

Chemistry

Advanced GCE **A2 7882**

Advanced Subsidiary GCE **AS 3882**

Report on the Units

January 2009

3882/7882/MS/R/09J

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Reports should be read in conjunction with the published question papers and mark schemes for the Examination.

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Advanced Subsidiary GCE Chemistry (3882)

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Chief Examiner's Report

General Comments

This January session was the first time that the transition from the old 'legacy' specification to the new revised specification could be observed. With new AS candidates entering the new F321 unit (*Atoms, Bonds and Groups*), the legacy unit 2811 (*Foundation Chemistry*) saw a much reduced entry from 16402 in January 2008 to 2469 in January 2009. The 2811 candidature also saw a large change, for the first time almost exclusively comprising re-sit candidates rather than coming largely from candidates new to A-level study in Chemistry.

The remaining entry pattern was very similar to last January.

The A2 examination *Chains, Rings and Spectroscopy* (2814), at 9437 candidates, had the largest entry. The entry for the AS *Chains and Rings* examination (2812) rose to over 6000 candidates, being almost exclusively re-sit candidates also sitting 2814.

For *How Far, How Fast?*, 1333 candidates made use of the January session of the A2 year re-sit. Of these, 57% carried forward coursework, 22% took the coursework component and 21% the Practical Examination, much the same entry pattern as in January 2008.

Over 1600 candidates were entered for *Trends and Patterns*. As in previous sessions, the most popular optional unit continues to be *Transition Elements* (56%), followed by *Biochemistry* (36%) and then *Methods of Analysis and Detection* (8%). This reflected a significant reduction in entry for *Methods of Analysis and Detection* and an increase in entry for *Transition Elements*.

The entry of 2816/01 (*Unifying Concepts*) increased by 65% with more large centres taking the examination as the first sitting for their candidates. Much of the entry however was made up of very small numbers of re-sit candidates.

The standard of candidates' responses continues to improve, partly due to the fact that the specification has been offered for many years and has a vast resource of past examination papers and mark schemes.

The transition to the new specification will take a further year. In June 2009, the legacy AS papers will be offered for the last time but A2 legacy papers will continue to be available for the January 2010 and June 2010 sessions; no legacy papers will be offered beyond June 2010.

2811 Foundation Chemistry

General Comments

This was not a typical paper, as this is now a legacy specification. The candidates were largely re-sits who were trying to improve their overall grade. In general, the level of the candidates' knowledge of Chemistry was very high, reflecting the extra maturity and experience gained from not only being a year older, but from studying Chemistry at A2. Certainly, the standard response questions were very well answered. This included the definition of first ionisation energy (2a), the trend in first ionisation energy down a Group (2c), the trend in boiling points of the halogens (4a) and electronegativity (4di). The ability to answer a question involving extended writing, as in the last question, was outstanding, with most candidates scoring high marks. Questions involving calculations were also very well answered, showing a high level of numerical skills amongst the entry for this paper.

- 1)
 - (a) This was a comfortable start for the majority of the candidates, with only the weaker candidates dropping any marks.
 - (b) Nearly all the answers to the first two parts were correct. In the calculation of the mass of sodium nitrate needed in the third part, a number did not read the question and used the relative formula mass of ammonium carbonate from the previous part. A few others could not calculate the number of moles needed. The last part of this section was unusual, as it involved using the Avogadro constant and this certainly proved more challenging. It was disappointing to see many incorrect answers such as 0.00417, where very good A level candidates apparently did not realise what an incorrect answer this was. Nevertheless many answers were correct.
 - (c) Oxidation numbers can be a challenge, especially when in an unusual formula.
- 2)
 - (a) As mentioned in the introduction, definitions were generally very well known, Occasionally there was confusion, removing a mole of electrons from one atom or one electron from a mole of atoms, but most responses earned at least two of the marks.
 - (b) Surprisingly, there were more correct explanations than correct identifications of element A. Common incorrect elements were aluminium and phosphorus, although many other elements made an appearance. Most realised that the big jump in ionisation energies meant that the electron was coming from a new shell, closer to the nucleus. There was the usual confusion between shells and sub-shells in some answers.
 - (c) A significant minority described the trend in first ionisation energies across a Period rather than down a Group; scoring few if any of the available marks. However, for the majority this was familiar territory and the answers were of a very high standard.
- 3)
 - (a) Only the weaker candidates slipped up here and failed to score the marks.
 - (b) The large majority of answers correctly showed the correct 'dot-and-cross' diagrams, complete with charges, for calcium chloride. There were the usual 'few covalent molecules'.
 - (c) Disappointingly, more than half the answers talked about electrons rather than ions, as has been the case throughout the lifetime of this specification. Many seemed to think that it was only the anions that conducted electricity.

- (d) The generally numerate candidates had little difficulty with these structured calculations. The commonest errors, although uncommon, were using 100 as the relative formula mass of calcium carbonate, rather than 100.1 using the data provided, and rounding the final answer down to one significant figure. In the last part some forgot to use the correct molar ratio and others forgot to convert from dm^3 .
 - (e) Equations were also produced with confidence on this paper. Most scored both marks on this part question, although there were a few incorrect formulae, such as CaOH and CaCl . A few equations used calcium carbonate, which was excluded in the question, as that equation had been given earlier.
 - (f) Empirical formulae calculations present little difficulty, although a few managed to get the sum the wrong way up or to use relative atomic masses. Those who did make errors found a balanced equation impossible in the second part. Nevertheless, most had no difficulty with either part.
- 4)
- (a) Candidates who read and understood the question tended to earn full marks with their answers. Too many misread the question and answered in terms of ionisation energies, or reactivity, or even the ubiquitous electronegativity.
 - (b) A pleasing number of candidates recognised this as a disproportionation reaction and went on to score full marks. Many could not remember the word but still scored full marks by their description. A few ignored the question and talked about loss and gain of electrons rather than changes in oxidation numbers, failing to score two of the available marks.
 - (c) Too often, there was confusion, the right equation being given in the wrong step. Observations suggested that the candidates had not seen these reactions for a long time, if ever. In the first step many of the observations would have been more appropriate had it been iodine being displaced. Both equations caused problems, but surprisingly the second equation proved the more difficult. Many did not know the formula AgCl , with many silver bromides or the chloride ion as a gas and the precipitate as a solution. Many of the equations given were not ionic.
 - (d) Most could recall the definition of electronegativity, but slips in the wording suggested that candidates did not always understand what they were writing. The shape of the molecule was generally well drawn complete with dipoles, but explaining why the molecule was non-polar proved more difficult.
- 5) As mentioned earlier few candidates had any real difficulty with this question. There were the usual contradictions, where, for example, diamond was correctly described as giant covalent in one sentence, and then as containing strong intermolecular forces in the next. The most difficult marking point appeared to be linking the high melting point of magnesium chloride with its strong electrostatic attractions. Nearly all candidates earned the mark available for Quality of Written Communication.

