

GCE 2003

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Report on the Examination

Chemistry

-
- Advanced Subsidiary
 - Advanced

Advanced Extension Award (AEA)

The report on this examination covers the Advanced Extension Award that AQA offers in Chemistry on behalf of all awarding bodies

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Chemistry

CHM1 Atomic Structure, Bonding and Periodicity

General Comments

Some of the work produced by candidates was of excellent quality and centres are to be congratulated on the effectiveness of their examination preparation; overall, however, the standard of the work seen by the examiners was rather variable. It was clear that, while some candidates were very well prepared for the examination and acquitted themselves with distinction, others seemed to lack much of the basic knowledge required at this level and had clearly not prepared themselves effectively for the examination. Examiners reported that on a significant proportion of the scripts the quality of written English was poor and that the use of scientific terms was often confused and inaccurate. Phrases such as 'ionic molecule' and 'hydrogen bonding within a molecule' (or even 'within a metal') were frequently seen, while terms such as atoms, molecules, and ions seemed to be treated as if they were interchangeable. The majority of candidates attempted all the questions, although a few made no attempt at some parts of the paper. This is not felt to be due to lack of time but rather due to lack of adequate preparation.

Question 1

Some good responses were seen but overall this question was not well answered however most candidates managed to earn some marks. Part (a) was generally satisfactorily answered with occasional errors in the electron configuration, and most candidates correctly assigned aluminium to the p block of the Periodic Table. In part (b), references to delocalised electrons were frequently seen, however mention of the existence of a close-packed lattice of positive ions was much less common. Some good answers were seen in part (c), although many responses were related to differences in ionisation energy rather than to differences in melting point. There was also much confusion over the type of attractive force present, with frequent references to 'ionic bonding', 'intermolecular forces', and to 'magnesium having a full s sub-shell'. Only rarely was the higher melting point of magnesium attributed to a greater attraction between the ionic lattice and the delocalised electrons that resulted from its higher ionic charge and increased number/concentration of delocalised electrons. In part (d), most candidates made mention of electrons but very few made reference to an electrical current being a flow of electrons through a metal. The incorrect idea of passing the charge from one electron to another was very common, as were vague references to electrons being free to move in the metal.

Question 2

Many candidates scored high marks on this question. Part (a), was generally well answered, however, some candidates omitted either the sign or the magnitude of the charge on the electron. Most candidates deduced the correct number of protons and neutrons in the atoms in part (b) but some clearly had not noticed that the isotopes in (b)(i) and (b)(ii) were different.

Even though many candidates realised that the relative abundance was also needed in part (b)(iii), a fair number of incorrect alternatives, such as M_r , 'number of electrons' and the 'mass of a ^{12}C atom', were seen. Most candidates were well prepared to answer questions on mass spectroscopy and coped effectively with parts (c)(i) and (ii). The correct linking of deflection to the m/z value of an ion, in part (c)(iii), was less common, and some candidates incorrectly suggested that a larger mass would experience a greater degree of deflection. In some instances the suggestion was made that the magnetic field was varied to allow different ions to be detected, without linking this to deflection. A few candidates suggested that a specific field strength would be needed before a specific ion would be deflected at all. The definition of empirical formula in part (d) was very poorly done. Very few candidates included any reference to atoms of each element in their definition. There were a surprisingly large number of errors in the empirical formula calculation. While the majority of candidates were able to complete the calculation successfully, errors such as omitting to calculate the percentage of oxygen, reversing the percentages of Cr and Na, dividing the percentages by the wrong A_r values and the incorrect scaling of the atomic ratio, to give a whole number ratio, were quite common. Some candidates used the symbol S for sodium, quoting the empirical formula as S_2CrO_4 ; while a few divided the sodium percentage by 32.

Question 3

Most candidates correctly stated the ideal gas equation but the calculation which followed was frequently incorrect. The most common errors included rounding the number of moles of ethanol to 0.03 mol and the use of 100 as the value for the pressure. There was a wide range of units suggested for the volume calculated from the ideal gas equation and few candidates were able to convert this volume in m^3 to the required volume in cm^3 . The equation in part (b) was usually correctly balanced, but rounding errors were again common in the following calculation. A significant number of candidates divided n by L in this calculation, rather than multiplying the two together. The calculation in part (c) proved to be easy for the more able candidates but posed considerable problems for many others. The calculation of the number of moles of NaCl was often correctly performed but the use of a 1:1 mole ratio between NaHCO_3 and Na_2CO_3 was very common. Some candidates assumed that NaHCO_3 was sodium carbonate and used an M_r value of 84 in their calculation. Some novel, and often successful, approaches to this calculation were seen.

Question 4

This question produced many good answers. In part (a)(i), electronegativity was frequently quoted as the required property of the atoms. A reference to the 'high electronegativity of fluorine and chlorine' was accepted here but vague references to 'high electronegativity of the atoms' was not. Errors included simple references to 'unequal sharing', which did not address the question, and arguments based on the number of protons present in the nuclei. Many candidates provided acceptable explanations in part (a)(ii) but many confused attempts were also seen. Most candidates attributed the difference in boiling points to differences in the strength of intermolecular attractions but the types of attraction present in the two systems were quite frequently confused. It was not always clear that the forces described were intermolecular in nature. In part (b), the origin of a co-ordinate bond was well known, however, some candidates confused the direction of electron pair donation. The quality of drawing seen in part (c) varied considerably. Most diagrams proved to be acceptable but some were very poor. In some cases, the use of dotted lines and wedges to show the direction

of the bonds was more of a hindrance than a help. It is recommended that candidates who intend to use these devices practice them beforehand. Some diagrams, especially that of PCl_4^+ showed a lone pair, while other diagrams clearly indicated a planar structure. Most candidates were able to deduce the appropriate bond angles, but errors were not uncommon.

Question 5

Some very good attempts at this question were seen but, in general, the attempts made by many candidates were disappointing. As all of the marks in the question required simple recall, it was anticipated that the question would pose few problems. However, it was clear from the answers seen that many candidates had not prepared sufficiently in this area and many responses were confused and inaccurate. Those candidates who had done the necessary preparation tended to answer concisely and to score well. It was not uncommon for an answer which covered two or more pages to earn very few marks as a consequence of candidates failing to address the questions.

In part (a), as in Question 1, attempts were made to answer the question in terms of ionisation energy and variation in atomic size. Many candidates were aware that silicon has a macromolecular structure but in some cases the structure of silicon was incorrectly compared to that of graphite. Answers were often spoiled by references to intermolecular forces, hydrogen bonding and ionic bonding. The comparison of the melting points of sulphur and phosphorus was well done by some candidates but the majority attempted an explanation based on ionisation energies, atomic size, electron arrangements and proton numbers.

In part (b), some very good efforts were again seen, however, the quality of drawing was generally disappointing, often amounting to no more than a few circles arranged to represent a single layer. In many instances, the Na^+ and Cl^- ions were not identified. Some candidates drew a dot-and-cross diagram of a NaCl covalent molecule, while others drew diagrams to show the formation of Na^+ and Cl^- ions from the atoms. The structure was frequently identified as being an ionic lattice, but this was often contradicted by a reference to covalent bonding, molecules, dipole-dipole attractions and van der Waal forces. For the final mark in this question, a statement to the effect that the high melting point of NaCl was a consequence of strong electrostatic attractions, or a description of this process, was required, rather than a vague reference to ionic bonding.

Part (c) was either very well or very poorly answered. There was much confusion with regard to the reactivity of beryllium with water or steam, with some candidates suggesting that beryllium was actually more reactive than magnesium. Descriptions of the reactions of the hydroxides or the sulphates were not uncommon, nor were suggested observations which were more appropriate to the reactions of Group 1 metals, such as sodium, with water. It was anticipated that candidates would describe the violent reaction of magnesium with steam, however, some candidates chose to describe the very slow reaction of magnesium with water; full credit was made available for this approach. Candidates who described the reaction of magnesium with both water and steam were credited with the higher scoring of these two approaches. The suggestion that the reaction between magnesium and steam would allow effervescence to be seen was not given credit.

