CHEMISTRY

Overall grade boundaries

Higher level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 18	19 - 33	34 - 47	48 - 58	59 - 68	69 - 78	79 - 100

Standard level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 16	17 - 30	31 - 44	45 - 55	56 - 65	66 - 76	77 - 100

Higher and standard level internal assessment

Component grade boundaries

Higher level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 9	10 - 15	16 - 21	22 - 27	28 - 31	32 - 37	38 - 48

Standard level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 9	10 - 15	16 - 21	22 - 27	28 - 31	32 - 37	38 - 48

The range and suitability of the work submitted

As ever the range of work submitted was wide but there was plenty of material that indicated that many schools are conducting excellent practical programmes and the students are benefiting as a result. The students and teachers at many schools have been praised in the 4/IAF feedback forms from the moderators and it is hoped that this improvement is reproduced in the May 2007 session.

As in May 2006 the moderating team were working to instructions from the Principal Moderator that emphasised that teachers are the primary markers and that moderators should support the teacher wherever possible. Moderators are not primary marking and if the teachers grading is a plausible interpretation of the criteria then it should be supported.

Guidance was then given as to when and how moderators should and should not change marks as follows:

When to mark down:

Planning (a):

- The research question, hypothesis and/or independent and controlled variables are given by the teacher. Mark the relevant aspect down to 'n'. A general aim is fine if the students have significantly modified it (e.g. made it more precise).
- The hypothesis has not been explained or the explanation is clearly counter to theory as can be reasonably expected to be known by an average IB chemistry student (eg. 'reaction rate will decrease with increasing temperature because ………'). Award 'p' for second aspect.

Planning (b):

- A method sheet is given which the student follows without any modification or **all** students are using identical methods. Moderator gives n, n = 0
- Teacher gives c, c, c but it is clear that the students have been told what apparatus and materials they require. Maximum moderator can award is n, c, c = 2.

Data Collection:

- A photocopied table is provided with heading and units that is filled in by students. Maximum moderator can give is p, n = 0.
- The teacher gives 3 (c, c), but the student has only recorded quantitative data (e.g., in a titration) and qualitative data such as colours of solutions, indicator, colour change etc. are missing. Moderator gives p, c = 2. However, do not be overzealous and penalize DC every time a student does not find qualitative data to record.
- Student has not recorded uncertainties in any quantitative data. Maximum 'p' for first aspect.
- Student has been repeatedly inconsistent in use of significant digits when recording data. Award 'p' for second aspect.
- In purely qualitative DC tasks such as establishing a reactivity series. Too often the students put in a reaction equation as opposed to the observation. This cannot be supported and will reduce first aspect to 'p' or 'n' depending on how much other raw data is present.

Data Processing & Presentation:

- A graph with axes already labelled is provided (or students have been told which variables to plot) or students follow structured questions in order to carry out data processing. Moderator gives c, n = 1.
- No evidence of errors being propagated (HL) or total random error being estimated in any way (SL). Maximum award c, p = 2. Remember that best fit line graph is sufficient to meet requirement for error and uncertainty propagation.

Conclusion & Evaluation:

- Structured questions are given to prompt students through the discussion, conclusion and criticism. Depending on how focussed the teacher's questions are and on the quality of students' response the maximum award is partial for each aspect the student has been guided through. You have to be judging purely on the students input.
- Teacher gives c, c, c = 3 but the student has only indicated as a criticism that they ran out of time. Maximum moderator can give is c, n, p = 1.

When not to mark down:

In the following cases support the teacher's stance.

Planning (a):

- Dependent variable has been given by teacher or student has made no mention of dependent variable (surprisingly it is not featured in aspect 3 descriptor!)

- You disagree with the explained hypothesis but you feel that it is a reasonable application of IB level knowledge.
- The hypothesis explanation is simplistic but the only one possible within the framework of the task (e.g. Student predicts vitamin C contents of juices based on evidence supplied by packaging.) In this case support student but feedback to teacher as to poor suitability of task for meaningful hypothesis generation.
- The independent and controlled variables have been clearly identified in 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).
- There is a list of variables and it is clearly apparent from procedure which is independent and which are controlled.

Planning (b):

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

Data Collection:

- In a comprehensive data collection exercise possibly with several tables of data the student has been inconsistent with significant digits for just one data point or missed units out of one column heading. If you feel the student has demonstrated that they were paying attention to these points and made one careless slip then you can still support maximum mark under 'complete not meaning perfection' rule. This is an important principle since often good students responding in full to an extended task unfairly get penalised more often than students addressing a simplistic exercise.
- Student has not included any qualitative observations and you cannot think of any that would have been obviously relevant.
- Purely qualitative DC such as in establishing a reactivity series. These are currently allowable but not recommended since they do not facilitate recording of uncertainties. Please provide feedback to that effect. However when marking do make sure that it is genuine raw data (see section A above).
- No table title when it is obvious what the data in the table refers to. I have seen students do all the hard work for DC and then lose a mark from the moderator because they did not title the table. 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.

Data Processing:

- Errors and Uncertainties

The expectation in chemistry, as described in the TSM 1, is:

"Standard level candidates are not expected to process uncertainties in calculations. However, they can make statements about the minimum uncertainty, based on the least significant figure in a measurement, and can also make statements about the manufacturer's claim of accuracy. They can estimate uncertainties in compound measurements, and can make educated guesses about uncertainties in the method of measurement. If uncertainties are small enough to be ignored, the candidate should note this fact.

Higher level candidates should be able to express uncertainties as fractions $\Delta x/x$, and as percentages, $(\Delta x/x)$. 100. They should also be able to propagate uncertainties through a calculation.
Note: Standard level and higher level candidates are not expected to construct uncertainty bars on their graphs."

Note that a best-fit line graph is sufficient to support 'c' for the second aspect at both SL and HL.
For both DC and DPP, if the student has clearly attempted to consider or propagate uncertainties (according to whether HL or SL) then support a teacher's award even if you may feel that the student could have made a more sophisticated effort. Please **do not** punish a teacher or student if the protocol is not the one that you teach i.e. top pan balance uncertainties have given as +/- 0.01g when you may feel that if we consider the tare weighing then it should be doubled. Moderation is not the time or place to establish the favoured IB protocol.

Conclusion and Evaluation:

- Simply apply the principle of complete not meaning perfect. For example if the students 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 be a bit more critical with respect to the third aspect that the modifications are actually relating to the cited sources of error. "

Finally the moderators were guided:

"So the broad message is be positive in your marking. Look for what is present in a piece of work and not for minor omissions. Try to avoid pettiness and remember that sometimes you can mark upwards."

