hence, should not provide too much information for the students. The use of workbooks and worksheets with spaces to be filled in by the candidates is strongly discouraged for assessed work.
- All candidates, both Higher and Standard Level, need to record, propagate and evaluate the significance of errors and uncertainties.
- Candidates need to explicitly identify the dependent variable as well as the independent and controlled variables in the Design criterion.

- All investigations for the assessment of DCP must include the recording and processing of quantitative data. Solely qualitative investigations do not give the students the opportunity to fulfil this criterion completely.
- Teachers are encouraged to set some DCP tasks that will generate a graph that requires further processing of the data, such as finding a gradient or intercept through extrapolation.
- Candidates must record associated qualitative data where appropriate, as well as the quantitative raw data.
- Candidates must compare their results to literature values when relevant.
- When assessing the CE criterion, require candidates to evaluate the procedure, cite possible sources of random and systematic errors, and provide suggestions to improve the investigation following the identification of weaknesses.
- Teachers should follow the instructions found in the chemistry subject guide; the 'Teachers Support Material', and instructions provided in the up to date Handbook of Procedures for the Diploma Programme before submitting work for moderation.

### Communication with moderators

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

### Design Aspect 1

- Aspect 1 is really a two part aspect (R.Q. and then Variables). Complete for both parts then gets 2 marks, cp, pp, and p,n would all get 1 mark (a broad band admittedly) and (n,n will get zero).
- If a teacher has supplied the Research Question then this nullifies the first half of the criterion. However, if they have satisfied the second half partially (e.g. by correctly identifying a good number of control variables) then maybe Partial can be awarded overall for Aspect 1.
- If the teacher has specified the independent and control variables then the second half of the aspect is nullified automatically. It could be felt that it has also completely focussed the research question so the final Aspect 1 award could well be Not at All.
- If the teacher has identified just the independent or just a control variable then Partial can still be awarded.
- The teacher is allowed to specify the dependent variable when setting the task.

### When not to mark down in Design Aspect 1

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

## Design Aspect 2

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

## When not to mark down in Design Aspect 2

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

## Design Aspect 3

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

- If the candidate has designed the procedure so poorly that you feel that no relevant data would be collected then award Not at All.

If the candidate has planned for less than five data points (if a graph is to be produced), or has not planned for any repeats in quantitative determinations (e.g. titrations or calorimetry, etc) then award Partial. **Note that early copies of the Subject Guide p 26 is misleading on this matter. It seems to imply that when collecting data for a graph there should be at least five data points plus repeats for each one.** (It states "If a trend line is to be plotted though a scattergraph then at least five data points are needed, **so** the plan should allow for repeated measurements to calculate a mean (for example, repeat calorimetric determinations when investigating an enthalpy of reaction)").

The “so” was inserted by the editors after we had finished with it. The minimum expectation for complete is five data points but not the repeats. This has since been corrected in the guide available for download.

### The material/apparatus

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

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

### Data collection and processing

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

### DCP Aspect 1

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

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

- If a photocopied table is provided with heading and units that is filled in by candidates then the maximum the moderator can give is n = 0.
- If the candidate has only recorded qualitative data (e.g. colour changes in titration; observation of soot due to incomplete combustion in calorimetry; residual solid left in a beaker when reaction has excess solid reactant; bubbles being released when a gaseous product is formed are missing;) then the moderator gives partial.
- However, do not be overzealous and penalize Aspect 1 every time a candidate does not find qualitative data to record. Sometimes there is no obviously relevant qualitative data to record.
- If a candidate has not recorded uncertainties in any quantitative data then the maximum award is Partial.
- If the data or uncertainties are *repeatedly recorded* to an inconsistent number of decimal places then Complete cannot be awarded. Be sensible and support the teacher if there is just one single slip in a large body of data where all the rest is consistent with each other and the stated uncertainty. In tasks such as establishing a reactivity series too often candidates put in a reaction equation as opposed to an observation. This cannot be supported and will reduce the first aspect to ‘p’ or ‘n’ depending on how much other raw data is present.

**When not to mark down in DCP Aspect 1**

- When the candidate has not included any qualitative observations and you cannot think of any that would have been obviously relevant.
- You may support a teacher who has awarded complete when the candidate has reported uncertainties to a degree of precision that has satisfied the teacher as being consistent with the data. This may be to the same number of decimal places as the data or to an extra decimal place. e.g it may sometimes be appropriate to have recorded an instrument reading as  $25 \pm 0.5$  as well as the more usual  $25.0 \pm 0.5$ . There is precedent for both scenarios being correct.
- If, in a comprehensive data collection exercise, possibly with several tables of data, the candidate has been inconsistent with significant digits for just one data point; or missed units out of one column heading; and you feel the candidate has demonstrated that they were paying attention to these points and made one careless slip then you can still support the maximum mark under the 'complete does not mean perfect' rule. This is an important principle since often **good candidates responding in full to an extended task unfairly get penalised more often than candidates addressing a simplistic exercise**.
- When there is no table title but it is obvious what the data in the table refers to. I have seen candidates do all the hard work and then lose a mark from the moderator because they did not give the table a title. Except for extended investigations it is normally self evident what the table refers to, and the section heading Raw Data is sufficient. Once again 'c' does not mean perfect.

**DCP Aspect 2**

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

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

**DCP Aspect 3**

- If you cannot easily determine the candidate's method of processing then award Partial at maximum.
- The candidate must report any final quantitatively determined quantity to a number of significant figures that is consistent with the precision of the input data. Failure to do so will reduce the maximum award to partial.
- Do not punish inconsistent significant figures reported in the middle of a stepwise calculation if the final answer(s) is(are) reported appropriately.

- If there is no evidence of errors being propagated through a calculation then award Partial at best. Remember that a best fit line graph is sufficient to meet the requirement for error and uncertainty propagation.
- The error propagation should be correctly followed through to a reasonable extent according to either the TSM's protocol or another accepted protocol. Try to support the teacher if the candidate has made a sincere attempt even if there is a small flaw.

### When not to mark down DCP Aspect 3

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

### Conclusion & Evaluation

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

### CE Aspect 1

- This is another 'multiple aspect'. The conclusion can take many forms depending on the nature of the investigation. It could be a clear restatement of the determined numerical quantity (e.g. the molar mass or activation energy); a statement of the relationship found; and so on. Such a clear statement earns Partial. To secure Complete the candidate must comment on systematic/random error and, where appropriate, relate this to literature values. The comment on systematic/random error may well come after the sources of error have been discussed. This is fine.

### CE Aspect 2

- Look to see that a candidate has identified the major sources of error. There will always be other possible sources but I do not want to force candidates into overly long lists of trivial points just so that they feel they have covered the options. I am more concerned at the number of twenty page reports that we are increasingly seeing from diligent candidates that could have been condensed into a quarter of their length.
- There is no written requirement to state the direction of each error source so we are not looking for an explicit statement. However, the candidate's comments on significance of sources of error must be CONSISTENT with direction of error. For example, heat loss to the environment being considered the main source of error when the experimentally determined enthalpy value is actually greater in magnitude than the literature value and, therefore, implying another more major source of error in the other direction. This inconsistency would reduce the aspect award to Partial.



**When not to mark down CE Aspect 2**

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

**CE Aspect 3**

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

**Other Issues****Simplicity**

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

**Data logging**

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

**Higher level paper one****Component grade boundaries**

<b>Grade:</b>	1	2	3	4	5	6	7
<b>Mark range:</b>	0 - 10	11 - 16	17 - 22	23 - 26	27 - 29	30 - 33	34 - 40

**General comments**

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

Teachers' impressions of this paper were conveyed by the 13 G2's that were returned. 59% found that it was of a similar standard, compared with last year's paper, 8% thought that it was a little more difficult and 8% were of the view that it was much more difficult. 83% described the level of difficulty as appropriate and 17% thought that it was too difficult. Syllabus coverage was considered satisfactory by 25% and good by 75%. In addition, 62% felt that the clarity of wording on the paper was satisfactory and 38% felt that the wording was good. The presentation of the paper was considered satisfactory by 25% and good by 75%.

