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Report on the Examination

Chemistry

- Advanced Subsidiary
- Advanced

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General Comments

Once again, the quality of work seen by the examiners was reported to vary widely. Some excellent attempts were seen, together with a significant number of scripts where it was clear that candidates had failed to prepare themselves adequately for the examination. Many of the questions requiring accurate recall were poorly done, suggesting that the required material had not been sufficiently well learned by many candidates. Examples included the definitions of *relative molecular mass* and *electronegativity*, the explanation of the trend in electronegativity across a period, the meaning of the term *empirical formula* and the chemical test for sulphate ions. As in previous years, terms such as *nucleus*, *atoms*, *molecule*, *macromolecule* and *ion* were used indiscriminately and out of context. The ability to construct concise and relevant answers to questions requiring explanation or description was frequently lacking, so that many disjointed and rambling accounts, particularly in question 5(a), were seen. In some cases, comments made in one part of an answer contradicted valid points made elsewhere in the answer and so marks were lost. The majority of candidates attempted all the questions, although a few made no attempt at some parts of the paper. As in previous years, this is not felt to be due to lack of time but rather may have been due to the lack of adequate preparation, but may also have resulted from time being wasted producing unnecessarily long answers to some questions.

Question 1

Most candidates gave an acceptable definition of *mass number* but many incorrect definitions of *relative molecular mass* were seen. Some candidates gave a definition of *relative atomic mass*, suggesting that they had not read the question with sufficient care. The most common errors were the result of omitting essential words such as 'average', 'mass of' and 'atoms' from the definition. In part (b), the majority of candidates gave the electron arrangement of copper as $1s^2\ 2s^2\ 2p^6\ 3s^2 3p^6\ 3d^9\ 4s^2$, rather than as $1s^2\ 2s^2\ 2p^6\ 3s^2 3p^6\ 3d^{10}\ 4s^1$. Given the very limited experience AS candidates have of transition metals, the former arrangement was accepted but centres are requested to ensure that candidates are aware of the correct electron arrangement for copper. Parts (b) (ii) and (b) (iii) were generally well answered. Most of the explanations offered in part (c) (i) referred to the A_r value being an average, or focussed on there being a greater peak height at $m/z = 63$. Only a minority of candidates deduced that the abundance of the ^{63}Cu isotope was greater than that of the ^{65}Cu isotope. Part (c) (ii) was generally well answered, although some candidates stated that an electron was knocked out of the Cu atom by an electron gun, rather than by an electron from an electron gun. Part (c) (iii) was well answered by those candidates who understood the processes involved and were able to deduce the formation of the $^{63}Cu^{2+}$ ion, explain the position of its peak in the spectrum and recognised that this ion would be less likely to be formed. Many errors were seen, which included omitting the mass number or the charge from the identity for the ion, suggesting that the copper ions fragment or that some other ion, such as $^{31.5}P^+$ or $^{31.5}S^+$ were present.

Question 2

This question was in general very well answered. Most candidates were able to display considerable numerical skill and full marks, or near full, marks were very common. Answers to parts (a)(i) and (a) (ii) were almost always correct. Part (a) (iii) was less well done, with some candidates subtracting their answer to part (a) (ii) from that for part (a) (i), rather than deducing that the number of moles of unreacted NaOH must be equal to the number of moles of HCl used to neutralise it. Many of these candidates then consequentially earned the mark part (a) (iv) by correctly applying the calculation process to their answers to parts (a) (i) and (a) (iii). Most candidates also coped well with part (a) (v); however, the incorrect use of the mole ratio, errors in calculating the M_r value of ammonium sulphate or arithmetical errors were not uncommon. Part (b) was generally very well done, clearly a well-practiced technique. The gas law equation was almost always correct and most candidates correctly calculated the number of moles of ammonia, although a surprisingly large minority used 18 as the M_r value of ammonia. The vast majority of candidates rearranged the equation correctly, however, a small number failed to convert the pressure to Pa. Examiners reported that in a small number of centres candidates had used the units of kPa and dm^3 in their calculations. Candidates were not penalised for using this approach on this occasion but centres are requested to ensure that candidates use the correct metric units of Pa and m^3 in future gas law calculations.

Question 3

Overall, this was the most poorly answered question. While some good answers were given to part (a) (i), many responses amounted to no more than a vague suggestion of electron transfer from magnesium to chlorine rather than explaining the formation of the individual ions. It was not uncommon for the formation of Cl_2^{2-} to be suggested, and electron transfer from chlorine to magnesium was occasionally offered. In part (a) (ii), candidates tended to limit their answers to statements such as ‘ionic bonds are strong’, rather than explaining the high melting points in terms of strong electrostatic attractions. Many attempts were spoiled by references to ‘atoms’ or ‘molecules’. Some candidates attributed the high melting points to the presence of intermolecular forces. While many correct definitions were given in part (b) (i), some attempts were incomplete or inaccurate. The trend in part (b) (ii) was well explained by many candidates but answers containing contradictions relating to size, shells and shielding were quite common. Some good answers were given in part (c) (i) but the majority were poor. The question described the polarisation of chloride ions by cations and required candidates to give the meaning of the term *polarised*. Many candidates did not do this but chose instead to describe the polarisation of a covalent bond. Similarly, the responses to part (c) (ii) were, in the main, poor. Some candidates correctly attributed the difference in polarising power to the smaller size and higher charge of the aluminium ion; both statements were required for full marks to be awarded. Many candidates referred to aluminium having a higher ‘nuclear charge’, while others based their explanation on the difference in electronegativities of magnesium and aluminium. Many answers contained a reference to atoms or molecules rather than to ions. In part (c) (iii), while covalent bonding was frequently given, ionic bonding, and ionic with covalent character, were often suggested.