2812 Chains and Rings

General Comments

The paper produced a spread of marks ranging from 0 to 58. It was pleasing to see a large number of candidates scoring highly but disappointing that no one scored maximum marks. This distribution of marks is perhaps inevitable as the entire cohort consists of re-sit candidates and it is highly unlikely that the very best candidates from AS were re-sitting.

There were very few weak candidates in the cohort, with only a small percentage scoring less than 20 marks. This again is perhaps predictable as the weakest candidates from AS will not have continued into A2.

Each of the five questions was accessible to all candidates, but each question contained parts that stretched most candidates. Candidates attempted all aspects of the paper. The majority of candidates seem to have been well prepared. Candidates displayed good examination technique in all of the questions and there was no evidence to suggest that candidates ran out of time.

Comments on Individual Questions

Question 1

Overall most candidates scored well with 7/10 being the norm. The most demanding part of the question was part (e) which required candidates to explain why ethanol is both renewable and environmentally friendly. There is a widespread misconception that renewable means that once used it can then be used again. It was equally worrying that many thought ethanol to be environmentally friendly because it only produced carbon dioxide and water.

Parts (a), (b) and (d) were well answered but many failed to score the marks in part (c) particularly if they drew a fully displayed structure for 1,2-dimethylcyclohexane. It was much easier to score the mark by using a skeletal formula.

Question 2

This proved to be a straightforward question with most scoring more than 10/18. The most demanding parts of the question were parts (a)(i), (d)(i) and (e).

In (a)(i) more than half the candidates were unable to name compound A correctly.

Question (d)(i) proved to be the most demanding and very many failed to recognise the essential symmetry of compound B.

In part (e)(i) a substantial number ignored the instructions and drew a displayed formula instead of a skeletal formula whilst others incorrectly linked the carbon chain to the H in the (OH) group.

Many failed to score the marks in (e)(ii) through a lack of knowledge or through a misunderstanding of basic Chemistry. It was surprising to see how many correctly used an acid catalyst but then negated this by adding NaOH.

Question 3

The majority of candidates scored well in part (a) and coped with the percentage yield calculation. However, many failed to score a mark in (a)(iii) by not quoting their answer to two significant figures. Part (b)(i) was very straightforward but many struggled with part (ii) and failed to select a suitable reagent to detect an alcohol. A significant number of candidates drew the product based on hexane rather than on cyclohexane.

Question 4

Part (a) was straightforward but a significant number failed to add any dipoles to chloromethane; others incorrectly concluded that the bond angle was 120° .

Most coped well with the unfamiliar mechanism in part (b) and scored well in part (ii). Parts (iii) and (iv) proved to be very demanding and it is difficult to understand why candidates find naming amines so challenging. In (b)(iii) many candidates failed to use the information given in steps 1 and 2 of the mechanism when deducing the overall equation.

Part (c) differentiated well with able candidates scoring both marks. A substantial number of candidates tried to relate reactivity with bond polarity rather than bond enthalpy.

Question 5

The question produced a range of responses with marks ranging across the complete spectrum. Few scored full marks.

In part (a) most recognised that alkanes were non-polar but few if any related the lack of reactivity to the C–H bond strength.

Part (b) was generally well done but it proved difficult to score all 10 marks. A significant minority scored poorly by describing the wrong mechanism. It was relatively straightforward to score more than half the marks but explanations of why it is difficult to produce a single organic product proved elusive. Most responses relied on 'radicals are very reactive' which gained no credit. Some did relate the possibility of producing both bromopentane and decane as part of the termination steps but only very few referred to multiple substitution of the Hs in pentane. Few, if any, appreciated that the radical substitution could occur at any point along the pentane chain thus leading to a range of isomers.

2813/01 How Far, How Fast?

General Comments

It was evident that the vast majority of candidates were well prepared for the unit and that many had reinforced their learning of the subject matter by effective practising of past papers. This meant that some of the errors that were apparent in the past were less common. Examples of this are given in the comments on individual questions.

In general, candidates coped well with questions, such as 4(a), that relied heavily on material that appeared in a 'standard' format but only candidates who really understood the work were able to correctly respond to questions that were in any way asked in a different way from that seen previously. This meant, for example, that the bond enthalpy calculations were less well answered than has been the case in recent papers.

Comments on Individual Questions

Question 1

- (a) This is an example in which it appeared candidates had learnt from previous papers since there were far fewer responses in which rate was confused with volume of gas on this occasion. Most candidates realised that the rate of reaction was decreasing and that this was due to less collisions occurring. Very few however considered that this decrease in rate of collision was due to a decrease in concentration.
- (b) Most candidates correctly drew the graph to show the change that using crushed marble would make.

Question 2

- (a)(i) In definitions of terms it seems that most candidates know that they must use a mole of something! However, in this case it was often a mole of substance/molecules/atoms. Only a few examples were seen when the definition implied bond making.
- (ii) Most candidates recognised that energy has to be put in to break the bond. It was not considered sufficient merely to state that the process was endothermic without any consideration of the reason for this endothermicity.
- (b) As noted above, this calculation was set in a slightly different way and, whilst many candidates who understood what they were doing correctly interpreted the data, others were less successful. Not surprisingly those who wrote down exactly which bonds were being broken and made generally gave the correct answer.