These statistics were also mirrored in the general comments, where it was generally felt that the paper was fair and straight-forward, albeit with some challenging questions.

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

The difficulty index (the percentage of candidates achieving each correct answer) ranged from 91.01% to 42.55%; and the discrimination index (an indication of the extent to which questions discriminated between high- and low-scoring candidates) ranged from 0.66 to 0.15 (the higher the value, the better the discrimination).

The following comments were made on selected individual questions:

### Questions 1 – 3

One respondent stated that it would be best to start HLP1 with a mole type question and that these first three questions could have potentially tripped up candidates at the beginning of this paper. It must be emphasised that P1 covers all topics on the syllabus and, hence, any question can be asked as an Objective 1 or 2 multiple-choice type question based on any of the corresponding AS's on Topic 1 - Quantitative Chemistry. As regards the questions themselves, none of these three questions, in fact, posed a significant problem for candidates. 76% of candidates got Q1 correct, 68% Q2 and 78% Q3.

### Question 15

On one of the G2's it was stated that this question was challenging as candidates are not used to dealing with three equations when the enthalpy change asked for specifically involves only two organic compounds. This question is based on AS 5.3.1 which states explicitly that candidates should be able to determine the enthalpy change of a reaction that is the sum of two or three reactions with known enthalpy changes. In this question three reactions were given with corresponding enthalpy change values of x, y and z. Hence, by fairly straight-forward manipulation of the reactions, the final enthalpy change of the given reaction could be determined as  $C = 2x + 2y + z$ . The question was answered correctly by 84% of candidates and in fact was found to be the seventh easiest question on the paper with a corresponding discrimination index of 0.32.

### Question 33

There were three G2 comments on this particular question, all of which suggested that the question was ambiguous as the nature of the electrodes was not stated for the electrolysis of aqueous copper(II) sulphate. Also noting the fact that candidates do not have access to a Data Booklet for P1. As regards the first point, it is a valid comment that the nature of electrodes could have been specified in the question itself.

However, on close examination of each of the first choices, it should be obvious to the candidate that inert electrodes were used as  $O_2$  is given as a product in all four cases. This would not be the case if copper electrodes were used. As regards the second point, it is also a fair comment that in the case of the electrolysis of aqueous copper(II) sulfate, candidates can work out the specific products using the standard electrode potentials from Table 14. of the Data Booklet. However, to do so, this would have made this question a clear Objective 3 type question which is outside the realm of P1. This was discussed at length at GA and it was felt that, realistically, candidates should have seen this electrolysis in the laboratory and, hence, as regards this particular electrolysis process candidates should have been able to determine the correct mol ratio of 2:1 for  $Cu:O_2$ . Although the question was, in fact, the hardest question on the entire paper, 43% of candidates did get the correct answer, C. Yet again this should emphasise the inherent importance of laboratory work as an integral part of the overall IB Diploma Chemistry programme.

### Question 36

One respondent commented that some candidates might choose C. (nucleophilic substitution) as the correct answer for this question instead of D. (reduction). Although this question is based on the overall sub-topic 20.2 (nucleophilic substitution reactions) from the guide, the question itself is based on AS 20.2.6, which mentions explicitly the **reduction** of nitriles using hydrogen and a nickel catalyst. The question was the fourth hardest question on the paper. However, 48% (almost half) of candidates got the correct answer (D.), with most in fact opting for A. of those that got it wrong. The least popular choice was, in fact, C.

## Higher level paper two

### Component grade boundaries

<b>Grade:</b>	1	2	3	4	5	6	7
<b>Mark range:</b>	0 - 14	15 - 28	29 - 39	40 - 49	50 - 58	59 - 68	69 - 90

### General comments

The range of marks awarded was very wide with the best candidates showing a thorough command of the material and a high level of preparation. The paper discriminated between those that knew the subject material and those that had a cursory understanding. Teachers' impressions of this paper were conveyed by the 12 G2 forms returned. In comparison with last year's paper, 67 % thought that the paper was of a similar standard or a little more difficult. 92 % considered the level of difficulty appropriate and 8% thought it too difficult. Syllabus coverage was considered good or satisfactory by 83%; clarity of wording good or satisfactory by 92% and presentation good by 100% of the respondents. It is difficult, however, to draw firm conclusions from such a small number of responses.

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

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

- Use of a temperature-time graph to deduce the temperature change that would have occurred if the reaction had taken place instantaneously.
- Formulation of a hypothesis of sufficient detail.
- Treatment of significant figures.
- Explanation of why low pressure is maintained in a mass spectrometer.
- Explanation of the conductivity of molten magnesium chloride and the production of hydrogen during the electrolysis of aqueous magnesium chloride.
- Description of the acidity of aqueous magnesium chloride.
- Explanation of the difference between theoretical and experimental lattice enthalpies.
- Description of the mechanism for the S<sub>N</sub>2 reaction with curly arrows.
- Description of observations that would distinguish a strong acid from a weak acid.
- Prediction of the bond angles in hydrazine.

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

Once again there were some excellent scripts seen from candidates, whose answers indicated detailed knowledge and understanding across the syllabus. Topics generally well answered included:

- Explanation of the formation of pi bonds.
- Calculation of relative atomic mass.
- Calculation of enthalpy changes from average bond enthalpies.
- Determination of the order of a reaction.
- Calculation of the pH of a weak acid.
- Application of Le Chatelier's Principle.

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

### Section A

#### Question 1

Many candidates found Question 1 challenging which underlines the need to make intensive use of ICT in the practical programme. Part (a) was quite well answered with many giving the assumption of no heat loss. In part (b) many had problems interpreting the graph and incorrectly read off both  $T_{\text{final}}$  and  $T_{\text{initial}}$ . The equation for the line had been included to help students but many were unable to apply it.

The time when the zinc was added,  $t = 100$  s, should have been used. Many students did not calculate the heat produced correctly as they confused the units, using  $50 \text{ cm}^3$  as the volume but not dividing by 1000 to give the answer in kJ as requested. A significant number of candidates mistakenly added 273 to the temperature change to convert it to kelvin. In part (c) most correctly determined the amount of zinc realising that copper sulphate was the limiting reagent but gave the answer to the wrong degree of precision. In part (d) many could correctly calculate the molar enthalpy change but omitted to give the negative sign which is essential for an exothermic reaction. Part (e) proved to be very challenging for many candidates with many hypotheses lacking precision. A common response was: "The more reactive the metal the greater the enthalpy change" with no reference to the exothermic nature of the reaction. Many struggled to sketch a graph to illustrate their hypothesis. This should have had a positive gradient and passed through the horizontal axis at the standard electrode potential of copper.

### Question 2

This question was generally well answered and many high scores were seen. Most candidates were able to explain the formation of  $\pi$  bonds in (a) and identify the type of hybridization present. Many candidates drew structures which were not geometric isomers in (b) with but-1-ene a common incorrect answer.

In (c) only the best candidates were able to identify a cycloalkane as a saturated isomer and it was fairly common to find structures that included double bonds despite the guidance in the question. The economic importance of addition polymers was well known in (d) with most candidates stating that they were plastics with versatile properties and low cost.

Addition polymerisation was well recalled but a large number of candidates made mistakes with the structure of the polymer. Continuation bonds, for example, were often missing from the ends. Many understood in terms of molecular size, why polymers have higher boiling points than monomers but not all correctly attributed it to the stronger van der Waals forces between the molecules.

### Question 3

This question showed that although many students knew about a mass spectrometer they did not necessarily fully understand the processes involved. A number of candidates discussed the deflection and acceleration of the ions with no reference to the electric and magnetic fields necessary and very few understood the need for low pressure to prevent collisions. Most candidates could correctly calculate the relative atomic mass of iron from the data although a few lost a mark by giving their answers to one or three decimal places despite the instructions in the question. Metallic bonding was a generally well-understood topic although some candidates were unable to give a clear explanation for the malleability of the metal. Many candidates identified the electronic configuration of Cu as an exception but the 3d electron was often removed in forming the ion instead of the 4s. Precision of language proved to be an issue in (e) with some candidates referring to Cu and Zn and not their ions and some students explained the colour as a result of "reflection" or "emission". In (f), many candidates mentioned proton donors and proton acceptors and made no reference to Lewis theory.