Question 4

The equation, in part (a) (i), was often correct but some candidates omitted hydrogen altogether, gave its formula as 'H' or failed to balance the equation correctly. In part (a) (ii), the shape of NH_3 was generally well known but it was not uncommon to see either no lone pairs, or two lone pairs, on the structure, or for a 'T' shape to be drawn. Fewer candidates drew an acceptable structure for the amide ion. The most frequently seen errors were drawings showing the ion as being linear or showing other than two lone pairs. Hydrogen atoms were omitted in some diagrams. The bond angle (107°) present in ammonia was generally well known but a significant number of candidates quoted 109½°; other incorrect angles were less frequently seen. The explanation in part (a) (iv) was often vague and unconvincing. Many candidates did not appreciate the significance of the second lone pair of electrons in the ion. Clear explanations of the differences in repulsion provided by bonding pairs and lone pairs were relatively rare. Descriptions of repulsions between lone pair electrons and hydrogen atoms or between bonds, rather than between bonding pairs of electrons, were quite common errors. In part (b) (i), answers were often incomplete, with words such as 'simplest', 'atoms of' and 'each element' being frequently omitted. The empirical formula calculation was generally well done, although the use of incorrect A_r values or the incorrect rounding of answers was not uncommon.

Question 5

Part (a) was well answered by many candidates but it was quite common for the bonding in both substances to described as ionic, or for intermolecular forces, van der Waals' forces or even hydrogen bonding to be quoted in relation to the bonding in diamond. In some cases, marks were lost because statements such as these contradicted other correct statements made by candidates. In part (b) (i) the trends in solubility were generally well known but some candidates reversed the two trends, while others claimed that both trends either increased or decreased. Some candidates described the solubility of the magnesium and barium compounds, rather than stating the trends in solubility. Many candidates wasted considerable time here. It was not uncommon for answers to cover in excess of half a page as candidates attempted to explain the trends, rather than simply quoting them as required by the question. The test for sulphate ions required in part (b) (ii) was not well known. Few candidates remembered that an acid, such as hydrochloric acid, should be added first, or were able to offer an appropriate reagent. Many vaguely suggested the addition of Ba^{2+} ions, rather than quoting a specific reagent. Others suggested the use of barium, barium hydroxide or even barium sulphate as the test reagent. In order to earn the marks for observations, it was necessary for candidates to have quoted an acceptable reagent. It was clear that in many cases the details of this test had simply not been learned. The equation also caused problems for many candidates. The trend in part (b) (iii) was well known but the equation proved more difficult.

CHM2 Foundation Physical and Inorganic Chemistry

General Comments

The paper proved to be a little more difficult than that in the previous year. The mean mark (31.1) was 3.5 lower than in January 2004. The standard of work displayed by candidates was similar to that in 2004.

Question 1

This question discriminated well between good and less able candidates. Unfortunately, weaker candidates usually do not find it easy to recall details about halogen chemistry and this year followed the regular pattern. However, it was encouraging to find that more able candidates were able to score high marks. In part (a) most candidates scored three out of the four possible marks. Marks were lost most often for failing to mention that the halogens exist as molecules or failing to mention or imply intermolecular attraction. Answers to part (b) (i) usually gave a correct observation but the equation was sometimes unbalanced. In part (b) (ii) most candidates described the cream precipitate correctly but a correct equation was less common. Candidates should be encouraged to write simple ionic equations for such precipitation reactions. In part (b) (iii) at least one observation was usually correct. Some candidates, however, appeared to think that it would be possible to observe a colourless gas. Many candidates could not write the correct equation for part (c). They did not attempt to use hydrogen ions to form water with the oxygens from the sulphate in sulphuric acid. Consequently a significant number of candidates attempted incorrectly to balance the equation on the right hand side by forming oxygen gas.

Question 2

This question also discriminated well between candidates of differing abilities. Almost all candidates gave a correct answer for part (a). However, part (b) proved to be difficult and many candidates suggested incorrectly that the meaning of the term *oxidation state* was the number of electrons lost by **X**. It was surprising and disappointing to find that answers to part (c) were often incorrect in sign and in magnitude. In previous papers candidates have found deduction of oxidation states to be straightforward. Perhaps these examples were more difficult than some requested in the past. In part (d) (i) the equation involving copper was usually correct but weaker candidates were unable to write a correct equation for the reduction of nitrate ions. The usual mistake was the same as that in *question 1* part (c). Instead of using hydrogen ions to react with oxygens from the nitrate ion, weak candidates showed the formation of oxygen as a product. It was pleasing to note that candidates who were able to write correct half equations almost always deduced a correct overall equation.

Question 3

This question was answered quite well and most candidates gained a reasonable number of marks. Answers to part (a) were usually correct though weak candidates sometimes suggested, incorrectly, that the rate could be obtained simply by dividing the volume by the time. In part (b) candidates were able to show curves with the correct initial gradients but curves showing the correct final volumes of oxygen were much less common. In part (c) (i) many candidates lost a mark because HBr was included incorrectly in the overall equation. Answers to parts (c) (ii) and (c) (iii) were often awarded full marks. In part (c) (ii), some candidates attempted to answer the question by describing how a catalyst works rather than answering the question by explaining that a catalyst is a substance that alters the rate of a chemical reaction whilst being chemically unchanged.