CHM2 Foundation Physical and Inorganic Chemistry

General Comments

Though good answers were seen to this paper, there were many poor scripts of a standard below that expected at AS level. Candidates, except for the best, found writing equations difficult and in many cases their understanding of the chemistry involved was not sufficient to predict answers to questions that required application of knowledge. Candidates' mathematical abilities, however, were of a higher order. The mean score of candidates for this paper was below the mean for June 2002 suggesting that the paper was harder than the corresponding paper last year.

Question 1

This question was expected to be easy because it demanded mainly recall of knowledge. In practice the question proved to be very effective at discriminating between good and weak candidates. In part (a) weaker candidates were unable to balance the equations. Some candidates could only recall one reducing agent and some of the weakest candidates considered oxygen to be the reducing agent. In part (b) only very good candidates were able to write a correct equation. Other candidates were unable to balance the equation or suggested a wrong formula for titanium(IV) chloride. The weakest candidates omitted chlorine from their equations. Only a very small number of candidates could suggest, in part (c), how metals are extracted from sulphide ores. They were expected to know that a sulphide ore is heated in air to give the metal oxide which can then be reduced in the normal way by carbon for example. Most thought incorrectly that the metal could either be obtained by reaction with oxygen or by direct reduction. Candidates were much more successful with their answers about pollution problems. This part of the question was marked independently of an incorrect answer to the method of extraction and most candidates mentioned, correctly, sulphur dioxide and acid rain.

Question 2

This question was answered well by good candidates but the remainder of candidates found the question to be very difficult. They were unable to balance equations and appeared to have only hazy ideas about the concept of redox. Most candidates answered part (a) correctly. In part (b)(i) the correct answers were rare. Common mistakes were to suggest silver metal or SO_2 for the oxidising agent and SO_4^{2-} for the reducing agent. Many weaker candidates attempted to balance the equation in part (b)(ii) without water or hydrogen ions despite the appearance of these species in the given equation. Answers to part (c) were usually more accurate than answers to part (b) although, as expected parts (c)(iii) and (c)(iv) were more difficult than the first two parts. It was very rare to see a correct answer to part (c)(iv) unless six electrons had been used to balance the half equation in the previous part. Answers to part (d) usually gave the correct equation though the attempted use of oxygen was a common error. Even after giving a correct equation, very few candidates recognised that the oxidising agent in this reaction is sulphur.

Question 3

This question discriminated very effectively. For part (a), most candidates were able to draw a correct curve to indicate how the Maxwell-Boltzmann distribution would change at lower temperature but curves showing what would happen at the same temperature but a higher pressure were not so accurate. The most common error was to show curve Y displaced to the right and/or lower than the original. Parts (b) and (c) provided no problems for good candidates but weaker candidates mixed up the distinction between equilibria and kinetics. Most of these candidates gave incorrect answers to part (b)(ii) in terms of equilibria and part (c)(ii) in terms of reaction rates.

Question 4

This question proved accessible to most candidates; even the weaker candidates were able to score marks approaching half of those available. Answers to part (a) were usually correct. Most candidates also gave a correct answer to part (b)(i) though there were a significant number of errors in the calculation of the relative molecular mass of propanone. Parts (b)(ii) and (b)(iii) were also answered well although there were some problems with units. The correct answer to part (c)(i) was known by most candidates but part (c)(ii) proved to be much more discriminating and only the best candidates were able to explain why the enthalpy of combustion is more negative when water is formed in the liquid state. A fair majority of candidates was able to give a correct answer to part (d) but as usual in this type of question, weaker candidates made an error in signs leading to an answer of $+773 \text{ kJ mol}^{-1}$ or made an error by omitting to multiply the relevant enthalpy of combustion by the number of moles of the substance involved.

Question 5

Candidates' responses to this essentially factual question were disappointing. Good candidates were able to give complete and correct answers to part (a) but other answers were poor. Some candidates described a decreasing trend in boiling points instead of an increase. Others referred to halogen atoms or ions instead of molecules. A significant number of weak candidates gave an explanation that related to the first ionisation energy of the halogens instead of to the intermolecular Van der Waals' forces. In part (b) candidates lost marks due to imprecise descriptions of observations. Candidates should know that silver chloride appears as a white precipitate, not as a white colour or a white solution or just white. The colour and the state to which it applies are required in order to gain a mark for the observation. In part (c) some good candidates were able to score full marks but some lost marks due to incomplete answers or inaccurate observations that gave the wrong colour. Iodine in aqueous solution or when solid does not appear purple. Some good (and most weak) candidates gave unbalanced equations for the displacement reactions. The equations were often unbalanced or a reverse of the correct equation. Some equations were irrelevant because they involved the use of concentrated sulphuric acid.

CHM3/W Introduction to Organic Chemistry

General Comments

The paper was more straightforward than June 2002, but still proved to be an appropriate challenge to the most able whilst allowing considerable access to the lower achieving candidates. All marks on the paper were accessible and correct answers were seen for every part of every question. The best candidates rarely obtained full marks, but were able to score marks above 50. Some very weak scripts were seen, but it was possible for the least able candidates to show what they could do. Again, this year, marks were lost because answers lacked precision in the presentation of ideas.

Candidates should be encouraged to draw organic structures correctly with clearly presented C=C, C=O, C-H and O-H bonds, where appropriate. In mechanisms, greater care needs to be given to the use of lone pairs of electrons and to the precision of where a curly arrow starts and where it finishes. The use of charges, partial charges and unpaired electrons needs greater care and the failure to use IUPAC names and to balance equations is penalised.

Section A

Question 1

This question was generally well answered. In part (a), most candidates understood that only carbon and hydrogen are present in a hydrocarbon and the idea of a fuel was presented clearly by the majority. Weaker candidates made errors in the equations with incorrect products and incorrect balancing. Rather too many candidates thought that an absence of oxygen, rather than a limited supply, gave incomplete combustion in part (a)(v). In part (b), a number of candidates encountered problems in writing the formula either for an ethyl or for a methyl carbocation, but those who understood that the process of cracking involved breaking C-C bonds, as stated in the question, had no difficulty in giving the correct answers. Part (c) was well answered, but incorrect formulae for ethane and ethene were seen and nickel, the incorrect catalyst, was quite common. The final part of the question was looking for some qualification to supply and demand.

Question 2

Many candidates found parts (a) and (b) difficult. It was obvious from their answers that the conversion from methane to chloromethane had been learned, but the application of this idea to trichloromethane proved difficult. Even when candidates were able to start with a correct formula for trichloromethane, equations were confused, typically with radicals appearing in the overall equation and incorrect products and intermediates throughout both of parts (a) and (b). Part (c) was generally well answered, but errors were observed, such as the failure to include hydrogen in the calculation or the use of various incorrect relative atomic masses for chlorine. A few candidates were unable to proceed from a calculation of the correct ratio to a correct empirical formula, but many were able to indicate the need for a relative molecular mass in (c)(ii).

Question 3

Part (a) proved straightforward for most candidates, although some of the weakest did have problems in knowing which compounds they were trying to draw. While the most able found part (b) of this question relatively trivial and scored full marks, it is clear that mechanisms continue to be a challenge for the less able candidates. Almost all of the candidates attempted the questions and a large majority were able to score at least 3 of the 7 marks available in part (b). The usual difficulties associated with the position and direction of curly arrows and either incomplete hydroxide ions or attempts to use an apparently covalent sodium hydroxide resulted in the loss of marks. The mechanism in (b)(ii) is one of the more demanding parts of the specification and the weakest candidates struggled to score any marks here.