## Section B

Overall the question selection and candidate performance for 4, 6 and 7 was well balanced. Question 5, though the least popular choice, was generally the best answered question. This is perhaps significant as some candidates have the perception that organic chemistry is an inaccessible area of the course.

### Question 4

In (a) several candidates failed to mention atoms in their definition of first ionization energy and others neglected to state that the gaseous state is involved. Only the strongest students mentioned the electrostatic nature of the attraction between the nucleus and the electrons in explaining trends in ionisation energies. Several candidates lost a mark in explaining the increase between the tenth and eleventh ionisation energies as their arguments were incomplete, with no reference to the change from  $n=2$  energy level to the  $n=1$  level. In (b) many candidates stated that free electrons rather than ions were responsible for the conductivity of magnesium chloride and others did not refer to the movement of both  $Mg^{2+}$  and  $Cl^{-}$  ions. The anode was generally identified as the electrode where oxidation occurs but some had difficulties giving the balanced equation for the half reaction. Only the strongest candidates were able to explain why magnesium is not formed during the electrolysis of aqueous solutions. In (c) most candidates were familiar with the enthalpy changes of atomization and formation but some struggled with the Born Haber Cycle. Only the strongest candidates were able to relate differences in experimental and theoretical lattice energies to the covalent character of the solid with a significant number mistakenly giving "heat loss" as the reason for the difference.

In (d) many were able to correctly describe the basic nature of magnesium oxide but the acidity of magnesium chloride was less well known. Some gave hydrogen gas as a product in the reaction between magnesium oxide and water.

### Question 5

Although this was the least popular question in Section B there was generally a good level of performance. In (a) most candidates scored at least 2 out of 3 marks for calculating the empirical formula. Many, however, managed to give a correct molecular formula based on their background knowledge once they had determined the molar mass from the density calculation. The conditions and mechanism of free radical substitution were well known but the  $S_N2$  mechanism in (e) caused more problems. Again the use of curly arrows proved to be difficult. In some case they originated from the H not the lone pair on O of the nucleophile, or were missing from the C – Br bond. Another common mistake was the omission of a negative charge from the transition state. As the attack of the nucleophile is on the opposite side of the carbon atom to the halogen leaving, the partial bonds in the transition state should be drawn at 180 degrees. Candidates were not penalised however if they failed to do this. Most candidates were able to draw accurate 3D diagrams for the stereoisomers of 2-bromobutane, to deduce the rate expression from the experimental data presented in (g), and correctly identify X as having a tertiary structure. It was also pleasing to see that most were able to describe the  $S_N1$  mechanism.

**Question 6**

Equilibrium is a topic that has shown substantial improvement in recent sessions with some very well produced arguments. The reaction was correctly described as exothermic with a reason correctly given in most cases. Most candidates knew that yield would increase with increased pressure, but some failed to identify the change in the number of “gaseous” molecules as the reason. More candidates had difficulty with the equilibrium constant calculation often using the initial not equilibrium concentrations. In (b) most correctly defined strong and weak acids and many also wrote correct equations. A few, however, missed the equilibrium sign for hydrocyanic acid. HA, CH<sub>3</sub>COOH and HCl were commonly given instead of HCN and HNO<sub>3</sub>, suggesting that students sometimes have difficulty applying general concepts to specific cases. It was encouraging to see many candidates determine the pH from the pK<sub>a</sub> value including the assumption that there is negligible dissociation, as this has challenged students in previous sessions. A significant number of weaker candidates reported however that the acid solution would have pH values above 7. Part (c) presented problems with many candidates unable to describe specific observations related to rate which would distinguish between a strong and weak acid and simply stated that the reaction would be faster. The moles calculation was answered well in (d) with most candidates able to identify phenolphthalein as a suitable indicator. In (e), the majority correctly identified the strong acid but often failed to explain its higher conductivity in terms of both ions present.

**Question 7**

The Lewis structure for hydrazine proved to be difficult for some in (a). Incorrect answers had double bonds appearing between the two nitrogen atoms or lone pairs missing. Those who could draw the correct structure in (i) gave the correct bond angle, but the explanation was often incomplete. Few mentioned either the four electron domains around the central atom or the extra repulsion of the lone pair.

In part (b) most candidates knew that hydrogen bonding was present in hydrazine and Van der Waals’ forces in ethene but failed to give a comparison of the relative strength of the intermolecular forces. Some candidates struggled to calculate the enthalpy changes from enthalpy changes of formation in (c) (i) as they were unable to relate the enthalpy change of combustion of hydrogen to the enthalpy change of formation of water.

The bond energy and entropy calculations were more successful with many candidates benefitting from ECF from their incorrect Lewis structures in (a). It was encouraging to see many correct unit conversions for the calculation of  $\Delta G$ . A number of candidates incorrectly described the combination of hydrazine and hydrochloric acid as a redox reaction, but many were able to identify the bond angle and hybridization in N<sub>2</sub>H<sub>6</sub><sup>2+</sup>.

## Recommendations and guidance for the teaching of future candidates

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

- Consider the units and the appropriate number of significant figures for the final answer in calculations.
- Be prepared to tackle hypothesis type questions.
- “Keep going” with calculations as errors are carried forward so that a correct method in a later part of the question is rewarded. Show all steps in a calculation.
- Include all non-bonding pairs of electrons in Lewis structures.
- Practise answering past exam questions as similar questions regularly appear in examinations. This is especially the case when we require candidates to refer to gaseous particles or the frequency of collisions, for instance.
- Use reversible arrows in equations representing the dissociation of weak acids and bases.
- Practise common organic reaction mechanisms using curly arrows to represent the movement of electrons and check with published markschemes that all requirements have been met.
- Write answers in the spaces provided in the examination booklet, using the number of lines and the mark allocation as a guide. The number of lines for a question part is meant to suggest the amount of space for a typical response.

The relatively poor performance on parts of question 1 (data logging and formulating hypothesis) question 7 (observation) underlines the importance of experimental work in the teaching programme.

## Higher level paper three

### Component grade boundaries

<b>Grade:</b>	1	2	3	4	5	6	7
<b>Mark range:</b>	0 - 9	10 - 18	19 - 22	23 - 27	28 - 33	34 - 38	39 - 50

### General comments

The range of marks awarded varied significantly. The best candidates showed a thorough command of the material and a high level of preparation. The most popular options were D and E. Very few candidates chose Option F. More candidates chose Option C this session than previously.

Teachers' impressions of this paper were conveyed by the 12 G2 forms that were returned. In comparison with last year's paper, a majority (72%) thought this year's paper to be of a similar standard, with 28% considering it a little more difficult.



100% described the level of difficulty as appropriate. Syllabus coverage was considered satisfactory by 50% and good by 50%. In addition, 25% felt that the clarity of wording on the paper was satisfactory and 67% felt that the clarity of wording was good. Only 8% thought that the clarity of wording was poor. The presentation of the paper was considered satisfactory by 33% and good by 67%.

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

This examination revealed weaknesses in candidates' knowledge and understanding in all options.

These included:

- Description of what occurs at a molecular level during IR absorption by CO<sub>2</sub>.
- Splitting of d-orbitals in an octahedral crystal field.
- Iodine mass calculations.
- Role of DNA for storing genetic information.
- Importance of nanotechnology.
- Alkaline hydrogen-oxygen fuel cell (anode and cathode half-equations).
- Membrane chlor-alkali electrolysis cell.
- Action of penicillin.
- Identification of indole heterocyclic ring system.
- Soil chemistry.
- Bonding in oxygen and ozone.
- Depletion of CFC by ozone.
- Chromophores.
- Description of how emulsifiers work.
- Conventions used for naming different enantiomers.
- Correct use of curly arrows in organic reaction mechanisms.
- Reaction of 2,4-dinitrophenylhydrazine with ketones.
- Reaction of acyl chlorides with amines.