Question 4

Good candidates were able to score high marks for this question but it continues to be disappointing that many candidates, at AS level, are unable to recall correct factual details about extractions of metals. Answers to parts (a) (i) and (a) (ii) were usually correct but part (a) (iii) proved to be much more difficult and only the best candidates were able to suggest that carbon monoxide would collide more frequently because, unlike carbon, it is a gas. Many candidates attempted to answer this question without reference to collisions despite being asked to do so in the question. Most candidates answered part (b) correctly. Answers to parts (c) (i), (c) (ii) and (c) (iii) demanded knowledge of the steel-making process after the Blast Furnace. Many candidates did not possess this knowledge and consequently scored no marks. It was surprising to find that many candidates continue to believe erroneously that the impurity, sulphur, is removed with oxygen and it is believed incorrectly that the phosphorus impurity can be removed as a slag without any prior treatment! Most candidates made a reasonable attempt to answer part (c) (iv) and part (d). However, in part (d) many candidates lost one mark because they failed to make any mention of, or any reference to, cost.

Question 5

In this question, good candidates were able to score full marks. Weaker candidates were less successful though they were usually able to pick up at least five or six marks.

Answers to part (a) usually gained all three marks. Answers to part (b) by weaker candidates were less successful. One common error in the expression $mc\Delta T$ was to use the mass of methanol (2.12 g) instead of the mass of water (100 g). Another common error was to give an incorrect sign for the final value of the enthalpy of combustion. Candidates were expected to recognise that this exothermic process should lead to a negative value for the enthalpy of combustion of methanol. Weaker candidates also lost marks for incorrect units or for giving no units. It is important for candidates to give correct units for intermediate values in the calculation as well as for the answer. In this case, if a candidate gave a wrong final answer, it was still possible to gain an intermediate mark for the heat released to the 100 g of water. However, if the candidate did not make it clear whether the intermediate value was expressed in Joules or in kJ, it was not possible to give any credit.

Answers to part (b) were of a good standard and in part (b) (i) almost all candidates were awarded the two marks. Answers to part (b) (ii) were not quite so accurate and, in particular, only the best candidates stated that 500 K achieves the best balance between rate of reaction and yield.

Good candidates found part (c) straightforward but weaker candidates often omitted to allow for two moles of hydrogen and also used the wrong sign for the enthalpy of reaction (-91 kJ mol^{-1}) relative to the enthalpies of combustion of carbon monoxide and hydrogen.

CHM3/C Internal Assessment

General Comments

As usual most candidates carried forward coursework marks achieved previously, but once again more new work was seen than last year. Most centres submitted the new work from a small number of candidates. The standard of marking of the new scripts which were submitted was usually very good. As a result very few adjustments were recommended during the moderation process.

The presentation and annotation of candidates' work was usually perfectly adequate. Indeed many centres submitted samples of an excellent standard, and this was greatly appreciated by the moderators.

Some centres submitted all of the candidate's work rather than only those pieces which count towards the final total. In addition one or two centres did not clearly indicate which pieces of work were to count, and moderators once again wasted a good deal of time putting the samples in order. To avoid the obvious danger of mistakes being made, moderators are instructed to send poorly prepared samples back to the centre for sorting.

The frequent clear warnings appear to have had the desired effect and hardly any centres used an Sc1 style approach to their assessment. As regular readers of these notes will have realised by now an Sc1 style approach to a complete investigation does not meet the current criteria, and usually results in a mark reduction. One or two centres submitted work with a demand level substantially below that required and suffered a mark reduction as a result.

The requirement to submit only one mark per skill caused no difficulties as expected, and happily all candidates fulfilled the minimum requirement of submitting work taken from at least two modules. A few centres submitted exercises more appropriate to A2 assessment. Centres are reminded that work used in the AS assessment **cannot be re-submitted for assessment at A2**.

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.

Centres are also reminded that when candidates repeat coursework they should complete **new** exercises. They should not repeat exercises already taken and submitted on a previous occasion, unless the centre limits the maximum mark achievable. The repeating of an exercise constitutes help and guidance and the candidate **must not** be awarded full marks. As the new Exemplar material contains over twenty exercises there shouldn't be any need for a candidate to repeat an exercise.

Moderation Procedure

A number of centres whose candidates were carrying forward marks did not submit a Centre Mark Sheet. Many other centres did not complete the Centre Mark Sheet correctly. As a result once again much time was spent contacting centres to discover what was happening. For each candidate carrying forward a mark the centre must enter “CF” in the Total Mark box and fill in the CF check box. The centre does **not** need to submit a sample of work carried forward.

Many centres submitted paperwork and samples well before the January deadline and this was much appreciated. A number of centres submitted new work several weeks after the January deadline. Sometimes a note explaining the late arrival accompanied the scripts. More often samples arrived late without any explanation of the very late arrival; the odd one had a curt note indicating that AQA had been "notified" that the sample would be late. **This is clearly unacceptable**. Centres must make every effort to comply with the deadlines. Inevitably this will not always be possible. In such cases common professional courtesy requires centres to advise the moderator without delay. Presumably the centres concerned would not accept a similar delay in the moderator completing the re-marking of their work!