Question 4

The naming of isomers was usually fairly well done, with penalties exacted if non-IUPAC names were used; the commonest of which was 2-methylpropan-3-ol. Identifying the type of isomerism caused more problems than anticipated with chain, position, geometrical, stereo and functional group all being seen. An acceptable alternative to structural isomerism, was to quote both chain and position and this gained the mark in part (a)(ii). In part (b)(i) most candidates knew that they were looking for a tertiary alcohol and many indicated the correct answer. Relatively few candidates were able to write a correct balanced equation for the dehydration and even fewer indicated that their chosen dehydrating agent of sulphuric acid needed to be concentrated. Part (c) caused little difficulty for most candidates, although some structures were spoiled by extra hydrogen atoms on the carbonyl groups. Candidates should be encouraged to draw out the functional group when presenting the structures of, for example, alkenes, aldehydes and ketones. Part (c)(iii) caused relatively few difficulties, with Tollens' reagent a popular response. Those candidates choosing Fehling's solution often failed to state that a precipitate was formed with an aldehyde. Most candidates were able to identify butanoic acid as the product of oxidation in part (d), but many fewer could balance the relatively demanding equation, tending to miss either the water molecule produced in the oxidation or the 2[O].

Section B

Question 5

Overall, this question proved to be relatively high scoring with the weakest candidates able to gain some marks and the more able gaining most, but rarely all, of the marks. Part (a) proved accessible for most, although some very odd names were seen. In part (b), significant problems were experienced by a minority of candidates, but the majority scored at least half marks with the reagent for Reaction 5 proving to be the most challenging. The mechanism in part (c) was straightforward and often high scoring with the usual proviso that candidates penalised themselves by imprecise and careless presentation of their ideas. The last part of this question proved to be the most demanding part of the paper. The requirement for an aqueous solution was not always indicated and the equation for fermentation was done rather poorly. Candidates need to appreciate that they should avoid writing contradictory ideas, such as the need for yeast or an enzyme, but a temperature well in excess of 45°C. The final two marks gave candidates an opportunity to express their ideas in continuous prose, as indicated in the rubric

for the paper and the chemistry required them to 'compare the relative rates and the purity of the product' from each process, rather than looking exclusively at fermentation. Some candidates seemed to be writing that the ethanol obtained by fermentation is low yield, but a higher purity product than that obtained from the hydration of ethene and inevitably this thinking leads to some confused statements.

CHM3/C Internal Assessment

General Comments

Centres are again congratulated for their excellent and much appreciated efforts in ensuring that the moderation scheme ran smoothly and successfully once more. The standard of marking and the application of the appropriate criteria continue to be very good for the great majority of centres, and as a result few adjustments were necessary during the moderation process. The presentation and annotation of candidates' work remains at an excellent standard. The superb work done by most centres in this regard is greatly appreciated by moderators.

Judging by the number of centres using the exercises, the exemplar material provided by AQA grows in popularity. Some centres, however, used the original versions of these exercises, presumably unaware that some updating of these exercises has taken place. Copies of the amendments were distributed again at the Standardising meetings for practical work held in Autumn 2002. Centres are advised to contact AQA if they need a copy of the amendments.

The marks awarded covered a very similar range to those awarded in June 2002. Candidates continued to have most difficulties in Skill 4. A small, and happily diminishing, number of centres have yet to come to terms with the new scheme, and consequently received lengthy feedback forms. A disappointing number of these centres had failed to act on advice given in previous feedback. For the benefit of these centres, and for anyone new to the scheme, the following points are once again brought to the attention of teachers:

- Many centres used their own exercises for assessment with great success. Problems which arose usually resulted from the demand level of the exercise being inappropriate, or the centre not providing the candidate with enough information in the student instruction sheet to allow them to fulfil the criteria for full marks. Any centre planning to produce their own practical exercise or modify an existing exercise is very strongly advised to submit a copy to their coursework adviser before using the exercise.
- Major problems have sometimes arisen when centres have modified the exemplar marking schemes. The modifications usually reduce the demand level of the exercise by removing some of the more difficult scoring points without replacing them with appropriate alternatives. This inevitably reduces the maximum mark available. Sometimes the centre ignores the deliberate sectioning of the Exemplar mark scheme. Instead all scoring points are lumped together and a simple, often rather generous, sliding scale is applied. In either case, the final mark awarded is all too often too generous. Any centre planning to modify an exemplar exercise is strongly advised to submit a copy to their Coursework Adviser before using the exercise.
- A number of centres still used an Sc1 approach despite frequent warnings of its unsuitability. Centres are once again reminded that **an Sc1 style exercise does not meet the current criteria**. When an exercise is used to assess several skills, the candidate must write a complete plan before the practical work begins. Scale cannot be justified by trial experiments; it must be justified by calculations. Where appropriate the candidate may use

hypothetical results, but the candidate must not use their own experimental results in the plan. The section for each of the four skills must be submitted as a distinctly separate item. An Sc1 exercise is almost certain to receive a significant mark reduction.

- Exercises may be marked according to the criteria as long as an appropriate commentary is provided for each mark awarded, with the focus on the way in which the candidate's work matches the criteria. Comments justifying the award of the mark for each skill must be provided for the moderator. Some centres are adept at explaining how marks have been awarded. Other centres provide virtually no evidence. If this detailed information is missing it is unlikely that a moderator can accept answers which appear to fall well short of the normal standard.
- Evidence suggested that a few centres continued to carry out assessments without proper supervision. Some candidates produce very long word processed scripts, with much background research, passages from books, and downloads from the internet. Candidates with access to such information sources may have received too much guidance, limiting the maximum mark available. From 2004 candidates will not be permitted to use books or laboratory notebooks in practical assessments. If an exercise is not carried out under direct supervision, the candidates' work should be annotated accordingly.
- Care should be taken with the use of ICT. Candidates should avoid downloading irrelevant information from the internet or CD ROM and using spreadsheets without any thought to the precision of recording. If ICT is used by candidates to calculate quantitative results, there needs to be clear evidence that the candidate can calculate the outcome independently and can arrive at a judgement of the errors.
- Surprisingly a small number of candidates failed to fulfil the minimum requirement of submitting work taken from **at least two modules**. Happily, thanks to the timely intervention of the moderator this error was usually brought to the attention of the centre sufficiently early for the candidates to complete an additional exercise from another unit, and avoid an impoverished marks as a result. Centres are reminded that the work submitted must cover at least two modules, and the candidate's marks which count towards the total cannot be taken from just one module. If a candidate submits one mark per skill only, and all of the work is drawn from CHM1, the candidate will lose the lowest of the four marks.
- A number of centres gave a zero score when the candidate had in fact made a little progress. Centres are reminded that for any skill a score of 0 should only be awarded when a candidate submits no useful work at all. If the candidate gains a few of the scoring points 1 mark must be awarded.

Skill 1 Planning

The standard of work seen was high. The sections on scale and use of results continue to be the most demanding, with only the better candidates scoring highly in these areas. Centres are reminded that they must not dilute the demand in these difficult areas if the candidate is to have access to the highest marks. In addition the sections on justification of scale and use of results have to be treated separately; one set of calculations cannot count for both.

Safety considerations are still not always specific to the exercise in question. To earn the safety mark candidates must consider the dangers posed by the reagents and products in the experiment, and suggest appropriate precautions. Simply giving a list of standard precautions does not merit the awarding of the safety mark.

Skill 2 Implementing

In general the standard of work seen was good, and most centres used tick lists well and placed a suitable emphasis on accuracy. Little inappropriate work was seen.

Centres are reminded that the candidate must record some results in an appropriate form of their own design.