Candidate performance against each criterion

Planning (a)

This criterion was generally well fulfilled with students able to pose a research question, make a sensible hypothesis with some level of explanation and to identify the relevant control and independent variables. One significant reason for some candidates not fulfilling this criterion was that the set task was too narrow to allow the candidates to make their own decision as to which variable(s) should be the independent variable and which of the others should be controlled.

Planning (b)

This criterion was fulfilled to a similar extent as in previous years. Candidates generally selected suitable equipment and devised appropriate strategies for carrying out investigations. An investigation that requires the teacher to specify the equipment or methodology is not appropriate for assessment of Pl (b). Teachers sometimes over-plan and set up an investigation leading to only one possible procedure, and this denies candidates opportunity to achieve in this criterion. Both Pl (a) and Pl (b) should evoke different responses from different candidates within the same class.

A common weakness in Pl (b) is the lack of control of variables even though candidates have identified variables to be manipulated or controlled when addressing Pl (a). The commonest example of this omission was that students failed to control reaction temperature when undertaking a kinetic study of a significantly exothermic reaction. Another failing of a large number of candidates was the absence of quantitative information regarding reactant concentrations, masses, volumes, *etc*. One common reason for incomplete fulfilment of Pl (b) was that the candidates often did not plan to collect sufficient data.

Data Collection

Most candidates had been presented with suitable data collection tasks and their performance was generally good with candidates independently able to present data in suitably constructed tables with appropriate column headings and units. The most common failings still related to the first aspect with uncertainties often being left out and there was frequent inconsistency in the use of significant figures. More candidates than previously took the opportunity to record qualitative data when it was clearly present and significant (*e.g.*, the evidence of incomplete combustion in an enthalpy of combustion determination).

Teachers were prone to over-reward their students in purely qualitative DC tasks with full reward being given for poorly phrased observations that either lacked detail or were not primary observational statements.

Data Processing and Presentation

Most schools had appropriately assessed DPP in quantitative tasks and the overall standard was satisfactory although a few schools still unwisely used purely qualitative investigations for DPP assessment. An increased numbered of schools encouraged meaningful treatment of errors or uncertainties in DPP and although this aspect is a demanding discriminator for able students at HL it is pleasing to see it being addressed.

Once again a disappointment was the relatively small number of graphs presented for moderation and their poor quality overall. Common failings were the inability to construct a best-fit line, inappropriate sketch graphs when a greater accuracy of plotting was required, as well as the poor use of Excel. Contemporary versions of Excel can be used to great effect in DPP but the normal expectations of graphing , *i.e.* labeled axes with units, best-fit lines and curves, *etc*., must still be observed, as well as the candidate's individual contribution being evident. A graphing programme that does not permit user control over the processing or output is not suitable for assessment of this criterion.

Few candidates undertook further processing of the data such as finding a gradient or intercept through extrapolation and teachers should really set tasks that will require them to do so. The fact that the second aspect's requirement to take into account uncertainties can be fulfilled through a suitable best-fit line should make data processing through graphing an increasingly important component of most school's programmes and hopefully the quality of graphs presented will as a result improve.

Conclusion and Evaluation

It was common this session for candidates to compare their results to literature values where appropriate which is encouraging. This criterion also requires a valid conclusion with an explanation that is based on the correct interpretation of the results and this is often missing. There is very little evidence that candidates make any attempt at background reading or research in order to interpret their findings. Most candidates did attempt to evaluate the procedure and list possible sources of error although very few were able to assess if the final result was explainable by random error or required the consideration of systematic errors. Some candidates were able to make appropriate suggestions to improve the investigation following the identification of weaknesses, although many were only able to suggest simplistic or completely unrealistic improvements.

Manipulative skills

In general, the practical programmes provided adequate scope for assessment of this criterion.

The Group 4 Project

All schools provided evidence for participation in the Group 4 Project for each of the candidates in the sample. This is an essential requirement of the IB programme. When submitting samples for moderation, teachers should provide evidence of participation in the Group 4 Project for each candidate in the sample. This can take a variety of forms as stated in the *IB Chemistry Guide* (page 32). Group evidence is not appropriate when the Group 4 Project is to be used to assess any of the written criteria.

Many schools seemed to have undertaken stimulating and imaginative projects. It is worth teachers noting that a significantly large proportion of schools use the Group 4 Project as an ideal opportunity to stimulate group collaboration within an interdisciplinary framework and assess the Personal Skills criteria, but do not award grades for the written criteria. This is in harmony with the aims of the Group 4 Project.

Recommendations for the teaching of future candidates

The following recommendations are made for the teaching and assessment of future candidates:

- candidates should be made aware of the different aspects of the criteria by which they are 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 students are solely assessed on their individual contribution to any activity used for assessment of the written criteria.
- teachers must ensure that candidates have the opportunity to achieve criteria, and hence should not provide too much information/help for the Planning (a), Planning (b), Data Collection, Data Processing & Presentation and Conclusion & Evaluation criteria.
- teachers should consult TSM 1 regarding the consideration of errors and uncertainties.
- it is recommended not to use workbooks and worksheets with spaces to be filled in by the candidates for internal assessment as they usually provide too much information and deny the candidates the opportunity to achieve criteria.
- encourage candidates to form a hypothesis that is directly related to the research question and is explained in terms of chemistry concepts, often at the molecular level.
- candidates should be encouraged to consider repeat trials, calibration or generation of sufficient data to undertake graphical analysis, when designing procedures for Pl (b).
- candidates must record qualitative as well as quantitative raw data, where appropriate, including units and uncertainties where necessary.
- candidates must compare their results to literature values where appropriate.
- when assessing the CE criterion, require candidates to evaluate the procedure, list possible sources of random and systematic errors, and provide suggestions to improve the investigation following the identification of weaknesses.
- teachers should not assess for a particular criterion if an investigation does not meet all aspects of the particular criterion.
- if candidates need to be introduced to the skills required for investigative practical work through simple introductory experiments that do not fully meet all aspects of a criterion then it is important that the marks generated are not included on the form 4/PSOW.
- evidence for participation in the Group 4 Project by each candidate in the sample must be submitted with evidence of individual contribution.
- teachers must refer to, and follow, instructions found in the chemistry subject guide, the Teachers Support Material, and instructions provided in the up to date *Vade Mecum* before submitting work for moderation.