Skill 1 Planning

In general the standard of work seen was good and the centres’ marking was generally accurate.

A small number of centres submitted planning exercises which did not allow access to 8 marks. Invariably the section on justification of scale was too undemanding for internal assessment and limited the maximum mark. When centres use AQA Exemplar material they can only award full marks if the justification of scale is complete. Excellent answers to other parts of the script cannot compensate for an incomplete justification of scale.

Skill 2 Implementing

In general the standard of work seen was good and the centres’ marking was again generally accurate.

One or two centres failed to provide a target value for accuracy, or written evidence for manipulative skills. Moderators can accept the centre’s marks as long as they are consistent with the evidence in the sample provided, but this is a time consuming exercise moderators should not have to undertake. To avoid any possibility of misunderstanding, centres must provide **a target value for accuracy clearly written on the tick list**.

A number of centres using the AQA Exemplar enthalpy change experiment once again failed to take account of variations in the initial temperatures of the two reagents. When the centre based the mark for accuracy on a class average, this resulted in the moderator spending a considerable amount of time recalculating the enthalpy change values for each candidate. The marks for accuracy were then re-awarded and the candidates' overall marks were adjusted appropriately.

When the centre based the mark for accuracy on a teacher value, this resulted in the moderator having to contact the centre to ask whether the teacher value had taken account of variations in the initial temperatures of the two reagents. Centres are once again asked to make sure that variations in the initial temperatures of the two reagents are taken into account when awarding marks for accuracy.

Skill 3 Analysing

The exercises seen were largely appropriate and well presented. The error analysis section was covered very well. Candidates often missed the precision mark, and occasionally lost the nomenclature mark through a failure to use the appropriate units. Centres are reminded that candidates who do not record with appropriate precision **cannot** be awarded full marks.

Skill 4 Evaluating

In general the standard of work seen was good and the very few centres used old versions of the Exemplar exercises.

Centres are reminded that the AQA Exemplar exercises were revised and extended in June 2004. **In future work based on older versions will be remarked using the current mark schemes.**

CHM3/W Introduction to Organic Chemistry

General Comments

The paper was less demanding than those of January 2004 and June 2004. It gave good opportunities for the lower achieving candidates to make some progress in every question, but was still an appropriate challenge for the higher achieving candidates. All marks on the paper were accessible and correct answers were seen for every part of every question, with occasional scripts at full marks. The comparatively large number of very weak scripts seen in June 2004 was not repeated and this was due, in some measure, to a large proportion of re-sits at this session and to the fact that many of these candidates had extended their studies into CHM4.

Equation balancing was generally good and further improvements were observed in writing mechanisms. It was pleasing to see candidates taking care in the presentation of organic structures with clearly presented C=C, C-C, C-H, C=O and C-O bonds, where appropriate.

Section A

Question 1

This question was generally well answered and often high scoring. Surprisingly, some candidates gave “cracking” as the answer to part (a)(i) and it was relatively common to see carbon monoxide rather than carbon, as the incomplete combustion product in part (a)(iv). In part (b)(ii), the need to draw the structure of methylpropene was recognised only by the best candidates. Part (c) usually produced at least one mark.

Question 2

This was the first occasion that fluorine had been used in a question of this type and it was good to see that the majority of candidates were able to apply their knowledge and score at least three of the five marks. The symbol “Fl” was penalised once only and the improbable recombination of two fluorine atoms into a fluorine molecule was given credit as a termination step, since it represented logical thinking by the candidate. The most difficult part of the question proved to be part (b) and unbalanced equations or equations with hydrogen or haloalkanes other than tetrafluoromethane were common.

Question 3

Parts (a) and (b) were intended as a straightforward start to this question, but many candidates struggled to express the idea of *position isomers* and “butan-2-ol” was a common answer for the name of compound C. Part (c) was generally well answered, although candidates need to be advised that whereas “potassium dichromate” will score one mark, no credit will be given for “dichromate” alone, since this is not a reagent. In part (c)(iv), the tertiary alcohol was well known and well drawn, with the alternative correct ethers gaining credit. Part (c)(v) caused a few problems for candidates and carboxylic acids other than methanoic acid were quite common. Part (d) was well answered and structures for methylpropanal were well drawn by many candidates.

It was considered appropriate in this question to insist on candidates drawing out the aldehyde and the main structural features of the carboxylic acid functional groups in their structural representations in order to gain full credit.

Question 4

Part (a) of this question took a familiar mechanism but presented it in a format different from previous papers. Candidates have had problems in the past with this mechanism, usually to do with drawing the organic compound or failing to use a lone pair of electrons on the hydroxide ion. It was decided to try to help candidates by drawing the organic structure and presenting the hydroxide ion in a position appropriate for a reaction to occur. There is no doubt that a larger proportion of the entry than hitherto were able to have a go at this mechanism as a consequence of this strategy. Regrettably, there was some evidence that a small minority of candidates appear to have missed this part of the question completely and left it blank.

In part (b), rather too many poor responses were seen and there was evidence to suggest that the idea of geometrical isomerism was not as well known as had been expected. Part (c)(i) was generally well answered with clear structures and mechanisms. Few candidates had problems with part (c)(ii) and the answers to part (c)(iii) were often well expressed. Candidates should be discouraged from using arguments which involve the Markownikoff rule and in their discussion of carbocations, they should be encouraged to make a clear link between the product formed and each of the possible intermediates.