In far too many cases a target value was not provided by the supervisor. In such cases, where the accuracy of the candidate's result cannot be assessed with confidence, the maximum mark is 5.

Centres are reminded that in exercise requiring the plotting of a graph, the supervisor must ensure that the candidate has plotted the graph correctly. If this is clearly not the case, the supervisor must plot the graph and base the candidate's marks for accuracy on the correct plot. Similarly the supervisor must check, where appropriate, that accuracy marks are based on a correct calculation.

Skill 3 Analysing

The standard exercises were usually well presented and error analysis was covered very well. The only mark that was often missed was the precision mark. Centres are reminded that appropriate precision is not an optional extra in Skill 3.

Happily very few centres attempted to analyse the results of observation or preparation exercises. The attempts were as is often the case largely unsuccessful as the depth of material available for analysis was too limited to compensate for the absence of precision and error analysis. Centres are strongly advised against using quantitative work for this skill at AS level. Centres are reminded that full marks cannot be awarded for a graph with a poor scale, which does not cover at least half of the graph paper.

Skill 4 Evaluating

Evaluation was once again the weakest area in terms of the level achieved in the candidates' scripts and the marking of the work. Unhappily far too many centres used old versions of the Skill 4 exercises. Candidates then answered at great length without making specific reference to the data available in the experiment as performed. The candidates consequently struggled to reach a high level, mainly because they do not know what was expected rather than because of any lack of ability. Some centres tried to compensate for this by awarding marks on very flimsy evidence.

Structured exercises based upon a common set of data tended to be more candidate friendly, and easier to mark accurately and consistently. Candidates found the new versions of the exemplar exercises much more accessible and centres are strongly advised to use them.

CHM3/P Practical Examination

General Comments

This examination discriminated effectively between able and less able candidates. Many good scripts were seen, with a good number of high marks. Although very few candidates obtained maximum marks, the great majority of candidates scored at least half marks. Candidates found this year's paper as accessible the paper in Summer 2002. Once again the Planning exercise was familiar to most candidates.

Exercise 1: Skill 2 Implementing

This was one of the easier exercises on the paper. Many candidates scored high marks, with a significant number scoring full marks. The great majority of candidates scored the marks for manipulative skills and completing the table. Most candidates also scored the mark awarded for precision of recording.

The examiners corrected the starting temperature when the candidate's reagents had different initial temperatures, and then recalculated the temperature rise from the candidate's graph. This worked smoothly, although a small number of centres failed to provide supervisor results. As expected, the accuracy of the candidates' results varied quite widely, but the majority of candidates scored at least one of the four marks. Where necessary the examiner replotted a candidate's graph and based the accuracy marks on the correct plot.

Exercise 1: Skill 3 Analysing

Most candidates scored at least one of the two marks for plotting a graph of their results. However many candidates used an inappropriate temperature scale, losing one mark automatically. Some candidates were unfamiliar with a cooling curve and could not extrapolate their graph correctly. A small minority of candidates chose at least one awkward scale, and consequently failed to plot the points correctly.

Exercise 2: Skill 3 Analysing and Skill 4 Evaluating

This exercise differentiated markedly between able and less able candidates. The weakest candidates failed to give correct answers to all but the simplest sections.

In the Analysing section a surprising number of candidates could not draw the appropriate best fit lines on the graph, even though the profile was identical to the graph in Exercise 1. Many candidates did not realise that there were two anomalous points, and tried to include all of the readings in the best fit line. The great majority of candidates were familiar with the $q = mc\Delta T$ equation in part 2 but many used the wrong number for the mass, m . In part 3 nearly all candidates could calculate at least one of the quantities correctly. Many candidates had considerable difficulty with part 4, and had no idea how to scale their answer from part 2 to molar quantities.

As in previous years, many candidates could not record their answers with an appropriate precision. Although most students recorded the temperature rise in part 1 to one decimal place, the need to record the enthalpy changes in parts 2 and 4 to three significant figures was

ignored by many candidates. Furthermore, in part 4 few candidates appreciated the significance of there being only 0.0191 moles of zinc and used 0.02 in the calculation. The great majority of candidates scored the mark for the estimation of errors in part 5.

A significant number of candidates failed to score the mark for nomenclature and terminology. Candidates are expected to explain calculations in full, lay their work out logically and clearly, and use the appropriate terminology correctly. Units must be used correctly.

The Evaluating section of Exercise 2 proved once again to be a difficult part of the paper. In part 1 many of the candidates who plotted the graph correctly failed to make an appropriate comment on the technique used. Once again a surprisingly large number of candidates could not calculate the 'percentage error in the experiment' in part 2. In part 3, only the most able candidates appreciated that heat loss was the main source of error. Too many candidates suggested vague improvements such as 'use a better thermometer' or 'repeat the experiment' which did not receive credit. Very few talked in terms of a slow reaction, or a relatively small temperature rise.

Exercise 3: Skill 1 Planning

This exercise was answered well by the majority of candidates who were quite familiar with the required experiment. A few candidates ignored the information in the stem of the question and described unworkable experiments involving thermochemistry. However once again a disappointingly large number of candidates could not justify their chosen scale, frequently choosing 0.1 mol dm^{-3} as a suitable alkali concentration and providing trivial reasons for their choice. The great majority of candidates were familiar with the basic method required, but lost marks because they could not provide the necessary detail. In the method section, the colour change at the endpoint was the scoring point most frequently missed. In the treatment of results, most candidates successfully demonstrated a knowledge of the volumetric calculation. Virtually every candidate scored the safety points.

CHM4 Further Physical and Organic Chemistry

General Comments

As last year, many candidates found the questions difficult by comparison with AS but the overall standard was better this time than in previous papers. Many of the answers to the physical chemistry questions were particularly pleasing, but responses to the organic chemistry questions were often surprisingly weak even from candidates whose answers to the physical chemistry questions were good. There was some evidence that a few candidates were short of time to finish the paper.

Question 1

In part (a) few candidates were able to explain correctly what the term 'order of reaction' means. However, despite this most were able to use the idea itself and scored highly in the rest of the question. The fact that the rate of reaction increased by a factor of nine, 3^2 , when the concentration of A increased by three times led some candidates to think that the order with respect to A was three rather than two.

Question 2

The first three parts of this question were answered well even by some of the weaker candidates. Credit was given throughout for correct working consequential to errors in a previous part. Many candidates gained full marks in parts (a) and (b). In part (c)(i), most answers were correct except where square brackets were used. These are essential in K_c expressions but should not be used in expressions for K_p . Wrong substitution of the partial pressures values were sadly common but the correct units kPa^{-1} were usually given. After well-answered numerical sections, it was less common for the answers to both parts of (d) to be correct. Part (d)(i), which involved an increase in the volume of the vessel thereby causing a reduction in the total pressure, discriminated particularly well.

Question 3

Definitions of the terms K_w and pH in parts (a)(i) and (ii) were usually well answered except by those who failed to write mathematical definitions and attempted to describe the terms in words. Provided there were no contradictions, the marks could be earned in the later sections. The most common error in the expression for K_w was to include water. However this water term was conveniently forgotten in part (iii) and correct answers for the pH of pure water at 50°C were common. As reported regularly before, too many candidates seem not to be aware **that pH values should be given to two decimal places**; these two figures give the value to the appropriate precision. The numbers before the decimal point only give the powers of ten involved in the hydrogen ion concentration. However, failure to give pH values to the correct precision was only penalised once in the question. Part (b)(i) was answered well but (b)(ii) was more discriminating. A common error was to forget that the moles of excess sodium hydroxide were present in a total volume of solution of 75 cm^3 and needed to be converted into a molar concentration before the pH of the solution could be calculated. A number of candidates tried to answer the question as if a buffer solution had been produced despite the use of a named strong acid. Several also gave pH values below 7 although there was an excess of alkali present. Part (c) was answered well by most candidates although some

failed to give the general expression for K_a and instead wrote the more specific $[H^+]^2/[HX]$. This expression was however credited in part (c)(ii).