Ans: 158 kJ mol^{-1}

- (c) In this example as well, the interpretation of the data was slightly unusual and few candidates succeeded completely. A common error was to try to find the enthalpy change for the formation of 2 moles of HCl.

Ans: -93 kJ mol^{-1}

- (d)(i) In a question that has the potential to score two marks, candidates would be advised to look for two marking points. In this case this meant that the large number of candidates who described partial dissociation but did not mention the nature of an acid were awarded one mark.
- (ii) Most candidates correctly made the connection between strength of an acid and the need to break the bond.
- (iii) A few examples were seen in which hydrochloric acid was used or the formula of sodium & fluoride was incorrect but many correct equations were seen in (iii). It was encouraging to note that more candidates now seem aware of what should be given in an ionic equation but a large number of singly charged carbonate ions were seen in (iv).
- (v) Candidates seem to find it difficult to differentiate between the theory involved and the effects of the theory in a practical context. This meant that many answers were based on the presence of less hydrogen ions rather than the effect of this on the rate of the reaction. Very few candidates recognised that, for the comparison of the rates to be valid, the concentrations of the acids must be the same. A few candidates clearly thought that the stronger acid would give a larger volume of gas – even on the completion of the reaction.

Question 3

- (a)(b) The effects on yield and on rate of changes in reaction conditions were separated so that there was less chance of candidates confusing one with the other. This proved successful so that some well-expressed and chemically correct answers were seen for both changes. To score both marks for the need to have a high temperature in order to have a fast rate, it was necessary to include a discussion of activation energy and not just that more collisions occur.
- (c) Since the example chosen was one with which candidates would be unfamiliar, it was pleasing to note the large number who discussed the significance of the conditions logically. The idea of compromises being necessary is clearly understood by many.
- (d)(i) The statement of Hess' law was somewhat disappointing. Many candidates failed to recognise that it was the enthalpy **change** that stayed constant, others tried to quote specific examples (usually involving enthalpy changes of formation) and others confused the law with le Chatelier's principle.
- (ii) As has been noted in previous reports, not surprisingly candidates who drew sensible cycles were far more successful than those who used the numbers in an apparently random manner. Of the latter group a large number completely ignored 210 kJ mol^{-1} quoted for **equation 3.1**.

Ans: -107 kJ mol^{-1}

Question 4

- (a) Most candidates were clearly familiar with the drawing and interpretation of enthalpy profile diagrams and of the Boltzmann distribution. This meant that some excellent answers were seen. Some errors noted included labelling ΔH instead of energy/enthalpy, not starting the Boltzmann distribution at the origin or allowing it to cross or meet the x axis.
- (b) This is another example in which a significant number of candidates have clearly learnt from previous papers. The majority of candidates realised that the presence of a catalyst has no effect on the equilibrium position and an appreciable minority explained the reason for this.

2813/2816/02: AS/A2 Coursework

General Comments

The Moderators were grateful to the majority of teachers who once again made a considerable effort to make sure that their candidates' work was well-ordered and included the detailed annotation that clarified where and why the various assessment levels had been reached. It was particularly appreciated where the published marking criteria for the suggested experiments had been used as a tick list to indicate how the overall total had been established.

As is usually the case in this session, the relatively small entry consisted largely of candidates who had failed to achieve the results they had hoped for in the June 2008 examination session. At A2, many had learned from their previous experience and the Moderators received work that reflected a much greater appreciation of the standard required. This was less apparent at AS and many scripts showed little understanding of how to write a coherent plan or to interpret and evaluate the results that they obtained from their experiments. The best marks at both levels were usually obtained for the 'Implementing' skill but even here carelessness over the recording of results often led to a loss in marks. A particular example was the recording of titration results where 17b was often not reached through the failure to record the initial burette reading or sometimes to record it as 50.00 cm³ rather than 0.00 cm³.

Some candidates seemed to hope that the sheer length of their coursework would be sufficient to guarantee a high mark. Unfortunately this was not always the case and it would be helpful if centres advised their candidates that there is no need to provide an extensive theoretical background before devising a plan to solve a particular problem. Some of what was written was relevant but much was often unrelated to any decisions that were subsequently made. Many adopted the same approach to the evaluation of an experiment and here there was the further risk that, in trying to be totally comprehensive, trivial points became indistinct from more serious issues thereby resulting in the failure to achieve level E5b. It should be noted that no marks can be awarded if the evaluation of a procedure or set of measurements focuses on avoidable human error. For example, the fact that the apparatus used might have been dirty could have been a reason for poor results but to suggest that cleaning the apparatus is an improvement would not be accepted as this should have been done as part of normal practice before starting the experiment.

Comments on AS Coursework

The decomposition of copper carbonate was much the most popular choice as an assessment for skill P. While most completed the calculation satisfactorily the masses chosen were not always ideal. A very small mass yielding less than 20 cm³ of gas would be subject to a considerable error and candidates who chose to do this really fall short of level 7. It is also unacceptable to award P7b if a candidate determines the end of the reaction by noting that the colour of the residue is completely black. This is both unreliable and already assumes the answer.

Skill I marks tended to be high and perhaps deservedly so although the standard of the recording of the observations in the oxidation of ethanol was often haphazard and insufficient for 17b.

Comments on A2 Coursework

Very little work was received at A2. The identification of a functional group dominated the assessments for skill P. Mostly these were assessed reliably although some candidates were allowed to ignore the reaction of bromine with phenol in constructing their flowcharts. However, this does mean that P7a should not be allowed. It is necessary to repeat again that P7b requires full details to be given for the tests used and common failings which were allowing the addition of a large excess of bromine to a small volume of the unknown when testing for a double bond, failing to acidify dichromate when testing for a primary alcohol and not adding an excess of 2,4-dinitrophenylhydrazine when identifying a carbonyl group.