Question 5

All parts of this question proved to be very accessible to all but the lowest achieving candidates. The most common errors arose from failing to use *concentrated* sulphuric (or phosphoric) acid in part (b)(ii) and from failing to give a clear statement of the advantage which ethanol offers as a fuel.

Section B

Question 6

This question allowed the full range of candidates to show something of what they could understand and do. Part (a) was well answered with many candidates demonstrating a clear understanding of the way in which polarity is induced in the bromine molecule by the proximity of the electron density of the double bond. In part (b) the mechanism was often well answered and many candidates were able to explain the susceptibility to attack by hydroxide ions in terms of a partial positive charge on the carbon atom of the C-Br bond due to its permanent polarity. Most answers to part (c) gained at least two marks and many gained all four. In part (d), candidates had problems focusing in on a specific hazard for each route, often giving vague references to hazardous chemicals. The risk of an explosion in the manufacture of epoxyethane was well known, but identifying the possible hazard associated with using, for example, sodium hydroxide or bromine was less well appreciated.

CHM4 Further Physical and Organic Chemistry

General Comments

This paper proved to be fairly straightforward and many high scores were observed. It was pleasing to see that the organic parts of the specification were better known than in previous examinations but, with the exception of buffer calculations, answers to the physical questions were still generally better answered.

Question 1

Part (a) was answered well by most candidates, but many did not note that both acids used in nitration are concentrated. Weaker candidates were unable to name the mechanism correctly and several lost marks by drawing the curly arrow going to the oxygen rather than the nitrogen of NO_2^+, by drawing the intermediate structure carelessly with the + charge shown too close to the tetrahedral carbon or by drawing the curly arrow showing the loss of H^+ the wrong way round.

Surprisingly, part (b) was badly answered: many incorrectly suggested $NaBH_4$ and in part (c) the need for an excess of ammonia was not well known. The first stage in the mechanism was answered well, but many were unable to show loss of H^+ correctly from the protonated amine. The explanation in part (d) was often unclear; too few stated that the lone pair on the nitrogen is delocalised into the ring. Only the more able were able to draw the quaternary ammonium ion correctly in part (e), but more were able to draw the correct structure in part (f).

Question 2

Better candidates found no difficulty with this question. For others, the drawing of the ions in part (a) was often careless and the name of the *zwitterion* was unfamiliar. Too many drew several repeating units in part (b) not one as requested. The name in part (c) was well done by many; a common error made by those who were close was to omit the number 2 in 3-methylpent-2-ene.

Question 3

Parts (a) and (d) were the least discriminating, but only the most able were able to identify both **E** and **J** correctly.

In part (b), most were able to identify **C** correctly as either ethanoic acid or methyl methanoate, but many suggested that **D** was ethanoic acid, despite the wavenumber given for the O-H infra-red absorption being that for O-H in alcohols not that for O-H in acids.

Most found **F** easy to deduce, but several forgot that both compounds were esters and suggested dimethylpropanoic acid for **E.**

In part (d), **G** was better answered than **H** and in part (e), more were able to deduce the structure of **I** correctly than that of **J**.

Question 4

As is normal, the use of rate equations is well understood and almost all candidates can answer these questions well. Very few failed to score the marks for deducing the orders with respect to **P** and **Q**. The calculation in part (b) using the given orders of reaction was well done by all except those candidates who could not rearrange the equation correctly. The same applied in part (b)(ii). In the few cases where the calculated value of the rate constant was incorrect, and greater than

4.2×10^{-4} mol^{-2} dm^6 s^{-1}, the usual answer of T_1 for part (b)(iii) was replaced by the answer T_2 consequential on their incorrect value of k.

Question 5

Only the better candidates were able to calculate the number of moles of C_2F_2 and of HCl correctly. However, if the rest of the answer used correct chemistry, no further marks were lost. The expression for K_c was well known, but there was uncertainty over the use of the volume of the container in the calculation. Many forgot to include it at all and so used a number of moles instead of the concentration in mol dm^{-3}. Some tried to include the number 18.5 dm^3 in the expression for K_c and others tried to convert the volume into m^3. Parts (b) and (c) were well answered even by those who lost marks in the calculation in part (a).

Question 6

The name *butanoyl chloride* was well known in part (a). Most stated correctly that chlorine has two isotopes or that Cl exists as ^{35}Cl and ^{37}Cl. But *isomers* was a fairly common answer and a several gave 35.5 as the mass number of one of the isotopes.

In part (c) the name of the mechanism was given correctly by the better candidates who went on to outline the mechanism correctly. Weaker students are careless with the position and direction of curly arrows and the correct position of charge on the intermediate structure.

Question 7

Part (a) was answered well. Most candidates were able to describe a correct chemical test to distinguish between the aldehyde, propanal, and the ketone, propanone. However, many thought that propanone had two peaks in its proton n.m.r. spectrum.

In part (b), better candidates had no difficulty in identifying propanoic acid as **X** and propan-2-ol as **Y** and in giving correct descriptions of oxidation in Step 1, reduction in Step 2 and esterification in Step 3. Weaker candidates lost marks for incorrect reagents or for wrong or missing conditions in the reactions.