During this session, many of the weaker candidates appeared to opt for Option E on Environmental Chemistry. However, in many cases these candidates tried to answer questions with limited specific chemical knowledge of the option itself and hence performed poorly. It is imperative that candidates are well prepared for their chosen options. In addition, many candidates with a strong biology background often over-depend on their biological knowledge and it is important that candidates choosing Option B on Human Biochemistry or Option D on Medicines and Drugs are well prepared for some of the specific chemical concepts embedded in these options. This pattern was evident with some candidates this session. Also this session, many of the stronger candidates tended to opt for Options A, D and G and performance here was generally of a very high standard. It was encouraging however to see more candidates choosing Option C and good scripts were often seen.

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

During this session many excellent scripts were seen. Good levels of knowledge, understanding and skill were demonstrated in the following areas:

- Application of IR,  $^1\text{H}$ , NMR, MS and AA.
- Functional groups in general.
- Anti-acids.
- Thermal pollution.
- Products of electrophilic addition and nucleophilic reactions.

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

### Option A – Modern Analytical Chemistry

#### Question 1

A1 (a) was generally well answered by most candidates, though some simply repeated the uses given in (b) which scored no marks. Question (b) was also well answered by most candidates, though a small minority simply stated chromatography in (i), which was not sufficient at HL. In (ii), the most common incorrect answer was AAS.

#### Question 2

The majority of candidates were able to describe the operating principles of the double-beam IR spectrometer, with the better candidates scoring all three marks. In (b), some candidates simply gave vibrations, scoring only one mark but the better candidates gave nice representations of the asymmetric stretch and bend, which was probably the best way to answer this question, followed by reference to the related induced molecular polarity.

Some candidates got totally confused and failed to recognise the fact that as  $\text{CO}_2$  is linear and non-polar, the symmetric stretch does not lead to a net dipole moment. In (c) (i), most candidates were able to relate B to  $\text{C}=\text{O}$  and C to  $\text{C}-\text{O}$ , but many gave  $\text{O}-\text{H}$  for A instead of  $\text{C}-\text{H}$ . In (ii), the most common mistake was candidates omitting the + charge. In (iii), only the best candidates scored the mark. One respondent stated in a G2 form that the value of 8.07 ppm is outside the range 9.4 to 10.0 ppm given in Table 18 of the Data Booklet and that candidates are not required to know how added shielding or deshielding from neighbouring groups affects the chemical shift. This is an interesting point and it should be emphasised that the spectra used are based on real spectra and, as is pointed out clearly in Table 18, chemical shift values may vary in different solvents and conditions. This is a very important point that teachers should emphasise to candidates in the teaching programme. In this question, candidates use a combination of spectra to deduce the structure of  $\text{HCOOCH}_3$ . In part (ii),  $\text{HCO}^+$  is identified corresponding to  $m/z = 29$ . Question part (iv) was usually well done but many candidates were not able to deduce the correct structure,  $\text{HCOOCH}_3$  in (v). Many candidates gave the answer as ethanoic acid. Part (vi) was usually well answered and a significant number of candidates scored both marks.

**Question 3**

The calibration curve was usually correctly represented by most candidates, though a small minority failed to connect the points. However (b) was very poorly answered and even the better candidates often scored zero marks here. In (i), it was very disappointing to see candidates failing to realise that in an octahedral crystal field the 3d sublevel splits into two sets of orbitals, a triply degenerate level which is lower in energy and a doubly degenerate level which is higher in energy. Many candidates put the triply degenerate level (the  $t_{2g}$  level) at the same energy as the five-fold degenerate 3d sublevel, thereby clearly misunderstanding the splitting pattern. In addition, it was further very disappointing at HL to see candidates failing to apply Hund's rule of maximum multiplicity and placing two electrons in one orbital and one electron in another orbital. All three orbitals in the  $t_{2g}$  level are degenerate and, hence, applying Hund's rule the electrons fill them singly first. Likewise in (ii), although some candidates stated that the splitting of the d-orbitals would increase if the ligand changed from water to ammonia, virtually no candidate mentioned a correct reason i.e. the fact that ammonia has greater charge density or is higher in the spectrochemical series. Clearly there were significant weaknesses in candidates' understanding of this topic overall.

**Option B – Human Biochemistry****Question 1**

Many candidates surprisingly struggled with the calculation for the energy value of glucose. A number forgot to divide by 0.85 g and others ignored significant digits. The latter was also commented on by one respondent in a G2 form. In (b) (i), glucose was sometimes represented linearly. In addition there were many examples of candidates having incorrect bonds such as C-HO, HC-H<sub>2</sub>COH. H's sometimes were missing. Surprisingly, very few candidates were able to deduce the correct structure of maltose.

**Question 2**

Another weakness this session was the inability of many candidates to work out the mass of iodine in the linoleic acid problem in (a), even though this type of problem has been asked a number of times in previous papers. Incorrect ratio calculations were common, yielding answers such as 90.4, thereby scoring only two marks out of three.

Parts (b) and (c) however were often well answered and many candidates scored full marks in these two parts. The weaker candidates in (c) tried to base their argument on differences in double bonds, which scored no marks; instead of stating the fact that the carbon to carbon double bonds in linoleic acid cause the chain to be more uneven or kinked.

**Question 3**

In (a), the most common mistake was candidates stating the aldehyde functional group instead of ketone. In (ii), some of the better candidates gave 21 hydrogens as the correct number of hydrogen atoms joined directly to the carbon atoms as part of the steroidal backbone in progesterone. The most common incorrect answer however was 9 hydrogens. One respondent stated that candidates may not have been exposed to the medical uses of testosterone. However, many candidates scored full marks for the two medical uses of testosterone as a steroid.

**Question 4**

Usually candidates had no problem scoring both marks for (a) (i). In (ii) however, many answers were too broad in scope dealing with transcription and translation, rather than concentrating on *how* the genetic information is stored. Candidates clearly did not interpret what was being asked for explicitly in the question. In (b), some candidates had not studied this procedure and often got confused and referred to protein amino acid sequence studies. However, virtually all candidates could give two uses, namely, criminal investigations and paternity.

**Option C – Chemistry in Industry and Technology****Question 1**

Most candidates scored at least two marks on this question, though only the better candidates scored full marks.

**Question 2**

Only the better candidates identified steam cracking as the procedure for obtaining propane and an alkene from hexane (thermal cracking was the most common incorrect answer), but most identified the products correctly.

**Question 3**

Although most were able to describe nanotechnology, very few knew why it is of interest to chemists which was very disappointing for any candidate taking this option! In (b), although candidates did seem to have some idea of the structure of carbon nanotubes and most mentioned hexagons and pentagons, often there was no mention of a cylinder (carbon hexagons) or the fact that the pentagons close the tubes at the ends. In (c), a significant number of candidates were able to suggest at least one concern, but rarely two.

**Question 4**

Candidates had simply no idea of the half-equations taking places at the anode and cathode in an alkaline hydrogen-oxygen fuel cell and essentially no candidate got this correct. The cell however was usually correctly identified as the lithium-ion cell in (b), though some candidates forgot to put “-ion”.

**Question 5**

Candidates generally knew very little about the membrane chlor-alkali electrolysis cell, ignoring the materials used to build it especially. Most were familiar with the reaction taking place at the anode in (a) (iii) and were able to explain the advantage of the membrane cell in terms of the toxicity of the mercury cell. In (c), again surprisingly, no candidate gave three distinct uses of sodium hydroxide, although most were able to cite at least one use.

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

In (a), some candidates gave the formula of hydrochloric acid instead of the name, hence scoring no marks. In (b), the most common mistakes involved either incorrect formulas for aluminum hydroxide or else unbalanced equations. Part (c) was generally well answered though many candidates could not state an example of an anti-foaming agent.