Higher level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 10	11 - 17	18 - 25	26 - 29	30 - 32	33 - 36	37 - 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 19 G2's that were returned. 56% found that it was of a similar standard, compared with last year's paper, 11% felt that it was a little easier, 11% thought that it was a little more difficult and 11% were of the view that it was much more difficult. 95% felt that the level of difficulty was appropriate, and just 5% thought that the question paper overall was too difficult. Syllabus coverage was considered satisfactory by 68% and good by 32%. In addition, 53% felt that the clarity of wording on the paper was satisfactory and 42% felt that the wording was good. The presentation of the paper was considered satisfactory by 42% and good by 58%.

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 92.95% to 33.39%, and the discrimination index, an indication of the extent to which questions discriminated between high- and low-scoring candidates, ranged from 0.60 to 0.12 (the higher the value, the better the discrimination).

The following comments were made on selected individual questions:

Question 15

For the reaction $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$, the units of ΔH were given as -196 kJ. Three respondents felt that kJ mol^{-1} should be used here. Similar comments were made with respect to the units of ΔH for questions 22 and 28. When considering this, $\Delta H_r^{\text{Ö}}$ is generally defined as: $\Delta H_r^{\text{Ö}} = \sum n\,\Delta H_f^{\text{Ö}}$ (products) - $\sum n\,\Delta H_f^{\text{Ö}}$ (reactants). As $\Delta H_f^{\text{Ö}}$'s would be given in kJ mol^{-1}, multiplying by n mol, would mean the units of $\Delta H_r^{\text{Ö}}$ are more correctly cited in kJ.

Question 26

One respondent stated that conjugate should have been used in the question, with respect to a Brönsted-Lowry acid-base pair. It is a fair comment that this could have been used. However, the difficulty index was 82.45 for this question and the discrimination index was 0.31. Therefore, based on the number of candidates who were able to correctly answer this question, it was very clear as to what was being asked in this question.

Question 38

One respondent suggested that it would be better to use the term radical in line with current IUPAC convention, as opposed to free radical. The term free radical is however currently used in the guide in As 20.2.2

Higher level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 14	15 - 29	30 - 40	41 - 49	50 - 59	60 - 68	69 - 90

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

Some fundamental topics proved difficult for substantial numbers of candidates, including the application of the VSEPR theory, mass spectrometry, the electron configurations of *d*-block elements and their ions and explaining colour in transition metal complexes. In addition, the use of an appropriate number of significant figures continues to be a problem for some candidates.

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

The levels of knowledge and understanding shown by the best candidates covered all the areas of the syllabus tested. Proficiency in calculations was often high, and an understanding of kinetics and equilibrium was noticeable.

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

Section A

Question 1

In (a), most candidates successfully calculated the empirical and molecular formulas, although some ended up with a formula containing five carbon atoms. In the calculation, many candidates rounded atomic masses to the nearest integer – although this was not a problem in this question, it may be in others. The definition in (a)(ii) was hardly ever correct – there were several slips in efforts that came close to scoring, but some answers referred to elements rather than molecules, or the addition of numbers of protons and neutrons. In (b), several formulas left out the lone pairs asked for in the question, while the bond angle explanation often lacked precision (lone pairs of electrons were said to exert repulsion on atoms rather than on bonding pairs, or just to exert repulsion, without stating on what).

Question 2

The definition in (a) often failed to mention "compound" or "elements", although standard conditions were better known. In (b), the expected answer was "greater than", with "more negative" being accepted. Many candidates seemed confused because of the negative values involved, and some who wrote "less than" suggested in their explanations that they meant "had a more negative value". In (c), weaker candidates had little idea of how to begin, but the majority scored well here, the commonest cause of losing a mark being to omit the negative sign or the units. Part (d) was very well answered, with only a minority of candidates having problems working with kilograms rather than the more usual grams.

Question 3

Many candidates did well in (a) and (b), but (c) was less well done. In (b), a substantial number thought that the carbon atom in HCN had different hybridizations in the bonding with H and N. Although the idea of end-on and sideways overlap of orbitals was generally well known (and the marks for these points were often scored from diagrams), the positions of atoms were often not clear, and many answers contained no reference to electrons.

Question 4

Although better candidates scored well in this question, there were many examples of answers from weaker candidates who had attempted every part but scored zero. Errors included hydrogen as a product in (a)(i), "covalent" as the type of bond fission in (a)(ii), the product in (b)(i) having two bromine atoms on the same carbon, and the reaction described as substitution in (b)(ii). Part (c) proved the most difficult in which to score marks, and few candidates obtained the expected value of $-360\ \text{kJ mol}^{-1}$.

Question 5

Not surprisingly, most candidates scored the mark in (a), but for many it was their only mark in this question. In (b), a magnetic field was a popular choice, while those who referred to "plates" rarely described them as having opposite charges. Very many candidates chose the wrong isotope in (c), and in spite of being asked to do so in the question, very few references to *m/z* values were seen (and there were some who referred to charge/mass ratios).

Section B

Question 6

Part (a) rarely brought full marks for candidates. In (i), although most knew the formulas, $SiCl_4$ was often thought to be a solid at room temperature. Few correct equations to explain the acidity of water after the addition of $SiCl_4$ were seen, and there were several equations written for reactions between $MgCl_2$ and water. Answers to part (b) frequently contained errors. In (i) "$4s^2$" was often included in the electronic configuration, and in (ii) ligands and the type of bond formed were unfamiliar to many. Attempted explanations for colour in complexes in (iv) frequently scored zero, or no answer was offered. Although most candidates knew the use of iron in the Haber process, the equation for the reaction was less well known, or incorrectly balanced. Part (c) discriminated well, with high scores for the best candidates, while weaker candidates tended to score only in (i). The half-equations in (ii) often appeared in the wrong direction or were added together. In (iii), many candidates did not use the half-equations in the Data Booklet to help them deduce an overall equation, and several explanations in (iv) referred to the reactivity series.