Skill I was well marked but it should be noted that a melting point must be within $\pm 4\text{ }^{\circ}\text{C}$ for I7b to be awarded.

As with the AS, centres are reminded of the importance of checking the accuracy of calculations when assessing skill A. The graphs produced by candidates tackling the rate experiment were usually plotted reliably but the units quoted on the axes were not always correct. In particular if $1/\text{time}$ is used as a measure of the rate of the reaction then its units are clearly not $\text{mol dm}^{-3} \text{s}^{-1}$. It was good to see that only very few made the mistake of using half-lives from a concentration/time graph as a means of determining the rate from this initial rate experiment.

There was a tendency to overvalue the work produced for skill E. For skill E5b candidates are expected to identify any errors that are significant and it is insufficient to provide an extensive list of failings only some of which could be described as important. For level E7b it should be made clear why any change would affect the overall reliability of the experiment.

The determination of ΔH was used by some to assess skills A and E and it was usually well marked. However, it is necessary to remind centres of the need to check that calculations have been completed correctly. It is appreciated that faced with a pile of marking it is tempting to assume that an answer given is correct when the procedure adopted seems adequate. But the Moderators detected a number of errors in candidates' work which meant that the mark awarded was not justified. This also applied to the determination of the relative atomic mass of lithium which was the most popular choice for the assessment of skill A.

The assessment of skill E using this experiment was reasonably well done but centres should note that the use of a syringe to counteract the possible loss of hydrogen in the lithium experiment is not accepted. It would do nothing to avoid the escape of the gas which would occur as the bung was replaced in the conical flask. It was also observed that a significant number of candidates seemed to believe that hydrogen has an appreciable solubility in water.

2813/03 How Far, How Fast? (Practical Examination)

General Comments

The quality of work from most candidates was pleasing. There were very few scripts that scored low marks. In particular, the evaluation was answered better than usual. Most candidates also found the Planning exercise to be reasonably straightforward.

Comments on Individual Questions

Plan A

The general standard of Plans was high. The qualitative analysis to distinguish the acids was generally done well and almost all candidates were able to describe four suitable tests. A few weaker candidates did not score marks by failing to describe their tests in a logical order. Occasionally, important practical details were omitted from tests, particularly the need to heat with concentrated sulphuric acid while attempting the esterification test for ethanoic acid or the need for excess ammonia and shaking the test tube when attempting to dissolve precipitates of silver halides.

In the description of the titration, most candidates included the basic details. However, many failed to realise the need to dilute the acid supplied, for safety reasons, before carrying out the titration. The indicator colour change was sometimes given back to front. In their specimen calculations, many candidates omitted to scale up, either because of dilution they had carried out, or because of the transfer of only 25 cm^3 of solution from a 250 cm^3 volumetric flask. The solid KOH was, by far, the most corrosive material used and candidates were therefore expected to state a significant safety precaution when using that material.

Test B Part 1

There are a few centres whose candidates do not write down all burette readings during a titration, while others failed to record all data to 0.05 cm^3 .

The titration involved the less distinct 'reverse' colour change for phenolphthalein, but the general standard of accuracy was very good.

The safety question was not well answered, perhaps because of a climate of unhelpful over-emphasis on what are low level hazards. Few candidates were bold enough to state that a 25-fold dilution of an acidic solution that was 'irritant' would result in a solution with negligible hazard. The answers of some candidates showed that they had taken no notice of the hazard information given on page 2.

Test B Part 2

The extended calculation on page 4 was generally done well. However, some candidates did not prove convincingly that the concentration of diluted acid was 0.04 mol dm^{-3} , as required in (a). Many failed to give all their answers to three significant figures as required. In (f), a surprising number of candidates multiplied their answers to (d) by 74.1, rather than using their answer to (e).

Test B Part 3

This relatively straightforward exercise was answered well and many achieved all 6 marks. In (a), a few candidates failed to use the word precipitate ('solid' was also accepted). In (d), some omitted the 's' state symbol for AgCl. A very large majority was able to correctly identify HCl from their test.

Test B Part 4

Questions (a) and (b) of the Evaluation were generally answered well, although some candidates failed to use the 1:2 molar reacting ratio correctly, particularly in (b). Question (c) was found to be more difficult. In (i), a number of candidates wrongly suggested that a gas syringe would be more accurately calibrated than a measuring cylinder. Answers referring to the removal of oxide layer on the magnesium or to the need to ensure that effervescence had ceased before taking the final reading were rarely seen. In (ii) many candidates showed their confusion between accuracy and reliability (= consistency) of data. Surprisingly few mentioned that the syringe experiment had not been repeated, and therefore could not be reliable.

2814 Chains, Rings and Spectroscopy

General Comments

This paper produced a very good range of marks with many centres clearly preparing their candidates very well. Many candidates demonstrated a thorough knowledge and understanding of the ideas covered in the specification and it was pleasing to see a good number scoring in excess of 80 out of 90. Teachers should be congratulated on their efforts and had obviously made good use of the published mark schemes to help their candidates. Most candidates seemed to finish the paper in the time allowed, although a few were perhaps rushing at the end.