Question 4

In organic mechanisms, a curly arrow must start at a lone pair or at a bond. This idea was still forgotten by some candidates. In part(a), several used a lone pair on the nitrogen atom rather than one on the carbon of the cyanide ion. A few confused the nucleophilic addition in part (a) with the addition-elimination in part (b) and tried in part (a) to reform a carbon to oxygen double bond. An appreciable number thought that the name of the product was a propanenitrile instead of 2-hydroxypentanenitrile. In both parts (a) and (b) the C=O bond should not be shown breaking before the nucleophile attacks. The ester was often correctly named as methyl propanoate but many other suggestions were also seen. Part (c) discriminated well. Only the better candidates were able to identify the correct electrophile, join it correctly to the benzene ring, draw the correct intermediate and show the loss of H^+ correctly.

Question 5

In part (a), the correct name, 2-methylbut-1-ene, for the hydrocarbon, **M**, was found difficult by many and only the most able could draw the correct repeating unit for the polymer. The name of the mechanism for the reaction of benzene with **M** was often given as Friedel-Crafts. This is a type of reaction and the mechanism is correctly called electrophilic substitution. Only the better candidates realised that the major product of the reaction would be formed via a tertiary carbocation and also that the structural isomer of **M** required was pent-2-ene. Answers to part (b) were good from many candidates although the repeating unit did cause problems for some.

Question 6

This question discriminated well. Able candidates scored well in all parts, with part (b) found the most difficult. In part (a), oxidation and reduction of propanal were well understood and propanoic acid and propan-1-ol were identified by most except the least able. Details of the oxidising and reducing agents were less secure and the role of sulphuric acid was not well known. In part (b), many candidates stated that all four isomers, **B**, **C**, **D** and **E** must be carboxylic acids but then drew structures which were not all acids. The structure of **E** was found to be the most difficult to deduce. In part(c) the splitting patterns were well explained by many candidates, but the number who could correctly predict the δ values for the labelled protons was much smaller. In part(d), most were able to state that isomer **G** contained an alcoholic OH group, but only the most able could draw the correct structure for **G**.

Question 7

There was evidence that some candidates had spent too long attempting to solve the problems in Question 6 and had left themselves short of time for the descriptive aspects of this question. The standard of the mechanisms given in this question was similar to that in Question 4 and although many realised that further reaction could occur leading to 'other amines' many could not explain that this process began with the reaction of the first product, ethylamine, with bromoethane to form a secondary amine. To reduce this problem an excess of ammonia is used; many suggested that an excess of bromoethane was needed. In part (b)

the five marks could be earned without giving detail in the answers. Several candidates unnecessarily wrote mechanisms and equations. The idea that the electron rich benzene ring repels nucleophiles was not expressed clearly by many. The two step synthesis of phenylamine via nitrobenzene was generally well known.

CHM5 Thermodynamics and Further Inorganic Chemistry

General Comments

This examination paper was set to test not only the knowledge and understanding a candidate had of the content of Module 5, but also their knowledge and understanding of the whole specification. Synoptic questions require candidates to make links between different topics and to apply their knowledge and understanding of content and concepts in a logical manner. It is appreciated that this is a higher order skill and inevitably this paper will be more demanding than those which cover the content and concepts in one just module. Candidates should not expect to find this paper easy and they should not be disheartened if they find themselves unable to score high marks in every question. It is indeed rare to find a candidate who has such a complete knowledge and understanding of the specification content and concepts that they have no weaknesses. There were many excellent answers to the questions included in this paper and full marks were scored in every questions. The synoptic plan, included as questions 9, proved most demanding and some candidates did not attempt it.

Although candidates needed to work rapidly through the questions on this paper, there was little evidence that the most able had failed to complete it. Weaker candidates often left blank spaces in their answers so that it was more difficult to judge whether this was due to lack of time or an inability to answer the questions set.

Question 1

The acidity of Period 3 oxides was well known but a surprisingly large number of candidates were unable to write equations for their reactions as required in part (b). The structure and bonding in P_4O_{10} and SiO_2 were well known and most candidates were able to make the link to the volatility of the compound.

Question 2

Part (a) of this question was not well answered and many candidates were unable to identify reagents for the three given conversions. Many candidates used the information given in part (b) to deduce correctly the required equations in section (i). Sadly, weaker candidates ignored this information and a wide variety of incorrect species were given. Part (b)(ii) was marked using the given mole ratio and consequentially to the overall equation given by candidates in part (b)(i). Although many candidates did score full marks in this section a surprisingly large number failed to complete the question by calculating the concentration in $g\ dm^{-3}$ as required by the question.

Question 3

The term 'bidentate ligand' was well understood and most candidates were able to sketch the structure of the required complex in (a)(ii). The term 'chelate effect' was less well understood but many candidates were able to score both marks. In part (c) almost all explained correctly that chloride ions do not usually form octahedral complexes with metal(II) ions because of their relatively large size. Most were able to deduce correctly the formula of the linear complex formed when silver chloride dissolves in concentrated hydrochloric acid. Section

(i) and (ii) of part (d) were well answered but, having recognised Mn^{2+} as the catalyst for the reaction between the negative ions, MnO_4^- and $\text{C}_2\text{O}_4^{2-}$, the suggestions of how the catalyst might be involved in the reaction were sometimes given in general terms rather than by specific reference to the involvement of the Mn^{2+} ion.

Question 4

All of the required enthalpy changes involved in the Born-Haber cycle for the formation of BaCl_2 were given in section (ii) of part (a) and the question specifically stated that a full labelled cycle was required with symbols for all species. Nevertheless, many candidates lost marks when they omitted state symbols, electrons and steps and gave incorrect species. Consequential marks were awarded in (a)(ii) and only candidates who made three errors failed to score in this section. Part (b) was well answered. Candidates who failed to convert the values of the enthalpy and entropy changes into the same units lost one mark as did those who chose the wrong value for the enthalpy of the reaction from the data given.

Question 5

This question was well answered and many candidates scored full marks. Consequential marks were awarded in part (b) and (c)(i) when incorrect units for pressure and volume had been used. The equations in sections (i) and (ii) of part (c) were well done as was the calculation of the moles of iodine formed in section (iii). Marks for the number of moles of bromine reacted and the percentage by moles of ethene present in the gas mixture were awarded consequentially.

Question 6

Although there were many excellent answers to this question on transition element chemistry, some candidates clearly had little knowledge or understanding of these specification topics. Common errors in part (a) included failure to state that a precipitate would form initially and in giving incorrect cobalt complexes. Candidates who failed to state the observations in part (b) also lost marks.

Question 7

This question was not well answered. In part (a) candidates were required to state how sulphuric acid could be used to distinguish between solid samples of two sodium halides. Although candidates were free to select any two halides, many answers to this part were vague, inaccurate and incomplete. In part (b) candidates were required to state how sulphuric acid could be used to prepare isomeric alkenes from an alcohol. Candidates who chose an alcohol which does not form isomeric alkenes lost three marks but were able to score marks for an equation and for the role of sulphuric acid in the reaction. The role of sulphuric acid in the preparation of an aromatic nitro-compound was better known.