Question 8

Most candidates took note of the request to give all pH values to 2 decimal places in this question. Part (a) was answered very well and some who scored no further marks in the whole question were able to answer this part correctly. Most candidates were able to describe what a *buffer solution* is and although any equation which correctly showed the removal of ethanoate ions and the formation of ethanoic acid was accepted in part (b)(ii), many were unable to give a correct answer.

Part (c) involved buffer solutions. Many answers showed that some candidates have still not mastered numerical questions about buffer solutions. A good proportion of the candidates were able to use the original values of the number of moles of ethanoic acid and of sodium ethanoate in one dm^3, i.e. the concentration of these species, to calculate the correct pH of the original buffer solution. A much smaller number was able to calculate the correct answer for the final pH of the buffer solution after the addition of 0.01 mol of hydrochloric acid. Only the best realised that the number of moles of acid would have gone up by 0.01 mol and the number of moles of ethanoate ions would have fallen by the same amount. However it was pleasing to see a good number of candidates gaining full marks in this question.

CHM5 Thermodynamics and Further Inorganic Chemistry

General Comments

Only a small number of candidates were entered for this examination. The total mark achieved by these candidates varied widely ranging from almost full marks to single figures. The questions set covered a wide range of topics. Some questions tested only knowledge and understanding of the content of Module 5 but others also required application and analysis with questions covering the whole specification. Each question provided a wide range of marks and good discrimination.

Question 1

Sections (i) and (ii) of part (a) were well answered but candidates who gave answers to only two significant figures were penalised by one mark. The aluminium-containing species required in (a) (iii) was generally well known with $[Al(H_2O)_5(OH)]^{2+}$ being the most common incorrect answer. Candidates who gave the correct answer in (a) (iii) usually also gave a correct equation in (a) (iv). The calculation in (a) (v) was marked consequentially to answers given in (a) (i) and (ii) and was not dependent on a correct equation in(a) (iv). Full marks were, however, given to the very small number of candidates who did link their answer to an incorrect equation in (a) (iv). Most candidates stated correctly the observation in (c) (i) but the equation in (c) (ii) proved to be much more demanding. Only the best candidates scored two marks in (c) (ii) by stating that the formation of a white precipitate of aluminium hydroxide, insoluble in excess ammonia, would make it impossible to see if the precipitate of AgCl had dissolved. In part (d) the formation of hydrogen chloride was generally well known and many candidates gave correct equations for this reaction but not all stated that steamy or white fumes would be observed. Surprisingly, the role of concentrated sulphuric acid in this reaction was not recognised and many candidates stated incorrectly that it was either an oxidising or a reducing agent.

Question 2

Almost all candidates gave a correct electronic arrangement for the ion S^{2-} in part (a) and, in part (b), identified species **X** as S^{-}(g). Many, however, failed to state in part (c) that repulsion between the negative S^{-} ion and the added electron would result in Step **F** being an endothermic process. Part (d) was generally well answered but ‘enthalpy of sublimation’ was not accepted for Step **B** as gaseous sulphur does not consist of single sulphur atoms. There were relatively few fully correct answers to part (e). Candidates who stated that ‘more energy is needed’ were merely repeating the question and not giving an explanation. Part (f) was well answered with many candidates scoring full marks.

Question 3

Almost every candidate calculated the cell e.m.f correctly and gave a correct half-equation in answer to part (a). Many also gave a correct equation in part (b) (i) but candidates who failed to cancel out the excess hydrogen ions lost one mark. By contrast, few stated in (b) (ii) either that when current flows the concentration of the species change or that the e.m.f. is measured when no current flows. Most answered (b) (iii) correctly. The effect on the cell e.m.f of changing the concentration of IO_3^- ions, required in (b) (iv), was deduced correctly by the better candidates many of whom also made the link to the position of the half-cell equilibrium process. Only the best then linked this change to the value of the electrode potential and stated that this becomes more positive. Sadly, in part (c), many candidates failed to read the question carefully and gave answers based on the formation of the intermediate species, V^{3+}, rather than VO_2^+, the species present at the end of the reaction with an excess of acidified potassium manganate(VII).

Question 4

Most candidates started well scoring full marks in part (a). Part (b) was also well done. In part (c) (i), the sodium salt, $NaHSO_3$, formed when x cm^3 NaOH were added, was given correctly by the better candidates. These candidates often, but not always, then gave a correct equation in (c) (ii). Weaker candidates found these questions very difficult. The most common correct indicator given in answer to (c) (iii) was phenolphthalein. Spelling proved to be a problem and phonetic spellings were allowed.

Question 5

Surprisingly the majority of candidates gave an incorrect electronic arrangement for Co^{2+} in answer to part (a). The answer $3d^5$ $4s^2$ was one common incorrect answer but there were many others. Parts (b), (c) and were then generally well answered with only the role of hydrogen peroxide in part (d) attracting a significant number of wrong answers.

Question 6

The term *ligand* was generally defined correctly but rather than define the term *co-ordinate bond* many candidates described how such a bond is formed. Most candidates gave a correct equation for a ligand substitution reaction in which both the co-ordination number of the metal and the colour change. Marks were lost by candidates who gave complex ions with charges missing or incorrect. The colours of ions were generally well known. Complex ions formed with bidentate ligands were less well known and answers were only accepted if the formula of the bidentate ligand was given. Most candidates gave good explanations for why this type of substitution occurs. A general statement that the symbol ΔE in the relationship $\Delta E = h\nu$ means 'enthalpy change' was not accepted and a more precise answer linking the energy of the light absorbed to electron excitation was required. A surprisingly large number of candidates gave an incorrect meaning for h most commonly stating it to be the frequency of the light absorbed. The three factors which result in a change in the frequency of light absorbed were well known with even the weaker candidates often scoring full marks.