Comments on Individual Questions

- 1(a) The names of the two alcohols were known by most candidates, although some did not specify the position of the OH group for 2-methylbutan-1-ol. Most were also able to identify the chiral centre in 3-methylbutan-2-ol and arrange the four groups around the 3-D carbon.
- 1(b) For this part, candidates had to identify that only 2-methylbutan-1-ol would still have its chiral centre after oxidation and to correctly draw the structure of the aldehyde.
- 1(c) Most candidates could name the splitting pattern and the number of adjacent protons responsible. Many however did not select which type of proton was causing the peak from the alternatives within the range given in the *Data Sheet*. Those who were able to interpret all the information given could then identify the alcohol correctly as 2-methylbutan-2-ol. However, nearly all candidates knew that without D₂O an additional peak for the OH proton would appear in the range 3.5–5.5 ppm.
- 2(a) Most candidates knew the chemical tests needed to identify the carbonyl group as a ketone. However, only the more confident could apply their knowledge of the nucleophilic addition mechanism to the unfamiliar compound given. The unstructured calculation also proved to be a good discriminator with calculation of the *M_r* (113), the scaling of the masses and dealing with the % yield as the three steps required to obtain the correct answer (0.88 tonnes).
- 2(b) This part proved to be a more demanding than expected, with a fair number of candidates giving the structures of the monomers for nylon-6,6, rather than deducing that 6-amino-hexanoic acid (or the acid chloride) would be needed in this case.
- 3(a) The definition of stereoisomerism was not well known. Candidates must specify that stereoisomers have the same structure or the same order of bonds but a different spatial arrangement. Many were confusing this with the definition of structural isomerism and only specifying the same molecular formula. Many however were able to identify both the chiral carbon and the C=C bond in the given structure of oleocanthal.
- 3(b) A fair number of candidates could identify that the substitution of bromine would occur for the phenol, while addition would be at the alkene group. However, only the most able deduced that four hydrogen atoms would be required to reduce oleocanthal with NaBH₄. A common error was to assume that the ester group or the C=C would be reduced and include too many hydrogen atoms in the equation. The final part also proved challenging for all but the most able candidates. Most recognised that the ester bond would be hydrolysed to give an alcohol and a carboxylic acid. However, for full marks they had to realise that both the carboxylate group and the phenol would be ionised under these conditions.

- 3(c) This proved relatively straightforward with most candidates recognising that they needed to calculate the M_r of the compound (304). However, in the second part, a few candidates were not specific about which bond would cause each absorption on the infra-red spectrum. It is not sufficient to identify the functional group, as there is typically more than one type of covalent bond involved in each group.
- 3(d) The presence of a mixture of stereoisomers in the laboratory synthesis leading to a lower concentration of the pharmacologically active isomer was well known, although some candidates got distracted by giving detail about harmful side-effects rather than focusing on the question asked.
- 4(a) Most candidates selected LiAlH_4 or ethanolic sodium as a suitable reagent to reduce a nitrile. If they chose hydrogen gas, they did need to specify a suitable catalyst, such as nickel or platinum. The most common error was to try NaBH_4 , which can only reduce carbonyl compounds. Many identified the reaction as a reduction. Addition and hydrogenation were also accepted as valid descriptions of the reaction.
- 4(b) The salts formed by the neutralisation of ethylamine did need the presence of the counter ion to score the marks. More candidates identified ethylammonium chloride than ethylammonium ethanoate.
- 4(c) The explanation for the relative basicities of ethylamine and phenylamine was well known by those candidates who had prepared well. It is important to identify that for ethylamine the inductive effect moves electrons towards to the nitrogen atom, while for phenylamine the delocalisation of the lone pair around the ring moves them away from the nitrogen atom. Some candidates seemed to be confused between these different effects.
- 4(d) Many candidates identified that reduction of the nitro group and esterification would be needed to synthesise benzocaine from 4-nitrobenzoic acid. The steps were allowed in either order, although ideally the reduction should be done first to prevent hydrolysis of the ester in the acidic conditions needed for the reduction. As in (a)(i), any suitable reducing agent was credited, although most chose to reflux with tin and HCl .
- 4(e) Most candidates recognised that acidic hydrolysis of benzocaine would produce ethanol, although relatively few picked up the cue in the question to ionise the amine group in their structure.
- 5(a) Addition polymerisation was well known, although a few candidates did not show displayed formulae as required by the question. Many candidates recognised that atactic poly(phenylethene) would have side chains oriented in random directions along the chain. However to score full credit, the 3-D bonds had to be correctly drawn so that all the side chains were shown coming up or down on one side of the given chain. Most knew that the isotactic polymer would have every side chain oriented in the same direction. While examiners accepted any suitable wording to imply this, some candidates were too vague – just describing the arrangement as ‘regular’ or having side chains in the same ‘position’.
- 5(b) The conditions for the manufacture of an azo dye were very well known, although some candidates found it harder to interpret the given dye structure and to draw the correct structures of the amine and the diazonium ion. Note that in the diazonium ion, the + charge on the triple-bonded nitrogen should be located on the nitrogen that joins the ring.
- 6(a) The displayed formula of benzoyl chloride was well known, although only the better prepared candidates could write a correct equation for its formation using phosphorus pentachloride or thionyl chloride. A common incorrect response was to try and react benzoic acid with hydrogen chloride.

- 6(b) Any alcohol and any amine (or ammonia) could be used to show the synthesis of an ester and amide from benzoyl chloride. Again, well-prepared candidates found this relatively straightforward and identified that hydrogen chloride would be the inorganic product in each case.
- 6(c) Most candidates identified a suitable iron(III) or aluminium halide catalyst for the given Friedel–Crafts reaction. In the last part, the mechanism did have to be identified specifically as electrophilic substitution to score the mark.
- 7(a) This part gave the opportunity for candidates to demonstrate the depth of their knowledge and understanding about the relative reactivities of cyclohexene and benzene. Many able candidates scored full marks and it was pleasing to see some excellent explanations. A comparison of the electron density of the π -bond and the effect of this on the electrophile was needed here. It was also necessary to identify somehow that benzene was less reactive (*i.e.* more stable) and that benzene undergoes substitution rather than addition. A balanced equation was required for each example and the need for a catalyst to allow the benzene to react. Some weaker candidates seemed to be confused between cyclohexene and the Kekulé structure of benzene.
- 7(b)(c) These parts required candidates to deduce from given information a compound and a reaction that does not appear in the specification. In (c), it was very pleasing to see how many were able to correctly obtain the correct product ($\text{C}_6\text{H}_6\text{Br}_6$) with a balanced equation for its formation.

2815/01 Trends and Patterns

General Comments

The average mark for the paper was 30, considerably higher than the mean mark in the June 2008 examination paper. The whole mark range was covered from 1 to 45. There was very little evidence that candidates ran out of time and only a small proportion of candidates left questions blank.