Question 8

The calculation of the equilibrium constant, K_c , required in part (a)(i) was generally well done. The most common error was made by candidates who subtracted the equilibrium moles of ethanoic acid from the initial moles of alcohol when calculating the moles of alcohol at

equilibrium. Consequential marks were awarded after any arithmetic error. In answer to (a)(ii), most candidates recognised that similar bonds were being broken and made during the formation of the ester, but not all stated that the same number of these bonds was involved. Part (b)(i) most candidates stated correctly that hydrogen bond between ethanoic acid molecules explains why it is a liquid at room temperature but rather less candidates referred to the weaker dipole-dipole attractive forces between molecules of hydrogen chloride. Almost all candidates were able to give two advantages of using ethanoic anhydride rather than ethanoyl chloride in the manufacture of aspirin.

Question 9

This question tested the ability of candidates to use given information, together with their knowledge and understanding of chemistry contained in modules 2 and 5, to plan an experiment. Since credit was given for every correct statement, even when it did not form part of an overall logical plan, every candidate who made a reasonable attempt at this question scored marks. There were some excellent answers for which full marks were awarded. Generally, part (a) was less well answered than part (b). Only the better candidates first removed SiO_2 by filtering a solution formed by the addition of either water or hydrochloric acid before adding barium chloride to precipitate out the sulphate ions as barium sulphate. In part (b), most stated correctly that the precipitate could be removed by filtration. Some, but not all, then washed the precipitate before drying and weighing it. The better candidates then gave fully correct explanations of how the percentage by mass of sulphate ions in the solid waste could be calculated whilst many weaker candidates scored some marks for a partially correct answer.

CHM6/W Synoptic Assessment

This objective test paper proved to be of a very similar standard to the corresponding paper in June 2002. The mean mark out of a total of 40 was slightly higher this year (22.1 compared with 21.4) and the improvement in the mean facility from pre-tests to examination was also greater. Thus candidates performed significantly better than in 2002.

Questions 1,3,6,7,9,11,13,26,29 and 35 proved to be easy with a facility greater than 65%.

Questions 15 and 31 were difficult having facilities less than 35%. For question 15 the facility was 29.8%. This question discriminated very effectively between good and weak candidates. Response D was most the popular response for many candidates who did not appear to understand how to calculate percentage yield. The incorrect response D (a percentage yield of 81%) was obtained by expressing the ratio of the mass of the reactant to the mass of product as a percentage. This ratio is clearly incorrect as the ratio is the inverse of the method required to obtain the correct answer and also uses masses incorrectly instead of moles. Response D was a notable distractor for the candidates as a whole attracting 50.4% of answers.

For question 31 the facility was 29.6%. The correct response was C but the percentages of candidates giving other responses were almost equal, each over 20%. Thus it appears that many candidates may not have understood the question and may have guessed the answer. Perhaps their understanding of electronic configurations had suffered since they last met this topic in the first module.

All the questions in the examination discriminated well between candidates of differing abilities.

CHM6/C Internal Assessment

General Comments

Centres are congratulated for their efforts in ensuring that the second year of the new assessment scheme ran as smoothly and successfully as the first. The standard of marking and the application of the appropriate criteria were usually very good, and as a result few adjustments were necessary during the moderation process. Centres had clearly benefited from their experience with the scheme last year.

Although relatively few candidates obtain maximum marks, even fewer candidates score below half marks. Single figure totals were invariably due to an impoverished mark.

A small minority of centres continued to experience sadly familiar difficulties in meeting the requirements of the scheme. Full details are given in the report for CHM3/C. Rather than repeat the long list of recommendations here, this report will concentrate on aspects which are particularly relevant to CHM6/C.

- A smaller number of centres used experiments based on exercises from the legacy exemplar books. The criteria for the new scheme do not match the criteria for the legacy syllabus. Some of these old exercises can be successfully adapted, some cannot. Whenever a centre used the legacy exercises and marking schemes without appropriate change a downward adjustment of marks was invariably recommended.
- Centres are once again reminded that the exercises from the current exemplar book¹ were designed on the assumption that candidates do not have access to notes or literature sources. In addition centres must ensure that candidates do not receive help and guidance from any external source e.g. the Internet or another student. Candidates who are sent away to research an organic preparation are receiving significant help. Some even included photocopies from books of the apparatus needed.

Supervisors should help a candidate who is in difficulty, and apply a suitable penalty if the help is significant. This is the only guidance candidates should receive.

- The standard of the annotation of scripts was very variable indeed. Some centres provided brief, vague mark schemes and scripts with virtually no annotation. This makes accurate moderation much harder to achieve, especially when a centre is using its own exercises. To provide little or no indication of where candidates have scored marks is unwise. If detailed information on how marks have been awarded is missing it is unlikely that a moderator can accept answers which appear to fall short of the normal standard.
- Centres are reminded that exercise submitted for AS cannot be re-submitted for A2, even when the exercise is of an appropriate standard.

¹ Guidance for Practical Work Exemplar Assessment Material (Issued June 2000)

Skill 1: Planning

Much good work was seen, but one or two small points are worth repeating:

In Exemplar Exercise 9, 'The Analysis of Lawnsand', to score 8 marks the candidate must filter the mixture, with appropriate washing of the sand, when preparing a standard solution. Many candidates omitted this vital step, without penalty.

Exercises taken from other Awarding Bodies or from text books frequently fail to match all of the AQA requirements, particularly in respect to justification of scale, safety and overall demand level. Any centre planning to use such an exercise is very strongly advised to submit a copy to their coursework adviser before using the exercise.

Skill 2: Implementing

In general the standard of work seen was very good, and most centres used tick lists well and placed a suitable emphasis on accuracy. Little inappropriate work was seen.

However, as in CHM3, too many centres failed to provide a target value. As at AS, where the accuracy of the candidate's result cannot be assessed with confidence, the maximum mark is 5.

The two exemplar exercises both require the plotting of a graph. In Exemplar Exercise 8, 'The Reaction of Hydrogen Peroxide and Iodide Ions', some centres greatly reduced the demand level by allowing the candidates to plot a simpler graph or simply omitted the graph section altogether. A mark adjustment was inevitable. In addition the supervisor often failed to correct a candidate's incorrect plot or best fit line. In Exemplar Exercise 9, 'The Decomposition of Sodium Hydrogencarbonate', candidates were often guilty of completely erroneous extrapolations. Centres are reminded that the candidate's marks for accuracy must be based on the correct plot. Similarly the supervisor must check, particularly in Exemplar Exercise 9, that accuracy marks are based on a correct calculation.

Exemplar Exercise 8, 'The Reaction of Hydrogen Peroxide and Iodide Ions', caused difficulty in some centres. Strictly speaking the order of the reaction should always be 1 as long as the candidate uses the same reagents and apparatus throughout. In that sense, the concept of a target value determined by the centre is irrelevant. Nevertheless a number of centres based accuracy marks on a class average. This sometimes meant that candidates did not score full marks for an order near to unity. This change to the mark scheme was not penalised this time, but it is to be avoided in the future. If a supervisor suspects that the experiment is not working as it should the supervisor should perform the experiment him/herself. Accuracy marks can be judged against this supervisor value, with a note to this effect to the moderator.

Skill 3: Analysing

The standard exercises were usually well presented and error analysis was covered very well. In Exemplar Exercise 9, 'The Decomposition of Sodium Hydrogencarbonate', candidates were not penalised as they should have been for poor temperature scales, or completely erroneous extrapolations. Centres are reminded that the use of appropriate precision is not an optional extra in Skill 3.

Skill 4: Evaluating

The attention of centres is drawn to the notes on Skill 4 in the CHM3/C report, which also apply to the work seen for CHM6/C.

Given the pressures on centres to deliver the teaching programme are ever present at A2, this was another very positive and encouraging session. Centres are again warmly commended for their efforts, which are much appreciated by the moderator team.

CHM6/P Practical Examination

General Comments

This examination discriminated effectively between able and less able candidates. Many good scripts were seen. Although very high marks were relatively rare, the great majority of candidates scored at least half marks. Candidates found this year's paper as accessible the paper in Summer 2002.