Question 7

Questions based on the extraction of metals continue to prove challenging. In part (a) candidates were required to explain why the given methods were chosen and to state how the method chosen influences the cost of the metal. Although a wide range of acceptable marking points were available, many candidates failed to make six correct statements. The calculations in part (b)(i) and (iii) were rather better answered. Good candidates gave clear well presented answers to to (b)(i). Weaker candidates gave either an incorrect equation for the reaction between Fe^{2+} and MnO_4^- or gave an incorrect $Fe^{2+} : MnO_4^-$ ratio. Consequential marking enabled these candidates to score marks for correct statements in the remainder of their answer. The equation for the reaction between iron and dilute sulphuric acid required in (b) (ii) proved difficult. There were a large number of wrong answers with incorrect formulae or incorrect reacting species e.g. Fe^{2+} rather than Fe. The calculation in (b) (iii) was not made dependent on a correct equation in (b)(ii) and most candidates used the number of moles of iron, calculated in (b) (i) and assumed an $Fe : H_2$ ratio of 1 : 1 when calculating the volume of hydrogen evolved. Full consequential credit was given to candidates who did link their answers in (b) (i) and (ii) when calculating the volume of hydrogen evolved even if these answers were incorrect.

Question 8

Part (a)(i) was well answered. Many candidates chose a correct alkene, gave two structural isomers formed in the reaction with HBr and named the type of structural isomerism. Candidates who chose an incorrect alkene were able to score three marks for a correct mechanism. In (a)(ii) choosing a carbonyl compound with the molecular formula C_3H_6O which forms two isomers when HCN is added proved more difficult and many candidates gave the incorrect carbonyl $(CH_3)_2CO$. Marks were again allowed for a correct mechanism even when the carbonyl was incorrect. Candidates were only allowed to score a mark for stating that the isomers formed were optically active if the isomers given had an asymmetric carbon. As square planar molecules are not optically active, structure marks were only awarded when isomers were shown as tetrahedral arrangements. Almost all candidates were able to write an equation for a nucleophilic addition-elimination reaction of ethanoyl chloride but equations involving NH_3 were only given full marks if NH_4Cl rather than HCl was given as a product. Many candidates omitted to state the polarising effects of both the oxygen and the chlorine atoms when explaining why the reactions occur readily. Most also failed to state that nucleophiles are able to react because they have a lone electron pair which they can donate.

Question 9

In answer to part (a), most candidates identified iron as the heterogeneous catalyst in the Haber process and explained the term *heterogeneous* correctly. Although poisoning of the iron catalyst by sulphur is clearly stated in the Specification, many other elements and compounds were stated incorrectly to poison this catalyst. The method by which the poison works was well known and well explained. Only the best candidates gave a correct equation for the reaction of an aqueous iron(II) salt with an excess of aqueous ammonia as required in part (b). Candidates who gave equations involving the reaction of either water or hydroxide ions were allowed to score full marks provided that they also gave an equation showing the equilibrium reaction of ammonia with water. Correct observations were given by most of the good candidates but others either failed to state any observations or gave incorrect answers.

CHM6/C Internal Assessment

General Comments

As usual most candidates carried forward coursework marks achieved previously, but a little more new work was seen than last year. Most centres submitted the new work from a small number of candidates. The standard of marking of the new scripts which were submitted was usually very good. All of the work submitted was appropriate to Unit 4 or Unit 5 and very few adjustments were recommended during the moderation process.

The presentation and annotation of candidates' work was usually perfectly adequate and very few centres seemed to experience any difficulty in meeting the requirements of the scheme. With so few candidates, moderators found little difficulty in completing the moderation process. Nevertheless centres are reminded of the need to provide well organised samples with a clear indication of which pieces of work are to count.

The requirement to submit only one mark per skill caused no difficulties as expected, and happily all candidates fulfilled the requirement of submitting at least one skill mark from Unit 4 and at least one skill mark from Unit 5. Consequently there were no impoverished marks.

Centres are reminded that when candidates repeat coursework they should complete **new** exercises. They should not repeat exercises already taken and submitted on a previous occasion, unless the centre limits the maximum mark achievable. The repeating of an exercise constitutes help and guidance and the candidate **must not** be awarded full marks. As the new Exemplar material contains over twenty exercises there shouldn't be any need for a candidate to repeat an exercise.

Moderation Procedure

One or two centres whose candidates were carrying forward marks did not submit a Centre Mark Sheet. Other centres did not complete the Centre Mark Sheet correctly. As a result much time was spent contacting centres to discover what was happening. For each candidate carrying forward a mark the centre must enter "CF" in the Total Mark box and fill in the CF check box. The centre does **not** need to submit a sample of work carried forward.

Virtually all of the centres submitted new work before or shortly after the January deadline. This greatly assisted the moderation process and was much appreciated.

Problem areas

With so little new work it was not surprising that few problems were encountered. Some of the more common problems have been considered in the report for CHM3/C and teachers are advised to refer to this section of the report. Points worth raising for CHM6/C include:

- Centres are reminded that the AQA Exemplar exercises 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. 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.