Question 7

Part (a) was generally well attempted. In (i), several candidates who chose the correct compound referred to van der Waals' forces and not to the hydrogen bonding in the other two compounds. Most candidates knew how to tackle the calculation in (ii), the commonest error being to use an incorrect combination of value and unit, such as $518\ \text{dm}^3$. The C–O bond was usually identified in (iii), and in (iv) most structures were correct, although with a number omitting the positive charge. Most candidates scored well in (b), although rarely full marks, with only a small minority thinking that the reaction was other than oxidation. Part (c) was well answered, with thankfully few references to polarized light bending or being refracted. The alkenes in (d) were often correctly identified. The mechanisms in (e) were correct only for the best candidates. The transition state in (i) should show all five groups correctly bonded (and HO--- rather than OH---), dotted lines to Br and OH and a single negative charge (ideally outside a square bracket) rather than negative charges on both Br and OH. In (ii), the expectation was for candidates to write two separate equations, one showing the loss of Br^-, followed by one showing the reaction between ^-OH and the carbocation. Candidates who used curly arrows in a two-step sequence were able to score both marks. Answers to (f) often chose "increase", justified by the greater reactivity of chlorine compared to bromine.

Question 8

Although most candidates were able to correctly deduce the equilibrium constant for the reaction in (a), the application of Le Chatelier's principle in (b) was not well done. In spite of the positive value given for ΔH° several answers assumed that the reaction was exothermic, while some wrote about the effect on the position of equilibrium but not about the value of K_c. The commonest error was to state that an increased pressure affected the value of K_c. The calculations in part (c) discriminated well, with the best candidates scoring full marks, while weaker ones made no attempt or produced incorrect answers after considerable amounts of working. The calculation in (c)(ii) did not need the use of the quadratic equation, although some candidates used it. The main reason why candidates did not score full marks in (d) were through stating that the catalyst produced more product or omitting to state that the increases in forward and reverse rates were equal. In (e), most candidates were able to correctly read off the pH value from the graph but many were unable to calculate $[H^+]$ from it; some left their answer as $10^{-2.8}$. The calculation in (iii) was often correct. The use of a suitable indicator was often poorly explained in (iv). Part (f) was poorly answered, with few candidates realising that the pH value at half-neutralisation was equal to the pK_a value of the acid, and surprisingly few were able to write an equation for the buffer action.

Question 9

Part (a) was generally well answered, although with some answers spoiled by arithmetic errors in the calculations. Part (b) was usually correctly answered. Many candidates in (c) did not realise that constant half-life is a feature of a first order reaction. Part (d) discriminated well, with the better candidates being familiar with the method, although few scored full marks. The enthalpy level diagram in (e) was often correctly drawn but not always correctly labelled. The commonest errors were to use the labels E_a and E_{cat} for the tops of the curves rather than for the vertical distances from the reactants line.

Recommendations and guidance for the teaching of future candidates

The specific points in this paper are to encourage candidates to:

- use relative atomic mass values from the supplied periodic table in calculations, and not to round them
- practice applying the VSEPR theory to a variety of molecules and ions
- remember to include vital details in precise definitions
- include a positive charge in the formulas of fragment ions formed in the mass spectrometer
- avoid leaving answers to conversions from pH to $[H^+]$ in the format 10^{-pH}
- to use the terms singlet, doublet, triplet and quartet when describing splitting patterns in ^1H NMR spectra , and not to present such information as if it were a ratio of peak areas, so a triplet, quartet and singlet should be described as such and not as 3:4:1
- to practise the use of curly arrows in organic mechanisms, especially to ensure that arrows start and finish in the correct places and point in the right direction (arrows should always start from an electron pair, either from a bond line or from a lone pair on a particular atom)

Higher level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 7	8 - 15	16 - 21	22 - 26	27 - 32	33 - 37	38 - 50

General comments

This paper indicated a very broad range of capabilities of candidates. Some candidates struggled with even the most basic concepts while others demonstrated an excellent depth of understanding of the higher-level course. It produced a range of responses from almost full marks to zero. In general, answers lacked precision in terms of wording used and explanations were often vague and repetitive. There were some schools where candidates seemed unfamiliar with most of the subject material and left many areas of the question paper blank.

Candidates must pay particular attention to the number of marks allocated to the question and write their answers accordingly. Calculations must be shown clearly and should be checked for accuracy and units where appropriate.

The 22 G2 forms that were returned conveyed teachers' impressions of this paper. 71% felt that the paper was of a similar standard as compared to last year while 24% felt it was a little easier and 6% found it more difficult. Regarding the level of difficulty, 86% found it to be appropriate while the remainder felt it was too difficult. For syllabus coverage, 48% found it satisfactory, 29% found it good while the remainder found it poor. For clarity of wording, 55% found it satisfactory, 35% found it good while the remainder found it poor. For the presentation of paper, 55% found it satisfactory, 30% found it good while the remainder found it poor.

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

Most candidates seemed very well prepared, although a small but significant number gave the impression that they had not encountered much of the information or concepts before and performed very badly. No one option proved easier to score marks as compared to other options. The paper proved to be a good discriminator, with the best students scoring high marks particularly on those areas testing objective three. More details are given under the individual options in the next sub-section of this report, but areas where considerable difficulty was encountered included:

- K_m and its relationship with enzyme activity
- oxidation and reduction of molecules during electron transport process
- half equation for the process of reduction
- photochemical smog
- removal of H_2S from crude oil
- modification of the properties of two named polymers
- production of ethanol from biomass
- splitting patterns
- formulae of complex ions
- *cis*- and *trans*- isomerism applied to cyclic compounds

- addition elimination reaction for ketones
- use of curly arrows to show the mechanism of pentan-2-one with hydrogen cyanide

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

Clearly, the majority of students were very familiar with the subject material. However, there are a few centres where students gave the impression that they had not been taught much of the material on the options they answered. Often this correlates with the choice of options. As in previous years, centres where all the candidates answer the same two options tend to do considerably better than when a range of options is chosen. There is also a strong correlation between candidates' abilities to express clearly and concisely their ideas with their overall scores. Generally, most students demonstrated a good knowledge of the factual content of the options chosen. Areas, which seemed particularly well known and understood included:

- sympathomimetic drugs
- penicillin and thalidomide
- steroidal hormones
- mercury and nitrates as pollutants
- fractional distillation
- doping of silicon
- interpreting simple mass and infra red spectra
- optical isomerism

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

Option B – Medicines and drugs

B1

Most candidates attempted all parts of this question, with varying degrees of success. Parts (a) and (f) were generally well answered. In (b), many candidates stated ketone instead of amide. Few candidates succeeded with (c) – nicotine was sometimes said to be acidic because of its "corrosive" effects. Very few candidates realised that nicotine is basic because it forms OH^- ions in the solution. Parts (d) and (e) required candidates to state *two* effects; apart from those who listed effects in the wrong part, several gave more than two effects.