Exercise One: Skill 2 Implementing

This was one of the easier exercises on the paper. Many candidates scored high marks, and a significant number of candidates scored full marks in this most familiar of practical exercises. The great majority of candidates scored the marks for manipulative skills, completing the table and concordancy of titre values used in calculating the mean. Most candidates also scored the mark awarded for precision of recording. As expected, the accuracy of the candidates' results varied widely, but the majority of candidates scored at least two of the three marks.

Exercise Two: Skill 3 Analysing and Skill 4 Evaluating

This exercise differentiated well between able and less able candidates. There were many very good answers but the weakest candidates failed to give correct answers to all but parts 1 and 6.

In the Analysing section the great majority of candidates scored marks for the reaction equation in part 1. In parts 2 and 4 (a) a surprising number of candidates ignored the instruction to use all of the concordant results in calculating an average titre. Part 3 was well done, but in part 4 (b) many candidates calculated a correct value for the total number of moles but then added their answer to part 2 to the total. Part 5 was well answered, and candidates who made basic errors in parts 3 and 4 often rescued a mark here. Virtually all candidates obtained the mark for the estimation of errors in part 6.

A significant number of above average candidates still fail to record results with appropriate precision. A similar number of candidates failed to score the mark for nomenclature and terminology. Candidates are expected to explain calculations, including the calculation of the average titre and the percentage errors, in full, lay their work out logically and clearly, and use the appropriate terminology correctly. Units must be correct.

The Evaluating section of Exercise 2 proved to be more demanding, and full marks were relatively rare. Most candidates scored the mark for commenting on the consistency of the results in part 1. A pleasingly large number of candidates correctly calculated the percentage error in the experiment in part 2. In parts 3 and 4 candidates either answered both sections correctly, or missed the point completely. In part 3 a number of candidates thought that zinc would react with iron(II) ions or act as an oxidising agent.

Exercise Three: Skill 1 Planning

In principle the Planning exercise should have been familiar to most candidates, representing a basic chemical process. Based on the evidence of the scripts, it is clear that many candidates had not encountered recrystallisation as a practical technique. Many candidates described a variety of hybrid, often unsafe, experiments which would simply not have resulted in a pure sample of the product. They tended to score the marks for scale and safety only.

Most candidates understood the basic principles of justifying their chosen scale, but the scaling for a 65% yield caused some problems. Nevertheless this section was better answered than in the past. Candidates who were familiar with the basic method often used a solvent other than methylbenzene, water being a popular choice. Apparatus was often limited to filtration only. The great majority of candidates scored at least half of the safety points, although a small minority of candidates then proceeded to describe an experiment which would be decidedly unsafe to carry out. The appreciation of the need to avoid naked flames did not preclude the use of a Bunsen burner. If candidates demonstrate a weakness in this area it is that the safety review is still restricted to general aspects only, rather than hazards specific to the experiment itself.

Advanced Extension Award

General Comments

The five questions included in this examination paper were designed to assess not only a candidates knowledge and understanding of chemistry but also their the ability to present information clearly and to make logical deductions from information given. Each question, in a different context, provided a challenge even for the most able. There were many very good answers but it was rare to find a candidate who could score very high marks in all five questions.

Question 1

The quality of the answers to the questions based on the passage about the manufacture and reactions of epoxyethane varied widely. In part (a) the weakest candidates were unable to list the bonds broken and made when epoxyethane is hydrolysed and even the better candidates did not always make the link between the strained ring structure and the exothermic hydrolysis reaction. The passage and the question in part (b) stated that the reaction of epoxyethane with water and ethanol was acid-catalysed. Nevertheless, in part (b), some candidates gave incorrect mechanisms for the reaction showing an initial attack by ethanol. Most candidates gave the structure of a correct product in part (c) but rather less deduced a correct structure for compound **X** in part (d). Candidates who did deduce the correct structure for **X** usually gave two correct hydrolysis products and deduced the number of peaks in the proton n.m.r spectrum of **X**. Part (e) was very well done and almost all candidates were able to identify compound **Y** and the organic product, butan-1-ol, produced by its hydrolysis.

Question 2

With very few exceptions, candidates plotted an accurate graph using the data given in part (a). Almost all drew correct tangents and calculated correct initial and maximum rates for the reaction. Most, but not all, explained the shape of the curve and deduced that the reaction was autocatalytic. Many candidates suggested correctly that, as the rate was changing rapidly, the value for the initial rate of reaction was less accurate than that for the maximum rate.

Part (b)(i) was well answered and most candidates used the data to determine the rate equation for the reaction and used it to deduce the value of the rate constant. Most candidates then calculated the higher initial rate of reaction using the values given in part (b)(ii). Only the best candidates then drew a correct sketch graph for the reaction under these new conditions. Almost all sketch graphs showed a greater initial slope and an asymptote to the same final concentration of X. Few, however, drew a curve which crossed the original or explained that, as the solution was buffered, the rate of reaction did not increase.

The buffer calculation in part (c)(i) was well done. Marks were awarded consequentially to errors made in calculating the concentration of H_2CO_3 . The calculation of ratio of the concentration of HCO_3^- ions to H_2CO_3 was also well done but a number of candidates did not then suggest what happens to dissolved carbon dioxide in the blood as required by the question. Part (c)(iii) proved to be very difficult and only a small number of candidates answered this question correctly. There were two common errors; the first was to assume that

the hydrogen ion and the carbonate ion concentration were equal; the second was to assume that the hydrogencarbonate ion concentration was 0.20 mol dm^{-3} .

Question 3

This question produced a very wide spread of answers with some candidates scoring almost full marks whilst others scored very few. Most candidates identified some of the species **A** to **F** in part (a)(i) but few scored full marks. The half-equation for the oxidation of aqueous SO_2 to SO_4^{2-} was generally well done but few candidates gave a correct equation for the reaction of SO_2 with complex **B**, $[\text{CuCl}_4]^{2-}$. The role of air in the conversion of **D**, $[\text{Cu}(\text{NH}_3)_2]^+$ into **F**, $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})]^{2+}$ was well known and most candidates were able to explain why complex **D** was not coloured. Part (b)(i) was well answered and most candidates gave the correct formula of **J**, HClO_3 , and many also gave correct equations for the formation of chlorine dioxide. Candidates scored marks in (b)(ii) for the species formed when chlorine dioxide reacts with H_2S and $\text{Fe}^{2+}(\text{aq})$ ions but few gave correct equations. Candidates who deduced the correct formula for compound **K**, NaClO_2 , in part (b)(iii) often lost marks when they gave incorrect equations for its formation and disproportionation. Most candidates used the data given in part (c)(i) to determine the correct formula, BaO_2 , for the oxide of barium. The equation for the reaction of BaO_2 with H_2SO_4 was well done but a surprisingly large number who knew that BaSO_4 is insoluble in water failed to realise that a protective layer would soon form. The quality of answers to part (c)(ii) varied enormously. Some candidates found this section very easy and scored full marks whilst others found it very difficult. For weaker candidates, writing half-equations for the reduction and oxidation of H_2O_2 proved to be very difficult and some failed to give correct half-equations for the oxidation of iodide ions and the reduction of manganate(VII) ions.

Question 4

In part (a)(i) some candidates lost a mark when they only considered the interaction of aqueous sodium hydroxide with one of the two given compounds. Most, in section (ii), deduced the empirical formula of compound **L** correctly as $\text{C}_7\text{H}_6\text{Cl}_2$ but many then failed to explain, using the data given, that only one of the two chlorine atoms in **L** could be readily be removed by hydrolysis. As a result only the better candidates gave the three possible structures for compound **L**. Marks were awarded consequentially for the mechanism for the reaction of **L** with aqueous sodium hydroxide.