**Question 2**

Surprisingly some candidates had difficulty scoring full marks in (a). In (b) (i), some candidates stated incorrect functional groups, such as amide instead of amine. Another common incorrect answer was methyl. In (ii), many candidates stated hydroxide ion instead of hydroxyl.

**Question 3**

Most candidates had no problem with (a), but in (b), although most candidates knew that penicillin interferes with cell wall synthesis, most did not know the actual mechanism i.e. the fact that the ring opens to allow the penicillin to bond to the enzyme. In (c) (i), sometimes candidates put the chiral centre on either the carbonyl carbon or the nitrogen of the amide functional group. However, (ii) was usually well answered. One respondent stated that the answer to this question can be quite variable as thalidomide racemises within the blood, so irrespective of the isomer given production of both isomers results.

Due to racemization, each isomer of the drug has the potential to cause deformities. This aspect was not seen on any script but is a valid point and is worth mentioning by teachers in their discussion of thalidomide.

**Question 4**

Most candidates could detect some similarities between LSD and psilocybin, while nearly all were able to describe the short-term effect of psilocybin. Some candidates did not read the question carefully and were quite content to give structural differences! Very few scored full marks, however, and even the better candidates did not refer to the indole heterocyclic ring system.

**Option E – Environmental Chemistry****Question 1**

Most candidates had little difficulty in listing at least two pollutants produced in the combustion of engines of motor cars. In (b), the most common error involved candidates not writing correctly balanced equations. In (c), candidates struggled in writing the polluting effect of each of the three pollutants and often tried to guess the answer.

**Question 2**

In general, candidates could answer this question satisfactorily.

**Question 3**

Candidates generally were able to describe a nutrient in (i). In (ii), harvesting was often not stated. In (b), candidates had great difficulty explaining the effect of pH on CEC, and there were a number of misunderstandings here.

**Question 4**

At HL, it was very surprising and disappointing that candidates did not do well on this question as many of the questions were based on core chemical principles applied in an environmental context. Candidates could not usually relate the strength of the oxygen to oxygen bond in ozone versus that in oxygen to energy needed to break the bond.

Some of the better candidates mentioned bond order and supported their answer with well represented diagrams. In (ii), many candidates were able to state at least one equation for either the formation or depletion of ozone, though many were not consistent with the use of the dot symbol to represent the radical. Radicals can be represented with or without a dot, but it is important that candidates are consistent in whatever representation they use. In (b), many candidates were not able to write the equations for the depletion of ozone by CFC, and only a small minority scored all three marks here. In addition, it was very disappointing that candidates could not explain why CFCs are so effective at ozone depletion.

### Option F – Food Chemistry

#### Question 1

This was very well done.

#### Question 2

In general, most candidates were able to distinguish between a food dye and a food pigment. In (b) very few candidates scored both marks in (i), though (ii) caused no problem. In (iii), candidates had little idea of what was required here and all sorts of strange values were suggested. A specific anthocyanin was not specified in the question, so the answer was looking for a general qualitative type response, unless candidates specifically related their values to a stated anthocyanin in answering the question. This however was not the case. Part (c) was very poorly answered, again this was surprising at HL. Very few mentioned conjugation and candidates had no idea of a chromophore.

#### Question 3

Very few accurate descriptions of how an emulsifier works were seen.

#### Question 4

This question was poorly answered and many candidates did not even attempt part (a).

#### Question 5

This question was reasonably well answered, except for part (d), where candidates did not know the difference between  $-l$  and (R) notation. Some candidates also did not state that it is the *plane* of polarized light that rotates counter-clockwise for the  $-l$  notation.

### Option G – Further Organic Chemistry

#### Question 1

Some candidates did not seem to interpret what was meant by a description of the structure of benzene, though usually they could provide at least one piece of evidence that supports its description. In (c), very few candidates scored all four marks for the mechanism of the reaction of benzene with chlorine. One G2 comment stated that the command term “explain” implies the use of language to explain the mechanism. It should be noted that in the guide, explain is the command term used for AS’s corresponding to organic reaction mechanisms and the statement “explain the mechanism of a reaction using curly arrows to represent the movement of electron pairs” is the standard format of expression for this type of question. No explanation in words is required. Careless use of curly arrows was widespread. Nitrobenzene was usually easily identified in (d).

**Question 2**

This was typically well answered, though the imine functional group was often not given in (b).

**Question 3**

In (a), many candidates did not state that the acid was concentrated, and often failed to read the question carefully as the first step involved dehydration of the propan-2-ol. In (b), UV light sometimes was not mentioned.

**Question 4**

All parts of this question proved challenging for candidates and in (a) candidates did not realise that 2 mol of  $\text{CH}_3\text{CH}_2\text{NH}_2$  were involved. One respondent stated that the question should have stated 1 mol instead of 2 mol of  $\text{CH}_3\text{CH}_2\text{NH}_2$ . However, ethanoyl chloride reacts with ethylamine to give a mixture of N-ethylethanamide and ethylammonium chloride. HCl is not produced as if any is formed it reacts immediately with excess ethylamine to produce ethylammonium chloride. The mechanism of the reaction is in two steps. The first step involves addition and is nucleophilic attack by the non-bonding pair on the nitrogen atom of ethylamine on the positive carbon atom of ethanoyl chloride. The second step is an elimination step,  $\text{C}=\text{O}$  reforms with loss of chloride ion, followed by removal of hydrogen ion from nitrogen.

## Recommendations and guidance for the teaching of future candidates

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

Provide answers that involve proper chemistry and not superficial or 'journalistic' type answers and avoid the use of everyday or 'journalistic' language, and use correct scientific terms.

- Practise setting out calculations in a logical way, showing each step, and emphasising the final answer by paying due attention to units and significant digits. In this session, many candidates paid no attention to significant digits, particularly in the energy value of glucose calculation in Option B.
- When writing organic structures, check that the valency of each atom is correct and always include hydrogens in full structural formulas.
- Write your answers in the spaces provided. There should be no need to use extra continuation sheets.
- Be consistent with the use of dots in radical representations.
- Be fully familiar with all organic reaction mechanisms in Option G and pay special attention to the correct use of curly arrows in mechanisms.

## Standard level paper one

### Component grade boundaries

<b>Grade:</b>	1	2	3	4	5	6	7
<b>Mark range:</b>	0 - 7	8 - 12	13 - 17	18 - 20	21 - 22	23 - 25	26 - 30

### General comments

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

Teachers' impressions of this paper were conveyed by the 18 G2's that were returned. 39% found that it was of a similar standard, compared with last year's paper, 22% thought that it was a little more difficult and 11% were of the view that it was a little easier. 100% described the level of difficulty as appropriate. Syllabus coverage was considered satisfactory by 53% and good by 47%. In addition, 42% felt that the clarity of wording on the paper was satisfactory and 58% felt that the wording was good. The presentation of the paper was considered satisfactory by 35% and good by 65%.

These statistics were also reflected in the 'general comments', where it was generally felt that the paper was fair with a good balance of difficult and easy questions.

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

The difficulty index (the percentage of candidates achieving each correct answer) ranged from 92% to 15% and the discrimination index (an indication of the extent to which questions discriminated between high- and low-scoring candidates) ranged from 0.65 to 0.02 (the higher the value, the better the discrimination).

Comments were made on the following questions.

#### Question 3

One G2 comment stated that this was a challenging question for SL candidates. In fact this was the second hardest question on the entire paper and only 20% of candidates gave B. (i.e. Mg) as the correct answer.

#### Question 11

This question asked which species contain a dative covalent bond from a list of three. One respondent stated that the term coordinate bond is often used, which is correct. However, in the guide in the teachers note corresponding to AS 4.2.2, the term that is used is dative covalent; hence candidates should be familiar with this term when used in questions. 40% of candidates gave the correct answer to this question.



**Questions 13 and 27**

One respondent stated that it would be best to write from least reactive to most reactive in both of these questions. However, “increasing” is written in bold in both questions and, also, this type of question has been asked extensively on previous papers and hence candidates would have understood what was asked for explicitly if they had looked at some of the previous examination papers. In the case of Q.13 60% of candidates gave the correct answer and in Q.27, 68% had the question correct.