B2

The molecular formula in (a) often had one too many hydrogens, presumably through including six from the aromatic ring and a surprising number could not get the molecular formula. In (b), several who mentioned acid did not include a reference to stomach and failed to recognise the effect of enzyme penicillase (produced by bacteria). The remaining parts were reasonably well answered, although several candidates lost marks using journalistic language. Terms such as "superbug" and "friendly bacteria", without further description, are not acceptable answers.

B3

Most candidates had no difficulty in identifying the chiral centre and were familiar with the effects of both isomers of thalidomide in (a). In (b), both *cis* and *trans* structures were often correct, but few candidates gave both points (state plus reason) required in the answer. To score the marks there had to be reference to geometrical isomerism (not just stereoisomerism) and some specific point about how Cl and NH_3 were arranged relative to each other. Parts (c) and (d) were well answered.

Option C – Human biochemistry

C1

Part (a) was well answered, although with some listing C and A in the wrong order. Most candidates managed to score well in (b), about electrophoresis, the commonest error being to write about applying a current rather than a voltage or potential difference. A large number of candidates identified amino acids at the wrong electrodes

C2

There were some confused attempts at this calculation, but many candidates scored full marks with no difficulty. Inevitably, a few lost a mark through using the A_r instead of the M_r values for iodine. Some candidates determined the number of double bonds present in linolenic acid as 274 or 137.

C3

Generally very well answered, with no obvious problems.

C4

Part (a) was poorly attempted, with few candidates showing an understanding of K_m and its relationship with enzyme activity. Competitive and non-competitive inhibition was frequently confused. Part (b) brought few all-correct answers. The majority of candidates ignored the word “molecule” stated twice in the question. Glucose undergoes oxidation and water undergoes reduction. The majority wrote various ions of Fe and Cu as an answer, which was incorrect.

Only five candidates left C4 blank thinking that option C was finished, although the paper stated “Turn over”. The scripts of these candidates were carefully reviewed and appropriate action was taken at the grade award meeting.

Option D – Environmental chemistry

Like Options B and C, this was another popular option answered by many candidates. Although there may be a perception that this is one of the easier options, the answers given do not provide evidence of this.

D1

In (a), most candidates were unable to recall the pH value below which precipitation is regarded as acid rain, and in (b) a disappointing number identified carbonic acid as a cause. In (b), several of those who correctly identified nitric acid went on to give "cars" or "car engines" without any reference to the high-temperature reaction between nitrogen and oxygen in the internal combustion or jet engines. Burning of fossil fuels is not a specific answer to score marks.

D2

Generally well answered, with no particular problems but a surprising number could not state how CO_2 is removed from the atmosphere.

D3

Generally, this question was not well answered. In (a), some incorrect answers were cited by including chlorine or ozone along with oxygen, while in (b) several vague answers, such as "industrial waste" were seen. The equations in (c) proved beyond most candidates, with several candidates not scoring the requisite number of marks because the formula of the precipitate was wrong or an otherwise-correct equation was not balanced.

D4

There were few good attempts at parts (a) and (b). Oxides of carbon and sulphur appeared as primary pollutants, and few could write a correct relevant equation in (b), although full credit was given for any reasonable equation. In contrast, (c) was well answered although many wrote “industry” as a source of mercury.

Option E – Chemical industries

Very few candidates chose this option.

E1

In part (a), majority of students could not state an equation for the removal of H_2S from crude oil. Other parts were generally well answered with no particular problems.

E2

Part (a) was done reasonably well with the identification of HDPE with appropriate reasoning. Part (b) produced vague answers by some candidates although it discriminated well between students. Often the wrong polymers were associated with particular modifications.

E3

Some candidates were able to compare different processes used to manufacture low-density and high-density polythene by stating the reaction conditions, name of catalyst and the type of reaction mechanism. In part (b), some candidates wrote the correct half equations and the function of the material used for the diaphragm.

Option F – Fuels and energy

F1

This question was well attempted by the majority of candidates, with few errors.

F2

The comparison of nuclear fission and fusion in (a) was poorly answered. Some candidates wrote that nuclear fusion was easier to achieve, and few answers referred to the very high temperatures needed and the difficulties of containment. In part (b), several answers failed to score through not being sufficiently specific. For example, to quote the low emissions of acidic gases or of carbon dioxide as an advantage of nuclear power plants is perfectly acceptable, but "no air pollution" or "cleaner" are not.

F3

This question was poorly answered, and scores of zero were quite common. In (a), the main component of biogas was sometimes identified as glucose, methanol or hydrogen, and some of those who correctly identified methane wrote about coal gasification or combustion. In (b), several answers referred to industrial conditions such as high temperature and pressure. The fermentation of glucose in (c) was better known.

F4

In part (a), most candidates scored well in describing the doping of silicon, but many did not answer the question in the second sentence, about the role of sunlight. The distinction between low-level and high-level nuclear waste was well known in (b). Better candidates used the correct method for the calculation in (c), although some weaker ones took 8% as one-eighth and based their answer on exactly three half-lives.

Option G – Modern analytical chemistry

G1

Very few candidates had problems with the formulas in (a) and (b). The fragment ions in (b) were usually identified correctly, although the positive charge was often omitted. There were few errors in identifying the bonds in (d). Part (e) proved much more difficult, with many candidates clearly giving a ratio of peak areas rather than a splitting pattern, while others gave a ratio such as 3:2:1 without any words, suggesting that their answer was a ratio of peak areas. The question stated that there were three structural isomers of X, based on the assumption that candidates would choose the obvious acid and two ester structures. Those who chose other structures were given credit for these, even though the compounds they represented might not exist. In (f), most identified X as the acid, although many of them did not refer to the infrared spectrum to justify their choice.

G2

Part (a) proved difficult for most candidates. In (i) several gave visible for both compounds and very few realised that nitrobenzene will absorb at a longer wavelength, while in (ii), although most recognised that reference to double bonds was needed in the answer, few mentioned conjugation or electron delocalisation. In (iii), some who mentioned full *d*-shells did so only for one of the two ions, while others spoiled their answer by giving an incorrect electron configuration that included $3d^8$. In (b), very few candidates could give a correct formula for either complex ion.

Option H – Further organic chemistry

H1

There are actually more than two isomers of the cyclic compound $C_4H_6Cl_2$, which was incorrectly stated in the paper although it did not disadvantage the candidates. A disappointing number of candidates gave alkene-type structures in part (a), ignoring the significance of "cyclic" in the question. Several of those who chose a correct structure for the *cis*-isomer did not show it in three dimensions, while others gave a structural isomer instead of the *trans*-isomer. Part (b) was poorly answered, with several candidates drawing structures with six, instead of four, carbon atoms, and showing all carbons horizontally and therefore were unable to indicate the *cis-trans* relationship between their structures. Few candidates succeeded in (ii) and (iii). Part (c) caused few problems.