Many candidates gave excellent answers to part (b)(i) with clear well presented structures. Only a small number of candidates gave an incorrect structure for the tertiary alcohol, $\text{C}_5\text{H}_{11}\text{OH}$, compound **P**. Candidates who made this error could score up to 4 consequential marks if they subsequently deduced two correct alkene products and gave the number peaks in their n.m.r. spectra. As the structure of compound **Q** could be deduced using the given n.m.r. data, these candidates could score full marks for the remainder of the question. Candidates who completed part (b)(i) correctly usually followed this with a fully correct answer to part (b)(ii). Some, who had failed to answer (b)(i), scored full marks in (b)(ii). Drawing the structural isomers of $\text{C}_3\text{H}_5\text{Cl}_3$ in part (c) proved quite easy but, whilst almost all identified the optical isomer, a surprisingly large number omitted one of the five structural

formulae. Most candidates deduced the number of peaks in the mass spectrum of $C_3H_5Cl_3$ and gave the m/z values for each peak. Deducing the relative abundance of each peak was far more difficult and few candidates gave the correct ratio, 27:27:9:1. Candidates who made one error and gave the ratio 27: 9:3:1 scored one mark. Fractional and percentage answers were also allowed.

Question 5 (a)

This question was the least popular of the two essay questions in Section C. There were few good answers and most were vague and confused. Better candidates did state the trend in the bonding of chlorides across a Period and illustrated their answer with three relevant examples. Many then, as anticipated, chose to discuss the trend in the melting point of the chlorides and the trend in their reactions with water. Failure to illustrate answers with suitable examples resulted in a loss of marks for many candidates. The trends down a single Group of the Periodic Table and the factors which influence them were less well explained. Marks were again lost when candidates failed to illustrate their answers with appropriate examples.

Question 5(b)

Many of the answers to this question concentrated on the listed properties of transition elements. These properties were often well explained but only the best candidates included in their answer an explanation of why these properties are not usually shown by compounds formed by non-transition elements. Nevertheless, most candidates were able to give an example of a compound formed by a non-transition elements which had each of the listed properties. Overall, it was omissions rather than errors which caused most candidates to lose marks in this question.

Mark Ranges and Award of Grades

Unit/Component	Maximum Mark (Raw)	Maximum Mark (Scaled)	Mean Mark (Scaled)	Standard Deviation (Scaled)
CHM1	60	60	34.3	12.5
CHM2	60	60	29.0	12.6
CHM3/W Written	60	75	42.3	17.3
CHM3/C Coursework	30	45	36.2	6.6
CH3C	--	120	78.7	21.5
CHM3/W Written	60	75	41.1	17.0
CHM3/P Practical Exam	30	45	30.8	6.6
CH3P	--	120	72.3	21.6
CHM4	90	90	50.0	21.3
CHM5	120	120	52.8	23.9
CHM6/W (OTQ)	40	60	33.2	10.5
CHM6/C Coursework	30	30	25.2	3.6
CH6C	--	90	58.6	12.5
CHM6/W (OTQ)	40	60	32.9	10.7
CHM6/P Practical Exam	30	30	21.1	4.5
CH6P	--	90	54.2	14.0

For units which contain only one component, scaled marks are the same as raw marks.

CHM1 Atomic Structure, Bonding and Periodicity (12553 candidates)

	Max. mark	A	B	C	D	E
Scaled Boundary Mark	60	44	38	32	26	20
Uniform Boundary Mark	90	72	63	54	45	36

CHM2 Foundation Physical and Inorganic Chemistry (19120 candidates)

	Max. mark	A	B	C	D	E
Scaled Boundary Mark	60	40	34	28	23	18
Uniform Boundary Mark	90	72	63	54	45	36

CH3C Introduction to Organic Chemistry with Coursework (14670 candidates)

		Max. mark	A	B	C	D	E
CHM3/W Boundary Mark	raw	60	45	39	33	27	22
	scaled	75	56	49	41	34	28
CHM3/C Boundary Mark	raw	30	26	23	20	17	14
	scaled	45	39	35	30	26	21
CH3C Scaled Boundary Mark		120	95	83	71	60	49
CH3C Uniform Boundary Mark		120	96	84	72	60	48

CH3P Introduction to Organic Chemistry with Practical Examination (3564 candidates)

		Max. mark	A	B	C	D	E
CHM3/W Boundary Mark	raw	60	45	39	33	27	22
	scaled	75	56	49	41	34	28
CHM3/P Boundary Mark	raw	30	22	20	18	16	14
	scaled	45	33	30	27	24	21
CH3P Scaled Boundary Mark		120	89	79	69	59	49
CH3P Uniform Boundary Mark		120	96	84	72	60	48

CHM4 Further Physical and Organic Chemistry (7331 candidates)

	Max. mark	A	B	C	D	E
Scaled Boundary Mark	90	68	59	50	41	32
Uniform Boundary Mark	90	72	63	54	45	36

CHM5 Thermodynamics and Further Inorganic Chemistry (10862 candidates)

	Max. mark	A	B	C	D	E
Scaled Boundary Mark	120	75	65	55	45	35
Uniform Boundary Mark	120	96	84	72	60	48

CH6C Synoptic Assessment with Coursework (9001 candidates)

		Max. mark	A	B	C	D	E
CHM6/W Boundary Mark	raw	40	29	25	22	19	16
	scaled	60	44	38	33	29	24
CHM6/C Boundary Mark	raw	30	26	23	20	17	14
	scaled	30	26	23	20	17	14
CH6C Scaled Boundary Mark		90	70	62	54	46	38
CH6C Uniform Boundary Mark		90	72	63	54	45	36

CH6P Synoptic Assessment with Practical Examination (1844 candidates)

		Max. mark	A	B	C	D	E
CHM6/W Boundary Mark	raw	40	29	25	22	19	16
	scaled	60	44	38	33	29	24
CHM6/P Boundary Mark	raw	30	22	19	17	15	13
	scaled	30	22	19	17	15	13
CH6P Scaled Boundary Mark		90	66	57	50	43	37
CH6P Uniform Boundary Mark		90	72	63	54	45	36

Advanced Subsidiary award

Provisional statistics for the award (13865 candidates)

	A	B	C	D	E
Cumulative %	23.7	42.0	58.6	73.9	85.8

Advanced award

Provisional statistics for the award (10831 candidates)

	A	B	C	D	E
Cumulative %	30.2	52.9	71.7	85.3	94.9

Advanced Extension Award (AEA)

Provisional sStatistics for the award (835 Candidates)

	Maximum Mark (Raw)	Maximum Mark (Scaled)	Merit	Distinction
Scaled Boundary Mark	160	160	74	94

	Merit	Distinction
Cumulative %	40.2	14.4

Definitions

Boundary Mark: the minimum mark required by a candidate to qualify for a given grade.

Mean Mark: is the sum of all candidates' marks divided by the number of candidates. In order to compare mean marks for different components, the mean mark (scaled) should be expressed as a percentage of the maximum mark (scaled).

Standard Deviation: a measure of the spread of candidates' marks. In most components, approximately two-thirds of all candidates lie in a range of plus or minus one standard deviation from the mean, and approximately 95% of all candidates lie in a range of plus or minus two standard deviations from the mean. In order to compare the standard deviations for different components, the standard deviation (scaled) should be expressed as a percentage of the maximum mark (scaled).

Uniform Mark: a score on a standard scale which indicates a candidate's performance. The lowest uniform mark for grade A is always 80% of the maximum uniform mark for the unit, similarly grade B is 70%, grade C is 60%, grade D is 50% and grade E is 40%. A candidate's total scaled mark for each unit is converted to a uniform mark and the uniform marks for the units which count towards the AS or A-level qualification are added in order to determine the candidate's overall grade.