**Question 15**

One G2 comment stated although this was a good question, it would be challenging for many SL candidates. In fact, although this was the fifth hardest question on the entire paper, 43% of candidates still managed to get the question correct.

**Question 18**

It was suggested by one respondent that increase of pressure might be ambiguous. In the guide, the effect of pressure on the rate of a reaction is mentioned in AS 6.2.4. 59% of candidates got this question correct.

**Question 29**

One respondent stated that elimination would be confusing to SL candidates. Although this is a valid comment as elimination reactions are not part of the SL syllabus, this did not cause a problem for candidates and 57% of candidates gave B (substitution; nucleophilic substitution) as the correct answer.

## Standard level paper two

### Component grade boundaries

<b>Grade:</b>	1	2	3	4	5	6	7
<b>Mark range:</b>	0 - 6	7 - 12	13 - 18	19 - 24	25 - 29	30 - 35	36 - 50

### General comments

The range of marks awarded was very wide; the best candidates showed a thorough command of the material and a high level of preparation. Teachers' impressions of this paper were conveyed by the 15 G2 forms that were returned. In comparison with last year's paper, 61% thought this year's paper was of a similar standard or a little easier, with the remainder considering it a little more difficult.

79% thought the level of difficulty was appropriate while 14% thought it was more difficult, and 7% thought it easier. Syllabus coverage was considered good or satisfactory by 93% of respondents; clarity of wording and the presentation of the paper were considered good or satisfactory by 100% of respondents. However, with so few G2's returned it is hard to draw firm conclusions about the paper from these.

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

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

- Using a temperature-time graph to deduce the temperature change that would have occurred if the reaction had taken place instantaneously.
- Stating a hypothesis with sufficient detail.
- Explaining why a very low pressure is maintained in a mass spectrometer.
- Predicting and explaining the bond angles in ethene and hydrazine.
- Defining electronegativity.
- Identifying an acid-base reaction.
- Writing a mechanism with curly arrows for an  $S_N2$  reaction.
- Predicting an ether as an isomer of an alcohol.
- Describing observations that would enable the distinction between a strong acid and a weak acid to be made.

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

Once again there were some excellent scripts seen from some candidates, whose answers indicated knowledge and understanding across the syllabus, especially when their answers in Section A matched the quality of their answers to their chosen Section B question. Topics generally well answered included:

- Economic importance of alkenes.
- Addition reactions of alkenes.
- Calculation of relative atomic mass.
- Explanation of metallic bonding.
- Equilibrium reactions.
- Oxidation numbers.

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

### Section A

#### Question 1

Question 1 was the most difficult question for candidates, but it underlines the fact that Chemistry is an experimental subject that candidates need to be exposed to. Part (a) was quite well answered with many scoring at least one mark by commenting that the assumption would be that there was no heat loss.

In part (b) many had problems interpreting the graph and incorrectly read off both  $T_{\text{final}}$  and  $T_{\text{initial}}$ . The equation for the line had been included to help candidates but many who used it did not factor in that the zinc was not added at  $T=0$ . Very few candidates realised the underlying assumption was that rate of heat loss would be uniform. It was possible to gain an ECF (error carried forward) mark from an incorrect temperature change used to calculate heat evolved; however, many candidates did not get the units correct here as they calculated using  $50\text{cm}^3$  as the volume and gave this answer in kJ, when it needed to be divided by 1000. In part (c) most could calculate correctly but gave 0.05 as the answer when it should be 0.0500. In part (d), again many could correctly calculate the molar enthalpy change but omitted the negative sign, which was essential as it was exothermic. Part (e) caused the most problems and the great majority gave the answer “the more reactive the metal the greater the enthalpy change” without mentioning negative or exothermic, so a mark could not be awarded. Again few successfully drew the graph which needed a positive gradient and had to pass through Cu at 0.

### Question 2

This question was generally well answered and many high scores were seen. Naming the initial compound was generally well done though many stated methylprop-1-ene which is incorrect. Most could describe the colour change with bromine correctly though some incorrectly used ‘clear’ instead of ‘colourless’ and many could draw the structure of the dibromoalkane formed. Most candidates stated that plastics were produced from alkenes and suggested versatility or low cost and so were able to score full marks. Addition polymerisation was well recalled but a large number of candidates made mistakes with the structure of the polymer, a surprisingly large number had bromine appearing attached to the carbon chain. Most understood that larger molar mass was why polymers had higher boiling points than monomers but not all correctly attributed it to stronger van der Waals’ forces between molecules.

### Question 3

This question showed that although many candidates knew about a mass spectrometer they did not necessarily understand why things happened and so, although most mentioned both acceleration and deflection, many did not mention electric and magnetic fields. Very few understood that low gas pressure prevented collisions and many suggested that the low pressure keeps the sample in the gaseous state. However, most candidates could correctly calculate the relative atomic mass although a few lost a mark by giving their answers to 1 or 3 decimal places.

Most candidates correctly calculated the number of electrons, but the most frequent incorrect answers were 28 and 54. The explanation of iron’s properties was well answered in terms of metallic bonding and most candidates correctly described its electrical conductivity as due to free flowing electrons. However, only a few could explain malleability in terms of the layers of ions being able to slide over each other.

## Section B

### Question 4

This was a popular question and was answered quite successfully. The Lewis structure for ethene was given correctly by the great majority of the candidates, but that of hydrazine by only about half of them. Incorrect answers had double bonds appearing between the 2 nitrogen atoms and lone pairs on nitrogen atoms not shown. Those who could draw the correct structure in (i) gave the correct bond angle, but the explanation was not given correctly by many. Only very few scored the five marks as many failed to mention the extra repulsion of the lone pair. The definition of electronegativity was not well known and many forgot to mention covalent bond or got confused with ionization and electron affinity and talked about a mole of gaseous atoms. In part (c) most knew that hydrogen bonding in hydrazine was stronger than the van der Waals' forces in ethene and explained its higher boiling point. However, some candidates described hydrogen bonding as the bond between N and H in the molecule, and some omitted a comparison of the relative strengths. The calculation for the enthalpy change produced some completely correct calculations but many candidates lost marks here for using the wrong bond energies, although ECF was applied to the structures drawn in part (a). In (e) 'addition' was correctly identified as the reaction type by most but when asked in (f) to identify the final reaction type few recognised it as an acid-base reaction, however, the bond angle was given correctly by many.

### Question 5

This was the least popular question in Section B but there was a generally pleasing level of performance. Most candidates scored at least 2 out of 3 marks for calculating the empirical formula. Several candidates correctly worked out the ratio but then rounded 2.7 to 3 to give an incorrect empirical formula of  $\text{CH}_3$  instead of  $\text{C}_3\text{H}_8$ . However many did manage to calculate a correct molecular formula even though their empirical formula was incorrect.

Free radical substitution was well known, however, there was some confusion about whether the reagent was supposed to be  $\text{Br}_2(\text{g})$ ,  $\text{Br}_2(\text{aq})$  or  $\text{Br}_2$  in  $\text{CCl}_4$ . Most stated that UV was required. In 5(d) most candidates scored at least 3 marks out of 4. A few used  $\text{Cl}_2$  instead of  $\text{Br}_2$ . Most knew the meaning of the symbols  $\text{S}_{\text{N}}2$ , however, a few did not correctly state the meaning of the 2. The mechanism caused some problems and some of the common errors here were drawing the curly arrow from the H; forgetting to include any curly arrow to show Br leaving; writing the partial bond from the nucleophile as  $\text{OH}^{\ominus}\text{---C}$ ; or missing the negative charge from the transition state. Unfortunately, most candidates had a combination of these errors. Also, in most cases the partial bonds were drawn at angles less than 180 degrees which, although not penalised, is totally incorrect as attack by the nucleophile must be on the opposite side to the halogen leaving.