There was evidence from the candidates' answers that they found the synoptic aspects of the examination much more demanding than those questions based on the content from the *Trends and Patterns* part of the specification.

As in previous sessions many candidates did not use chemical terminology with precision, although there was an improvement over previous examination papers with regard with the use of the terms atoms, ions, molecules, compounds and elements.

Question 1

This question focused on the chemistry of copper and the candidates found much of the question very accessible.

In part (a) a large proportion of the candidates were able to write the correct electronic configuration for Cu^{2+} . Only a small number of candidates included 4s electrons in their configuration.

The most popular copper complexes chosen in part (b)(i) were $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ or $[\text{CuCl}_4]^{2-}$ and almost invariably candidates were able to recall the correct colour of these complexes. A small proportion of the candidates gave the formula for a copper compound in (i) and these candidates were allowed a possible error carried forward in part (ii). The bonding between a ligand and the central metal ion was well known in part (ii) with candidates stating that it was a dative covalent bond formed by the donation of a lone pair from the ligand.

Candidates often gave the correct colour in part (c)(i) but failed to state that it was a precipitate. State symbols were not required for the ionic equation in part (ii) and this enabled more candidates to be awarded a mark.

Candidates found the empirical formula calculation in part (d) straightforward but a small fraction made silly errors such as missing out one of the elements in the calculation or using the wrong atomic symbol. Some other candidates rounded up numbers too aggressively and ended up with the wrong empirical formula rather than the correct $\text{K}_3\text{CuC}_4\text{N}_4$. Only an extremely small proportion of candidates could give a formula for the complex ion.

Question 2

This question focussed on chlorides and involved synoptic assessment of topics from the *Foundation Chemistry* module.

In part (a) only an extremely small proportion of candidates gave a covalent '*dot-and-cross*' diagram. The majority of '*dot-and-cross*' diagrams included the correct charges but a small fraction of candidates did not clearly indicate there was two chloride ions and wrote Cl_2^- rather than 2Cl^- .

In part (ii) candidates needed to clearly state the structure and bonding of magnesium chloride. Either strong ionic bonds or strong electrostatic attraction between ions were acceptable for the bonding. A small proportion of the candidates referred to intermolecular forces and this was considered a contradiction for the bonding mark.

The majority of candidates could recall the equation for the formation of silicon(IV) chloride in part (b).

In part (c) a significant number of candidates gave ionic 'dot-and-cross' diagrams giving P^{5+} and 5Cl^- . Other misconceptions included drawing PCl_3 or Cl_3PClCl (*i.e.* having a Cl–Cl bond).

Although in part (d) many candidates realised that the reaction of phosphorus(V) chloride and water was an example of hydrolysis a much smaller proportion of candidates could write an equation for the reaction. Balanced equations that gave either H_3PO_4 or POCl_3 were given credit. A significant number of candidates gave $\text{P}(\text{OH})_5$ as a product.

In part (e) only a small fraction of candidates suggested that Fe_2Cl_6 was ionic. Both covalent or dative bonding were allowed.

The blood red colour of $[\text{Fe}(\text{H}_2\text{O})_5(\text{SCN})]^{2+}$ and ligand substitution was well known in part (f). Ligand exchange and ligand displacement were acceptable alternatives but substitution on its own was not.

Question 3

This question focussed on redox reactions of the ions of some transition elements.

In part (a) the majority of candidates deduced the correct molar ratio of hydrogen peroxide and chromium(III) ions but only the most able cancelled out the electrons and the hydroxide ions to get the balanced redox equation.

Although a significant proportion of the candidates were able to get the correct relative formula mass of 392 and value of x to be 6 other candidates found the calculation quite demanding.

Many candidates gave no structure to the calculation and left their working out all over the space for the answer. Good answers were exemplified by a brief explanation *e.g.*

- Moles of MnO_4^- = conc x volume (in dm^3)
- Moles of Fe^{2+} = 5 x moles of MnO_4^-
- Relative formula mass = mass \div moles of Fe^{2+}

Error carried forward was allowed throughout the question and a common misconception was not to use the correct molar ratio of $\text{Fe}^{2+} : \text{MnO}_4^-$ resulting in a very large relative formula mass.

Question 4

This question focussed on lattice enthalpy and included the assessment for the quality of spelling, punctuation and grammar.

In part (a)(i) candidates needed to compare the ionic radius or charge density of the two cations, relate this to the polarisation of the carbonate ion, the distortion of the electron cloud around the carbonate ion and the weakening of the carbon-oxygen bond within the carbonate ion. Many candidates did not specify the particles involved for example referred to magnesium having a smaller radius or referred to the wrong particle such as the carbonate molecule.

Other common misconceptions included the polarisation of the cation rather than the anion and referring to the weakening of the ionic bond rather than the covalent bonds within the carbonate ion.

In part (ii) candidates often referred to the small radius of Na^+ rather than the lack of polarising ability of Na^+ or that it had a low charge density.

Part (b) was used to assess the quality of spelling, punctuation and grammar. To be awarded a mark the answer had to include at least two relevant sentences with correct spelling, punctuation and grammar. Nearly all the candidates who attempted this question were awarded this mark. Good answers used the bullet points to organise their answers.

A significant number of candidates could not define enthalpy change of formation and the lattice enthalpy. Common errors included not mentioning the amount or the state of the sodium oxide. The equations did not need the state symbols but any states given were used to give credit for the written definitions. Common errors included using ions for enthalpy change of formation, writing equations that gave $2\text{Na}_2\text{O}$ and using the wrong formulae e.g. Na^{2+} and O^- .

Many candidates could draw a Born–Haber cycle but often these included mistakes in the formulae used e.g., using Na_2 , Na^{2+} and O_2^{2-} . Candidates rarely gave incorrect state symbols but sometimes omitted to include a state symbol. Three correctly named enthalpy changes was awarded one mark, five named enthalpy changes given two marks and all seven enthalpy changes given three marks. The first and second electron affinity of oxygen had to be specified to get full marks.