H2

This question was poorly answered. In (a), many candidates seemed unfamiliar with the addition-elimination reaction in the syllabus. In (b), although there were several attempts at the mechanism, errors were widespread; curly arrows started from N rather than C in CN^-, and the arrow showing the attack by H^+ frequently showed the arrow pointing in the wrong direction.

H3

This question was well answered, although some candidates who had the acidities correct used incorrect reasoning to explain their choices.

Recommendations and guidance for the teaching of future candidates

The options form an important part of the overall syllabus. Many teachers leave the teaching of the options until last. If possible, reference should be made to the options when covering the core part of the course and ensuring that the recommended time is utilised in covering two options thoroughly. Students who are left to teach themselves the options material generally do not perform well in the examination. Teachers should strongly encourage students to answer questions only on the options they have studied.

Candidates and teachers are advised to bear in mind the following points:

- Teachers are strongly advised to refer to past examination papers and the corresponding markschemes to assist candidates with examination preparation.
- Candidates must know the meaning of the different action verbs that appear in the assessment statements and in the examination papers.
- Candidates should read the questions carefully and correctly address all points. Working must be shown for all calculations so that the chance of obtaining ECF marks is maximised.
- Candidates must ensure that they cover a sufficient number of different points to score the full range of marks assigned to each question. Journalistic answers to questions at this level will not suffice.
- Candidates must give only the number of responses indicated in the question – if a question asks for two effects and three or more are given, candidates may score zero if the extra answers are wrong or contradict the correct ones.
- Candidates should use the terms singlet, doublet, triplet and quartet when describing splitting patterns in ^{1}H NMR spectra, and should not present such information as if it were a ratio of peak areas, so a triplet, quartet and singlet should be described as such and not as 3:4:1.
- Candidates should practise the use of curly arrows in organic mechanisms, especially to ensure that arrows start and finish in the correct places and point in the right direction (arrows should always start from an electron pair, either from a bond line or from a lone pair on a particular atom)

Standard level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 7	8 - 12	13 - 17	18 - 20	21 - 22	23 - 25	26 - 29

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 24 G2's that were returned. 76% found that it was of a similar standard, compared with last year's paper, 6% felt that it was a little easier, 18% thought that it was a little more difficult. 92% felt that the level of difficult was appropriate, 4% considered the paper too easy and just 4% thought that the question paper overall was too difficult. Syllabus coverage was considered satisfactory by 33% and good by 63%. Only 4% felt that the coverage was poor. In addition, 36% felt that the clarity of wording on the paper was satisfactory and 60% felt that if was good. Again, only 4% felt that the wording was poor on the paper as a whole. The presentation of the paper was considered satisfactory by 17% and good by 83%.

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 93.67% to 42.01%, and the discrimination index, an indication of the extent to which questions discriminated between high- and low-scoring candidates, ranged from 0.60 to 0.11 (the higher the value, the better the discrimination).

The main comment made on this paper, related to Question 11.

Question 11

Three respondents stated that the shape of phosphorus pentachloride is not required on the SL syllabus, which is correct. The paper should have included a more appropriate example, however students should still have easily identified B, PF_3 as being polar.

Question 28

One of the reactions shown in this question (the dehydration reaction of a primary alcohol) was from the higher level syllabus, it was felt by the senior examining team that this made the question invalid and the question was therefore disregarded.

Standard level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 6	7 - 13	14 - 19	20 - 25	26 - 31	32 - 37	38 - 50

General comments

This paper identified the broad range of capabilities of candidates. Some candidates struggled with even the most basic concepts while others demonstrated an excellent depth of understanding of the standard level course. In general, however, answers lacked precision in terms of wording used and explanations were often vague. At some schools candidates seemed unfamiliar with most of the subject material and left areas of the question paper blank.

Candidates should show working out for calculation questions and should check answers for accuracy, significant figures and units where appropriate.

The 24 G2 forms that were returned conveyed teachers' impressions of this paper. In comparison with last year's paper 84% felt that it was of a similar standard, 5% thought it a little easier, 5% considered it a little more difficult. 85% of respondents thought the level of difficulty was appropriate. Clarity of wording was considered good by 58% and satisfactory by 33% of the respondents. The presentation of the paper was considered good by 79% and satisfactory by 21% of the respondents.

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

- Definitions of relative molecular mass, average bond enthalpy and electronegativity
- Significant figures and units
- The use of the VSEPR Theory
- Drawing structural formulas including the lone pairs
- Predicting bond angles
- Intermolecular bonding

- Interpretation of graphs to use data in acid/base concentration calculations.

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

- Determining the empirical formula and molecular formula
- Writing balanced equations
- Limiting reagent stoichiometric type problems
- Calculation of simple pH values from concentration values
- Difference between strong and weak acids
- Writing electron arrangements
- Calculating the number of protons, electrons and neutrons for a given ion or atom.

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

Section A

Question 1

(a) (i) Most candidates managed the calculation well. Some candidates did not display working out and consequently, when their answer was incorrect no marks could be awarded. One of the most common errors involved candidates forgetting to divide by the lowest ratio in the calculation of empirical formula. In addition, although it did not effect the answer obtained, many students approximated the atomic mass values, which is a practice that teachers should discourage as it may have ramifications in other questions.

(ii) Most candidates could not correctly define *relative molecular mass*. Candidates often did not state that this is an average mass of a molecule and failed to make reference to ^{12}C.

(iii) The determination of molecular formulae using the relative molecular mass and empirical formula was well managed.

(b) (i) Most candidates were able to draw the structural formula of the molecule but many omitted the lone pairs despite the fact that lone pairs were specifically asked for in the question.

(ii) Bond angles presented difficulties to candidates. Common errors included stating the incorrect shape and the incorrect bond angle associated with the tetrahedral shape.

(c) The hydrogen bonding was well identified; however, many candidates struggled to explain how it arises. A common error was candidates thinking that the hydrogen bonding network was between the H and N, within a molecule.

Question 2

(a) This question was very poorly answered. The definition of average bond enthalpy was not known. Candidates often omitted that the value was an average value over similar compounds and that compounds must be in the gaseous state.