Part (f) proved to be very confusing for many candidates. The structural isomers of propan-1-ol were commonly drawn as propan-1-ol and propan-2-ol, which then caused enormous difficulties in 5(f)(ii) when they had to identify the isomer with the higher boiling point.

Those who were relying on ECF marks here often predicted the wrong isomer or found it very difficult to explain their prediction. The few candidates who drew the isomers correctly as an ether and an alcohol were generally able to score full marks by predicting and explaining the different boiling points.

### Question 6

This was the most popular question and it was well answered by the majority of candidates. The reaction was correctly described as exothermic and the reason for this explained correctly in most cases. Most candidates knew that yield would increase with increased pressure, but failed to score a second mark because they did not mention “gaseous” although they did know the answer. The effect of increased temperature on rate was generally well described although some did get confused with yield and how it would affect equilibrium.

Most candidates correctly defined oxidation in 6(b)(i) but ‘hedged their bets’ by stating loss of electrons as well as an increase in oxidation number. In 6(b)(ii) the oxidation states were generally deduced correctly but sometimes written as ionic charges (5+ for instance, instead of +5).

In 6(c) most correctly defined strong and weak acids, and many also wrote correct equations. A few, though, had no idea. In (c), arrows proved to be a minefield for several candidates, especially the equilibrium sign. HA was commonly given, as were CH<sub>3</sub>COOH and HCl, instead of nitric and nitrous acid.

6(d) presented problems with many candidates unable to describe observations and instead stating there would be ‘more hydrogen produced’ or just that ‘the reaction would be faster’. However, better candidates were able to answer this part correctly and scored full marks.

In 6(e)(i) the calculation was answered well, but 6(e)(ii), that asked for a comment on the hypothesis, was not and few candidates stated that the same volume of acid was needed.

In 6(f), the majority correctly identified the strong acid but often failed to explain its better conductivity in terms of the ions. Many could give a correct balanced equation and scored the 3 marks, and others scored 1 mark for giving the correct reactants and products. However, not many candidates used oxidation numbers to deduce the balanced equation.

## Recommendations and guidance for the teaching of future candidates

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

- Practise balancing redox equation using oxidation numbers.
- Practise common organic reaction mechanisms using curly arrows to represent the movement of electrons and check from published markschemes that all requirements have been met.
- “Keep going” with calculations, as errors are carried forward so that a correct method in a later part of the question is rewarded. All steps in the calculation should be shown.
- To include all non-bonding pairs of electrons in Lewis structures.
- To practise calculations involving bond enthalpies.
- To distinguish between those changes in conditions that affect equilibrium concentrations and those that affect rate.
- Practise answering past exam questions as part of their preparation as similar questions regularly appear on exams.

- Teachers should give candidates an opportunity to experience a wide range of experimental activities to assist with this understanding.
- To check that both significant figures and units are correct in all calculations.
- To be prepared to tackle hypothesis type questions, teachers should try to include some of these in the teaching programme.
- Write answers in the spaces provided in the examination booklet, using the number of lines and the marks as a guide to how much to write.

## Standard level paper three

### Component grade boundaries

<b>Grade:</b>	1	2	3	4	5	6	7
<b>Mark range:</b>	0 - 6	7 - 13	14 - 17	18 - 21	22 - 24	25 - 28	29 - 40

### General comments

This was an accessible paper and a very wide range of performance was seen - there were some excellent responses and also there were a number of candidates that were insufficiently prepared for the paper. The major problem continues to be that candidates do not answer questions with sufficient detail and their answers can tend to be journalistic rather than based on chemical principles.

Many candidates appeared to be uncomfortable with questions requiring an understanding of the chemistry in Options B and D, which suggests that some candidates who are strong in biology hope to get by with biological knowledge, even though this is a chemistry paper and the emphasis should be in chemistry.

Weaker candidates still continue to struggle with Option E. Indeed, candidates should be careful with choosing this option unless they are well prepared.

Where all the candidates in a centre studied the same two options they tended to perform better than those candidates who appeared to have had a wide variety of choice of options studied.

Of the 15 G2s sent in 77.5% of the respondents felt that the paper was of a similar standard to last year, while the remainder were equally split between the paper being a little easier and a little more difficult. The vast majority (93%) of the teachers who responded felt the level of difficulty was appropriate and 7% felt it was too difficult. Syllabus coverage was considered to be good by 53% and satisfactory by 47%. For clarity of wording 67% felt it was good and 33% satisfactory. Finally, for presentation of the paper, 67% chose good and 33% satisfactory.

One respondent mentioned that in A2(c) "The mass spectrum has a small peak at 75 when the molar mass of the compound is only 74. Otherwise a good question". Wherever possible actual spectra are used in questions. The M+1 peak is caused by the presence of the  $^{13}\text{C}$  isotope in the molecule.  $^{13}\text{C}$  is a stable isotope of carbon and makes up 1.11% of all carbon atoms. However, this did not seem to affect the candidates' responses.

One respondent mentioned that in A3 “The value given for the WHO limit is extremely small and well out of scale of the calibration curve so it is obvious without plotting the graph that the sample must fail - unless I have misunderstood the question”. This is true, but only one of the 3 marks allocated could be picked up from this.

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

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

- Describing the operating principles of a double-beam infrared spectrometer.
- Drawing the structures of glucose and maltose.
- Distinguishing between the structures of  $\alpha$ - and  $\beta$ -glucose.
- Calculation of the mass of Iodine which reacts with 100g of linoleic acid.
- Stating the half-equations at the electrodes in the alkaline hydrogen-oxygen fuel cell.
- Comparing fuel cells and rechargeable batteries.
- Discussing sociocultural difficulties associated with AIDS.
- Stating and explaining methods of disposal of high-level waste.
- Stating the combination of pH and temperature that produces the strongest colour in anthocyanins.
- Suggesting why the fatty acids in olestra are smaller than those in cooking fats.
- Organic reaction pathways.
- Explaining the difference in acidity of organic compounds.

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

The areas which seemed well understood were:

- Use of analytical techniques.
- Interpreting IR, mass and  $^1\text{H}$  NMR spectra.
- Functions of carbohydrates.
- Explaining why fats have a higher energy value than carbohydrates.
- Definition and use of steroid-based hormones.
- Use of antacids for dyspepsia.
- Analgesics.
- The effect of thermal pollution on water quality.
- Factors that cause food spoilage and rancidity of fats.
- Distinguishing between food dyes and food pigments.
- Genetically modified food.
- Structure of Benzene.

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

### Option A – Modern Analytical Chemistry

This was one of the more popular options and many candidates performed very well, some obtaining all 20 marks.

#### Question 1

Most candidates answered (a) very well, though some candidates opted to repeat the examples in (b) which obviously scored no marks, or were very vague in their responses making statement such as 'used in medicine'. Most candidates answered (b) well. However, very few candidates gave a specific chromatographic technique used to separate a mixture of sugars, the most common answer was just 'chromatography'. AAS was often incorrectly given in (ii).

#### Question 2

Despite the generous markscheme, candidates struggled to achieve full marks in (a). Often absorbance/transmittance was not mentioned and the splitter was not stated. In (b) the main misconception stated by candidates was that non-polar compounds do not absorb infrared radiation. Most candidates scored a mark for vibrations, but many misunderstood the difference between symmetric and asymmetric stretching. Part (c)(i) was well answered by the great majority of candidates; giving C-H bond instead of O-H for A was a popular incorrect answer. In (ii) the most common mistake was missing the + sign. Most candidates answered (iii) and (iv) correctly.

#### Question 3

Many candidates scored the 3 marks allocated. Most candidates were able to draw the graph. Although a number of candidates clearly did not have a ruler in the examination. Some did not state the value ( $[\text{Pb}^{2+}]$  in  $\text{mg dm}^{-3}$ ) for the sample or read the graph incorrectly and, as a consequence, did not score M2.

### Option B – Human Biochemistry

This was one of the most popular options.