Only a very small proportion of candidates were able to explain how to calculate the lattice enthalpy for sodium oxide. Good answers gave this explanation as an equation with symbols that they had already defined in the Born–Haber cycle. A large number of candidates did not account for the two moles of $\text{Na(s)} \rightarrow \text{Na(g)}$ and two moles of $\text{Na(g)} \rightarrow 2\text{Na}^+(\text{g}) + 2\text{e}^-$.

Many candidates could arrange the three ionic compounds in the correct order. Candidates often gave extremely detailed explanations that took up more space than the Born–Haber cycle. Candidates had to compare the ionic radii and charges of the respective anions and cations. Common misconceptions included reference to the radii of magnesium oxide, sodium chloride and potassium bromide or not specifying that the particles were ions.

2815/02 Biochemistry

General Comments

Scores were generally improved. There were confident answers in the questions on protein structure and nucleic acids. Candidates had prepared themselves well and, through their teachers, had taken note of previous mark schemes and reports.

In places some had not read the questions with sufficient care, and in others, poor quality of written expression limited the responses. Generally there were few unprepared candidates this time.

Comments on Individual Questions

- 1(a)(i) This was generally well answered. The common mistake in the diagram was to insert an extra O atom into the amide link. Some candidates wrote dipeptide instead of peptide to describe the link.
- 1(a)(ii) The great majority of candidates correctly chose alanine and phenylamine, though a few guessed incorrectly. About half the entry managed to outline their reasoning, often based on the elimination of unsatisfactory alternatives. The simple statement that the pair fitted the formula was not enough on its own to earn the mark.
- 1(b) All knew at least three types of R group interaction that might be used to stabilise tertiary structure, and the majority were able to connect these with the amino acids provided in the stem. A large minority did not make these connections. In some cases carboxyl groups and amino groups in their diagrams clearly belonged to main chains and not to the side-chains. These same two groups were sometimes used in both ionised and unionised forms by a candidate who did not also explain how this would be possible. Weaker candidates often showed disulphide bonds as dotted or even double bonds.
- 2 (a)(i) This question was about the different shapes of optical isomers which would or would not fit into the active site. Candidates found it difficult to find both parts of the answer. Some used the idea of complementarity successfully.
- 2(a)(ii) This was generally well done. A few candidates ionised the phenol group also.
- 2(a)(iii) Only a minority gave both points – the formation of an unionised amine and its inability to form ionic bonds.
- 2(b)(i) The expected answer covered the idea of the inhibitor binding or fitting the active site with some further comment about this – reversible/blocking the site from tyrosine etc. and not just repeating the 'competitive' given in the question. About half the candidates managed this. A few described non-competitive inhibition instead.
- 2(b)(ii) This was generally well done. A few drew the curve for non-competitive inhibition. A number of candidates drew their curves with too much falling off at the end of their plateau section.

3(a)(b) These were generally well done.
(c)

3(d) This was well done across the ability range, with many scoring 5 or 6 marks out of 6. Weaker candidates were not able to write anything useful about bond making and bond breaking apart from the hydrogen bonds between complementary bases in mRNA and tRNA triplets. A minority described replication or transcription instead, in spite of being told what translation involved in the first line of the question. A few had not learnt this at all.

4(a)(i) Most candidates could explain the term alpha. Very few understood pyranose. A few candidates correctly analysed the structure as involving a ring containing five carbon atoms and one oxygen, and earned the mark.

4(a)(ii) The majority of candidates completed this well. The usual mistakes were to draw the carboxylic acid or fructose instead, or to end up with a pentavalent carbon.

4(b) (i) This was well done by the great majority of candidates.

4(b)(ii) The majority correctly wrote maltose. Others tried sucrose, fructose, cellobiose or amylose unsuccessfully.

4(c)(i) This was well answered by the top half of the entry. They were able to correlate the scarcity of available OH groups for hydrogen bonding to water with the OH involvement in glycosidic links and in hydrogen bonding between cellulose chains.

4(c)(ii) Better candidates knew that the tensile strength of cellulose fibres is due to the hydrogen bonding between linear cellulose molecules. Many described the properties of cellulose rather than the structural features that give rise to them. Several described the useful features of amylose instead.

5(a) The better half of the entry was successful in working out that there were three C=C bonds in a molecule of punicic acid. Others seemed to be guessing.

5(b)(i) This was generally well done. Some lacked an oxygen atom in their ester link but were otherwise correct.

5(b)(ii) Only the best candidates wrote simply the ester and alkene as expected. Many forgot about the alkene groups and tried to get two groups from their O=C=O atoms, suggesting ketone and ether, aldehyde and ether and so on. Perhaps these candidates were not yet familiar with esters.

5(b)(iii) Better candidates correctly homed in on the hydrocarbon chains in the triglyceride and the van der Waals' forces which these made possible. Unfortunately poor technical vocabulary was often seen, for example, using fatty acid tails and hydrophobic bonding.

2815/04 Methods of Analysis and Detection

General Comments

Candidates for this option continue to show a very pleasing level of understanding of this area of Chemistry that encourages candidates to apply their knowledge in relevant ways. Many candidates demonstrated that they are competent in applying knowledge of how analytical techniques are used and that they understand the scientific principles behind how they work.