(b) This question was well attempted by most candidates. Common errors included missing bonds. Most common bonds missed include C – N and C – O. A number of candidates made careless calculation errors or deduced an endothermic reaction. Some candidates incorrectly used $\Delta H = \sum H(products) - \sum H(reactants)$ and hence obtained the incorrect sign for ΔH.

(c) (i) Candidates easily managed to obtain the correct answer due to the 1: 1 mole ratio of the reactants. A number of candidates did not convert the masses to grams.

(ii) Candidates managed this question well particularly if they correctly calculated (i). The application of, error carried forward, ECF, also allowed candidates to score full marks in this question. The most common error by candidates was providing the answer in grams rather than in kilograms as requested.

Question 3

(a) Candidates described metallic bonding well but had difficultly explaining why the melting point of aluminium was higher than that of sodium.

(b) Electron arrangements were very well managed. Candidates in general identified the correct number of electrons for P^{3-}.

(c) Many candidates demonstrated a good knowledge of the number of protons, electrons and neutrons in the species shown.

(d) Candidates identified the intermolecular forces (van der Waals'/dispersion) consistently but had difficultly explaining the difference in melting point between S_8 and P_4 primarily because candidates did not know that sulfur and phosphorus existed as molecules.

Section B

Question 4

(a) (i) Candidates found it difficult to express their responses correctly. They could not use chemical terminology correctly, often not referring to the ionic radius or nuclear charge.

(ii) The definition of electronegativity was not well known. Very few candidates mentioned the bonding pair of electrons. Common misconceptions by candidates included *'the energy needed by an atom to gain an electron'* and *'the tendency of an atom to gain an electron'*.

(b) (i) and (ii) Equations were generally well done. Typical errors included the use of Cl or I rather than Cl_2 or I_2 respectively. Candidates often did not include a correct observation.

(c) Although some candidates correctly identified the redox reaction, very few were able to discuss the redox nature in terms of a change in oxidation number.

(d) (i) A number of candidates tried to draw a voltaic cell rather than an electrolytic cell. Often candidates missed one or more essential component/s on their drawing of the electrolytic cell and incorrectly included a salt bridge. Candidates had difficulty correctly identifying the nature of the products at the electrodes.

(ii) Candidates often missed the ions moving towards the electrodes as the second means of conductivity of electricity.

(iii) The $K^+ + e^- \rightarrow K$ equation was well managed but often candidates wrote Br rather than Br_2 for the second equation.

Question 5

(a) (i) and (ii) were handled well.

(iii) Candidates often did not convert the temperature from ^oC to K for use in the equation: $pV = nRT$. The units for volume were also often confused.

(b) Candidates generally managed this well.

(c) Candidates were able to explain enantiomers well but had some difficulty describing how to distinguish them experimentally.

(d) Candidates often did not mention that the conversion of the aldehyde to carboxylic acid needed to be heated under reflux and often omitted the acid needed in the reaction.

(e) Candidates found it difficult to draw the monomers and often could not identify the essential feature of the condensation monomers.

Question 6

(a) Candidates often did not explain their choices in this question. It is not clear whether candidates just missed this part of the question or did not know how to explain their choices.

(b) Many candidates demonstrated good understanding of the nature of a catalyst but omitted either of the following two points when answering this question: constant concentrations of reactants and products occur at equilibrium /K_c only changes with temperature or both the forward and reverse reaction speed up equally.

(c) Most candidates managed (i), (ii) and (iii) well but some students could not interpret the graph to determine required values. Most candidates struggled with this calculation because they did not know the relevant formula correctly, not being able to calculate the number of moles or not converting cm^3 to dm^3.

Candidates distinguished between strong and weak acids well. Most common erroneous responses in (ii) included '2' or '10^{-2}'.

Recommendations and guidance for the teaching of future candidates

- Teachers are strongly advised to refer to past examination papers and the corresponding markschemes to assist candidates with examination preparation.
- Candidates should practice questions from past examination papers.
- Candidates must know the meaning of the different action verbs that appear in the assessment statements and in the examination papers.
- Teachers should emphasise the importance and use of significant figures and units.
- Teachers should emphasise the importance of clearly set out calculations to maximise the opportunity for obtaining marks by error carried forward (ECF).
- Candidates should check calculations to avoid the loss of marks due to careless calculation errors.
- Candidates should learn definitions accurately.
- Candidates should practice drawing Lewis structures, including the lone pairs.
- Candidates must write the answers in Section A in the question paper and not on separate sheets. In addition, answers should not be written in pencil, and underlining with red pen should be avoided.

Standard level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 5	6 - 11	12 - 16	17 - 20	21 - 25	26 - 29	30 - 40

General comments

A very wide range of performance was seen, and many students seemed insufficiently prepared for the paper. All students followed the rubric and answered two options.

The 24 G2 forms that were returned conveyed teachers' impressions of this paper. 59% felt that the paper was of a similar standard as compared to last year while 34% felt it was a little more difficult and 6% found it much more difficult. Regarding the level of difficulty, 88% found it to be appropriate while the remainder felt it was too difficult. For syllabus coverage, 56% found it satisfactory, 24% found it good while the remainder found it poor. For clarity of wording, 50% found it satisfactory, 42% found it good while the remainder found it poor. For the presentation of paper, 39% found it satisfactory, 57% found it good while the remainder found it poor.

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:

- structure and bonding in benzene
- pH calculations using K_b
- acid base nature of nicotine
- effects of caffiene and nicotine on the body
- determining a molecular formula from a structure
- calculations using iodine number
- naming functional groups
- fluidized bed process
- balanced equations
- source of phospahates in waste water and precipitaion reactions
- reduction of lead
- nuclear equations

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

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

The areas which seemed well understood were:

- order of reaction
- administering drugs
- antibiotics
- electrophoresis
- hormones
- acid rain

- global warming
- fractional distillation
- power plants

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

Option A-Higher physical organic chemistry

Question 1

(a) Very few candidates were able to correctly describe the structure of benzene, their knowledge seemed to be general rather than specific. The markscheme allowed for the fact that many would be unfamiliar with hybridization, but even so, very few candidates gained the marks available.

(b) Many candidates correctly stated there would be one peak but then relatively few could justify why.

(c) Calculating the enthalpy change was straightforward but many candidates did not do it correctly.

(d) A large number of candidates tried to explain the difference in enthaply values as being due to experimental error, rather than explaining it was due to the extra stability of benzene.

Question 2

(a) Most candidates could recognise that the graph showed a first order reaction, but far fewer were able to explain why.

(b) Most candidates were able to gain this mark for the rate equation as the error from part a was allowed for.