#### Question 1

In (a) SD's proved the major issue. Most candidates scored the mark for  $\Delta T$ . The candidates who struggled made the following errors: incorrect mass (0.85 g) of water was used in  $q=mc\Delta T$ , and failure to convert to J per g by dividing q by 0.85.

In (b)(i) many candidates struggled to draw the straight chain structure of glucose. In many instances the -OH groups were positioned incorrectly and some candidates were careless with bonding writing '- C - HO' rather than '- C - OH'.

In (ii) a significant number of candidates mixed up the positions of the substituents on the two faces. In (iii) C1 was commonly omitted. It was surprising to see that quite a few candidates could not draw the structure of maltose in (iv). The most common mistake involved an incorrect linkage. Part (c) was answered well by the vast majority.



**Question 2**

In (a) the vast majority of candidates did not recognise that linoleic acid had two C=C double bonds and hence the ratio  $n(I_2):n(\text{acid}) = 2:1$ . Candidates also made careless errors in calculating the molar mass of either/both iodine or/and linoleic acid. Part (b) was answered well by about half of the candidates. In Part(c) many candidates scored both marks, but there were cases which indicated poor preparation of candidates on this rather trivial question which appears so often in examinations.

**Question 3**

Most parts of this question were answered well by candidates.

In (a) many candidates mentioned “chemical messenger”. In (b)(i) ketone or carbonyl was invariably mentioned but alkene was missed by quite a few of the candidates. Part(ii) was not well answered. Very few candidates were able to deduce the correct number of hydrogen atoms. In (c) the vast majority of candidates scored one mark and only about half scored the two marks allocated.

**Option C – Chemistry in industry and technology**

This was one of the least popular options.

**Question 1**

Candidates tended to provide vague, journalist answers rather than provide specific points to score the marks, e.g. candidates would suggest ‘pollution’ as an argument against without being specific.

**Question 2**

Most candidates were able to state the equation (in quite a few cases the molecular formula of propane was not known) for the cracking process, but only about half correctly identified steam cracking.

**Question 3**

Many candidates were able to define the term nanotechnology and scored M1 but only about half managed to score M2. In (b)(i), although most mentioned hexagons and pentagons, many failed to mention cylinders and ends of tubes. In (c) many candidates were able to score at least one mark, some scored both marks but, again, some vague answers were seen.

**Question 4**

Most candidates struggled with all parts of this question. Correct relevant equations at the electrodes were given by only a very few candidates in (a). In (b) about half mentioned Lithium-ion. In (c) many candidates were not able to compare fuel cells and rechargeable batteries. Some managed to score M1.

In (d) many candidates stated the  $H_2(g)$  is dangerous but did not explain why. Some scored M1, but no candidate scored the second mark regarding the storing and transporting of  $H_2(g)$ .

**Option D – Medicines and Drugs**

This was another very popular option.

**Question 1**

The vast majority scored the mark in (a), but a small number of candidates gave the formula for hydrochloric acid rather than writing the name. In (b) many correct answers were given but it was surprising to see that some candidates did not know the correct chemical formulas and how to balance equations. In some cases candidates wrote an equation for the reaction between aluminium hydroxide and calcium carbonate. In part(c)(i) many candidates scored both marks, but many candidates could not provide a specific example of an anti-foaming agent in part(ii).

**Question 2**

In general, and in comparison to other questions this part of the option was answered well. However, in some cases the answers confused aspirin and paracetamol and gave reverse properties in (a); amide and/or ketone were given in (b)(i) and oxidation appeared in (b)(iii).

**Question 3**

This part of the question proved very challenging to most candidates. Many journalistic responses were given here also. Candidates struggled to provide a sociocultural difficulty associated with AIDS and found it difficult to articulate a coherent response. However, *OWTTE* allowed candidates to score some marks.

**Question 4**

Most candidates scored the mark in (a). A number of journalistic responses were given in part (b) where candidates did not discuss the activities of humans that have created an increase in resistant bacteria. Some candidates misread the question and discussed how penicillin had been modified to combat resistant bacteria. Overuse and developing resistance was generally the only valid reason given.

**Option E – Environmental Chemistry**

This was a very popular option. The performance in general can be considered average to poor.

**Question 1**

The vast majority of candidates scored 2 marks in (a). Many candidates incorrectly think that  $\text{SO}_2$  and  $\text{SO}_3$  are emitted from car exhausts, so they appeared in about half of the responses. In (b) only about half of the candidates could write a balanced equation for the reaction that occurred in the catalytic converter. The usual response was the reaction of CO with oxygen. In (c) many candidates tended to give “global warming” as their response for all pollutants and some thought that  $\text{NO}_2$  was a greenhouse gas, instead of  $\text{N}_2\text{O}$ .

**Question 2**

Many candidates were very familiar with the effect of thermal pollution on the quality of water, so they answered this part correctly.

**Question 3**

In (a) many candidates had a sound understanding of the term nutrient in the context of soils and were able to describe how nutrients were removed and added to the soil. In (b) many candidates could not state the chemical term for organic constituents of the soil. SOM was mistaken for humus by many.

**Question 4**

Many candidates were able to score marks in (a) and (b)(i), but in (b)(ii) they could not clearly state the name and explain why the method of disposal of high-level waste is better.

**Option F – Food Chemistry**

This was one of the least popular options.

**Question 1**

Candidates answered this part of the option very well. They had a thorough understanding of factors that cause foods to spoil and the rancidity of fats.

**Question 2**

Most of the candidates could describe the difference between a food dye and a food pigment well in (a). In (b)(i) that blue is reflected was mentioned invariably, but not many mentioned correctly the colours absorbed. Part (b)(ii) was answered correctly by many candidates but a number of candidates did not read the question correctly and listed foods or vegetables rather than fruits. In (b)(iii) only very few candidates managed to describe the best combination for pH and temperature for the strongest colour in anthocyanins.

**Question 3**

Many candidates answered (a) correctly, but some candidates confused hydroxide for hydroxyl and incorrectly identified the reaction as a hydrogenation reaction. Candidates found (b) very challenging and only a handful could answer it correctly.

**Question 4**

Many candidates were able to define the term *genetically modified food* well in (a). In (b) many of the candidates' responses were very good, but there were cases with rather vague and journalistic answers.

**Option G – Further Organic Chemistry**

This was the least popular option. Those who did attempt it either scored very high marks or performed very poorly.

**Question 1**

In (a) describing the structure of benzene was well known by many candidates, but the evidence required in (b) to support this description was not well answered by about half of the candidates and chemical language was used imprecisely.

**Question 2**

Most candidates gave the correct structure in (a), but only about half could give the structure correctly in (b) with incorrect bonding between atoms being illustrated.

**Question 3**

About half of the candidates struggled with part (a), with only the best candidates scoring the marks, which demonstrated that the candidates found reaction pathways difficult. Part (b) was answered better, but quite a few candidates did not state concentrated.

**Question 4**

The vast majority of candidates were able to identify the strongest acid in each part, but many found it difficult to articulate a coherent chemical explanation, with only the few best prepared candidates scoring the explanation marks.

## Recommendations and guidance for the teaching of future candidates

- It is important that the recommended time is devoted to cover the two options thoroughly and in depth (there was evidence that some areas had not been covered by some schools). Candidates who are left to teach the material to themselves generally do not perform well.
- Teachers should stress the importance of correctly writing balanced chemical equations and formulas.
- Candidates must read the questions carefully, ensure they answer exactly what has been asked with precision (vague answers rarely gain the marks) and from the perspective of a chemist, using appropriate terminology and avoiding superficial or “journalistic” answers.
- Candidates must pay particular attention to the action verb and use this as a guide to the depth of the answer required.
- Candidates must pay particular attention to the number of marks allocated in each part and use this as a guide to the detail needed in the answer required.
- Candidates should prepare for the examination by practising past paper questions and carefully studying the markschemes provided and be encouraged to highlight the salient points in the questions and markschemes.
- Teachers should emphasise the importance of clearly set out calculations and addressing significant figures in the final answer.
- Candidates should practise drawing accurate structures of organic macromolecules.