- In the Exemplar planning exercise, Analysis of Lawnsand, candidates scoring full marks **must** justify an appropriate volume of acid to use in the titration.

- In the Exemplar analysing exercise, The Enthalpy Change of Decomposition of Sodium Hydrogencarbonate, candidates scoring full marks **must** plot graphs with suitable scales **and** a correct extrapolation.

Centres are reminded that the AQA Exemplar exercises were revised and extended in June 2004. **In future work based on older versions will be remarked using the current mark schemes.**

CHM6/W Synoptic Assessment

General Comments

This objective paper proved to be a little easier than the corresponding paper in January 2004. The mean mark out of a total of 40 was slightly higher this year (23.8 compared with 21.4). However, any statistics should be treated with caution because only 139 candidates completed the examination (98 in January 2004).

Questions 1, 3, 5, 9, 12, 13, 14, 16, 19, 20, 21, 26, 29, 31, 32, 34, 36, and 39 proved to be easy with a facility greater than 65%.

Questions 4, 8, 11 and 22 were difficult having facilities less than 35%. For question 4, response A was a distractor presumably because candidates did not deduce that in a Cl_2 molecule, with isotopes of ^{35}Cl and ^{37}Cl, the molecule can exist in three forms $^{35}Cl—^{35}Cl$, $^{35}Cl—^{37}Cl$ and $^{37}Cl—^{37}Cl$. In question 8, response B was a distractor. Perhaps candidates were unfamiliar with an equation that illustrates the amphoteric property of aluminium hydroxide by showing how it dissolves in acid. For question 11, response D was a distractor. Candidates are not expected to have met the term *disproportionation* but, in this question, enough information was given for candidates to deduce the answer by application of their knowledge and understanding. However, this deduction was perhaps too difficult for many candidates so they may have assumed that disproportionation did not occur. In question 22, response D was a notable distractor, attracting 70.5% of candidates. It is apparent that most candidates did not recognise, and were unable to deduce, that the liquefaction of methane would reduce its gaseous concentration (and its partial pressure) and therefore the equilibrium would move to the left in order to remove the effect of this constraint. Thus the yield of methanol would increase and the correct response to the question is C.

Apart from these difficult questions, no other question in the paper had a notable distractor.

Questions 4, 7, 20, 22 and 30 were judged not to discriminate effectively between candidates of differing abilities in this test. When used in pre-tests with larger numbers of candidates, all of these items had discriminated well.

Mark Ranges and Award of Grades

Unit/Component	Maximum Mark (Raw)	Maximum Mark (Scaled)	Mean Mark (Scaled)	Standard Deviation (Scaled)
CHM1	60	60	32.4	12.6
CHM2	60	60	31.1	11.5
CHM3/W Written	60	75	50.1	15.5
CHM3/C Coursework	30	45	36.6	5.6
CH3C	-	120	87.1	17.7
CHM4	90	90	57.5	19.4
CHM5	120	120	67.0	23.4
CHM6/W (OTQ)	40	60	35.7	9.9
CHM6/C Coursework	30	30	25.6	3.0
CH6C	-	90	61.6	11.1

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

CHM1 Atomic Structure, Bonding and Periodicity (13653 candidates)

	Max. mark	A	B	C	D	E
Scaled Boundary Mark	60	43	37	31	25	19
Uniform Boundary Mark	90	72	63	54	45	36

CHM2 Foundation Physical and Inorganic Chemistry (3257 candidates)

	Max. mark	A	B	C	D	E
Scaled Boundary Mark	60	41	35	30	25	20
Uniform Boundary Mark	90	72	63	54	45	36

CH3C Introduction to Organic Chemistry with Coursework (3437 candidates)

		Max. mark	A	B	C	D	E
CHM3/W Boundary Mark	raw	60	49	43	38	33	20
	scaled	75	61	54	48	40	34
CHM3/C Boundary Mark	raw	30	26	23	20	17	14
	scaled	45	39	35	30	26	21
CH3C Scaled Boundary Mark		120	100	88	77	66	55
CH3C Uniform Boundary Mark		120	96	84	72	60	48

CHM4 Further Physical and Organic Chemistry (7844 candidates)

	Max. mark	A	B	C	D	E
Scaled Boundary Mark	90	73	64	55	46	37
Uniform Boundary Mark	90	72	63	54	45	36

CHM5 Thermodynamics and Further Inorganic Chemistry (214 candidates)

	Max. mark	A	B	C	D	E
Scaled Boundary Mark	120	90	80	70	60	50
Uniform Boundary Mark	120	96	84	72	60	48

CH6C Synoptic Assessment with Coursework (147 candidates)

		Max. mark	A	B	C	D	E
CHM6/W Boundary Mark	raw	40	31	27	24	21	17
	scaled	60	47	41	35	30	26
CHM6/C Boundary Mark	raw	30	26	23	20	17	14
	scaled	30	26	23	20	17	14
CH6C Scaled Boundary Mark		90	73	64	56	48	40
CH6C Uniform Boundary Mark		90	72	63	54	45	36

Advanced Subsidiary award

Provisional statistics for the award (567 candidates)

	A	B	C	D	E
Cumulative %	17.6	33.0	55.4	74.6	89.6

Advanced award

Provisional statistics for the award (157 candidates)

	A	B	C	D	E
Cumulative %	34.4	59.2	80.9	89.8	96.2

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.