(c) Most candiates correctly calculated a half life from the graph and then correctly substituted it into the formula for $t_{½}$.

Question 3

(a) Most students were able to write the equation of ammonia with water.

(b) K_b did not present a problem generally, although some candidates did include water and lost the mark as a result.

(c) Lots of candidates substituted values to find [OH] and then pOH but they then said this was the pH value, instead of subtracting the value found from 14.

(d) Candidates who had arrived at a correct answer in part c had no problem here. Those candidates who had struggled in part c continued to have problems.

Option B- Medicines and Drugs

Question 1

(a) The majority of candidates recognised the functional group in nicotine and caffeine as that of an amine.

(b) Very few candidates identified the functional group in caffeine as that of an amide; the most common error being the identification of a ketone group instead.

(c) Surprisingly few students identified nicotine as basic not recognising the basic nature of the amine group.

(d) Very few candidates identified two effects of caffeine- often they got one correct use only.

(e) The same problem was seen here- students knew one effect and then came up with a guess from their general knowledge- a common suggestion was that nicotine made your teeth yellow.

(f) The term sympathomimetic drug was known by some and they had no problem explaining the term, and identifying amphetamines *etc.* as typical drugs. A large number of candidates made random guesses however.

Question 2

(a) The vast majority of students knew the methods of administering drugs.

(b) Most students seemed to understand the term placebo effect although some had difficulty expressing themselves clearly.

Question 3

(a) Students were not able to translate the structural formula into a molecular formula.

(b) Responses to this question were often rather vague and few mentioned the deactivation by penicillinase and the effect of stomach acid as reasons for modifying the side chain.

(c) Most candidates were able to explain the differences between broad and narrow spectrum antibiotics.

(d) Most candidates knew how penicillin interfered with the formation of cell walls in bacteria.

(e) Most candidates were able to suggest two effects of over perscription of penicillin.

Option C- Human Biochemistry

Question 1

(a) Relatively few candidates correctly stated C at low pH and A at high pH.

(b) Most candidate scored marks in this question as there were lots of possible marking points. However a common error was to discuss electric current rather than voltage.

(c) Only a few candidates correctly identified glutamic acid at the positive electrode and arginine at the negative electrode.

(d) Many candidates correctly realised that all could be metabolised to release energy but a few incorrectly stated they were all energy stores.

Question 2

(a) Many candidates had problems using the iodine number to calculate the number of double bonds present in the molecule.

(b) The majority of candidates correctly identified that palmitic acid had the higher melting point and were able to explain why in terms of intermolecular forces.

Question 3

(a) Generally candidates knew that hormone A could be used to build muscle mass after illness or injury.

(b) Again candidates knew that the drug could be used to enhance performance.

(c) Candidates knew in general terms how hormone B could act as a contraceptive but often they did not gain all the marks available as their answers lacked precision. Very few correctly explained that it mimicked the action of progesterone though many new it prevented ovulation.

(d) Many candidates correctly drew the functional groups present in hormone B only but few named them correctly and the marks were for naming them.

Option D- Environmental Chemistry

Question 1

(a) The precise answer of pH less than 5.6 seemed well known.

(b) Most candidates correctly identified sulphuric and nitric acid although a few only named the oxides and not the acids. Also most students could correctly identify a source although some answers lacked precision and simply said burning fossil fuels. Also some students mistakenly identified carbonic acid.

(c) Students generally could write an equation for the formation of sulfurous acid; however those forming sulphuric and nitric acid were poorly done.

(d) The fluidised bed process was not well done and few could suggest any relevant equations.

Question 2

(a) The candidates showed that they were familiar with the effects of increasing carbon dioxide levels.

(b) This was generally well answered although some candidates were confused about the long and short wave radiation.

(c) Most candidates could suggest that CO_2 was removed by photosynthesis of green plants or by dissolving in water- few were able to write the correct equation however.

Question 3

(a) Many candidates knew that the activated sludge process relied on bacteria but they often forgot to mention the need for aeration.

(b) Very few candidates knew that phosphates came from detergents many suggested fertilisers as the main source.

(c) Very few candidates correctly stated that precipitation was used to remove lead and phosphate ions, even fewer correctly wrote the equations.

Option E- Chemical Industries

Question 1

(a) Very few candidates correctly wrote the equation for the removal of hydrogen sulphide from crude oil.

(b) Most candidates knew the process of fractional distillation but it was rare for them to explain the process in sufficient detail and with enough precision to gain all the marks available.

(c) The equation for cracking only caused problems for a few candidates.

Question 2

(a) Some candidates were able to correctly identify HDPE as having the higher melting point and to explain why in terms of intermolecular forces.

(b) All candidates knew that disposal of polythene was a disadvantage of its use.

(c) Naming the polymers and explaining how their properties was modified was not well answered.

Question 3

(a) Most candidates knew that sodium was extracted by electrolysis but they forgot to state that the compound needed to be molten first.

(b) The candidates could not write the equations for the reaction of lead sulphide to form lead oxide and for its subsequent reduction using carbon.

Option F- Fuels and Energy

Question 1

(a) The candidates' ability to balance this nuclear equation varied tremendously, but many correctly got the mass number as 222 and the atomic number as 88.

(b) This was fairly straightforward and most correctly found there were 5 half lives and so an activity of 250 dpm.

Question 2

(a) Most students gained marks on this question about advantages and disadvantages, but few gained all the marks available mainly since answers lacked precision. For example they stated that fusion produced no waste when the correct answer would be little waste.

(b) Most candidates knew that nuclear plants worked by fission produced by neutrons and that conventional power stations combusted fossil fuels.

(c) Most candidates knew the relative advantages and disadvantages of nuclear power plants. If marks were lost it was due to imprecision. E.g. less pollution stated as opposed to less CO_2 emissions.

Question 3

(a) The candidates knew that green plants used photosynthesis to produce biomass, and most correctly wrote the chemical equation.

(b) Relatively few candidates knew that the main component of biogas was methane and that it was produced by bacteria. Also the need for enzymes in yeast and anaerobic conditions were not well known. The equation for the conversion of glucose to ethanol also proved difficult.

Recommendations and guidance for the teaching of future candidates

- Candidates need to study each option in depth and ensure they know the equations relating to the processes they study
- Candidates should practice writing balanced equations
- Candidates need to read questions carefully to ensure they answer appropriately and precisely
- Candidates should prepare for the examination by practicing past paper questions and carefully studying the markschemes provided.