Comments on Individual Questions

- 1 Throughout this question candidates needed to ensure they were referring to the correct isomer of bromobutane. Unfortunately, many candidates appeared to be careless or forgetful in their reading of the question.
- (a)(i) Candidates were required to give the fragments from 2-bromopropane that were responsible for m/e peaks at 122 and 124. Many candidates were able to do this; those that were not used 1-bromopropane instead or used the average atomic mass of bromine rather than the two isotopic masses.
- (a)(ii) Many candidates were able to give the ratio of 1:1.
- (b) Many candidates were able to give an m/e value of a fragment from 1-bromopropane that was not in 2-bromopropane. Those that did not, often quoted from the wrong molecule.
- (c)(i) A significant proportion of candidates were able to correctly work out which hydrogen atoms of 1-bromopropane gave rise to which peak. However, some candidates indicated that the letters a, b and c were associated with the carbon atoms rather than the hydrogen atoms as they were instructed to do in the question.
- (c)(ii) Many candidates were able to use the ' $n + 1$ ' rule to explain that a triplet was caused by the interaction with the two hydrogen atoms on an adjacent carbon atom.
- (c)(iii) Those candidates who recognised that there were two equivalent CH_3 groups present were easily able to identify two peaks in a ratio of 6:1. Common errors were often associated with candidates answering in terms of 1-bromopropane.
- 2(a) Examiners were pleased to read a very large proportion of correct answers to this question. Many candidates understood and could explain how an excited electron falls down energy levels and releases energy whilst doing so.
- 2(b) There were less but still a large proportion of candidates who could also explain the multiple energy levels and electron transitions between them that cause more than one series of lines.
- 2(c) Few candidates could interpret the initial diagram of the question to show **B** falling from $n = 2$ to $n = 1$ and **A** from $n = 4$ to $n = 2$.
- 2(d) It was pleasing to see that a great many candidates were able to perform this calculation well. Common errors included an omission of the use of Avagadro's constant or giving an answer in J mol^{-1} without stating that these were the units.

- 3(a)(i) Many candidates were able to define the R_f value correctly and in (ii) to suggest that a similar R_f value was a cause of non-effective separation.
- 3(a)(iii) Almost all candidates suggested the use of two-way chromatography but only about half of these candidates were able to explain that it is unlikely that a component will have a similar R_f value in two different solvents.
- 3(a)(iv) A pleasing number of candidates were able to recognise that partition happens between a mobile phase and a stationary phase although fewer were able to relate the separation that occurred to relative solubilities in the two phases.
- 3(b) This extended piece of writing was a mixture of knowledge of electrophoresis with application in the particular context of the importance of controlling pH. Many candidates were able to state that electrophoresis needs an applied voltage, is carried out in a buffered solution and separates molecules on the basis of their mass and charge. Candidates who scored full or almost full marks were able to illustrate their responses about changing the pH with examples of amino acids changing their charge (usually with a diagram of a structure). Almost all candidates were able to score the Quality of Written Communication mark.
- 4(a) A pleasing number of candidates were able to identify the features of molecules that cause them to absorb in the uv/visible region. These were lone pairs of electrons on the nitrogen atoms, delocalised ring electrons and triple bonds. Some candidates interpreted the question as asking whether the molecule absorbed either uv or visible and attempted to explain which one it would be. This type of question regularly asks whether there will be absorption anywhere within the whole of this region or not.
- 4(b)(i) Candidates who are able to express ideas of conjugation and its effects precisely gain more marks than those who are not. Language such as 'compound Y is in the visible region' is insufficient and needs to be more clearly a reference to Y being able to absorb energy in the visible region of the spectrum. The conjugation present in molecules X and Y was often poorly expressed. Those who made a comparison and stated that Y had greater conjugation/delocalisation of electrons were awarded the mark whereas those who simply stated that Y was conjugated were not (since molecule X does have some conjugation, just less than Y).
- 4(b)(ii) Many candidates were able to explain that compound X absorbed uv light so making it an effective sunscreen. There was a significant number of candidates who thought that compound X was effective because it did not absorb uv and so this radiation would not get to the skin.
- 5(a) Many candidates used the mass spectrum of Z to identify the molecular mass as 164 to compare this to the empirical formula given and to deduce that the molecular formula was twice this value.
- 5(b) A large number of candidates correctly identified the C=O absorbance in the infra-red spectrum of Z as around 1700 cm^{-1} . Some thought that there was an absorbance for OH at 3000 cm^{-1} . A large number of candidates identified a benzene ring either from the m/e value of 77 or from the chemical shift around 7.2 ppm. However, very few candidates were able to use the rest of the n.m.r. spectrum to identify two equivalent CH_3 groups next to a CH (rather than an OH as many candidates suggested, despite there being no evidence of OH in the ir spectrum).

2815/06 Transition Elements

General Comments

Many candidates performed well on this paper, but there was still evidence of candidates who were poorly prepared and these candidates scored very low marks.

Candidates clearly had sufficient time to complete the paper and most scripts were legible. The standard of drawing has improved significantly over the years and three-dimensional drawings for complex ions are now the norm.

Ideas relating to colour and the importance of d-orbitals in giving transition metal complexes colour is a weakness as is volumetric analysis using copper (II)/iodide and sodium thiosulphate.

Comments on Individual Questions

Question 1

- (a) (i) This was well answered with hardly any candidates failing to score.
- (ii) Surprisingly few candidates were able to score full marks for the diagram of the apparatus. Most included the salt bridge and the voltmeter. Common mistakes included using chromium as the electrode, using Cr^{3+} or $\text{Cr}_2\text{O}_7^{2-}$ as electrodes and not stating the temperature. Many candidates mixed the ions and had Cr^{3+} in one cell and $\text{Cr}_2\text{O}_7^{2-}$ in another cell. Standard conditions were generally well known, with pressure commonly stated in atmospheres.
- (b) Although many candidates gave the correct response a much smaller proportion were able to give an explanation in terms of Le Chatelier's principle.

Question 2

- (a) Many candidates gave the correct oxidising agent but the explanations were less convincing. Most referred to a greater positive electrode potential but did not refer to the ease of electron gain. A small number of candidates failed to identify the oxidising agent or simply gave the half-equation and were not specific enough to receive the marks available.
- (b) The colour of $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ was well known.
- (c) Many candidates could write the balanced equation but fewer candidates could demonstrate that the reaction was feasible. A variety of different cell potentials was quoted.

Question 3

- (a) (i) A majority of candidates answered correctly. A common misconception was to include $4s^1$ in the electron configuration.
- (ii) Many candidates realised the significance of an incomplete 3d sub-shell but others referred to a full 3d orbital rather than a full 3d sub-shell.

- (b) The important point here was the d–d splitting and the effect of different ligands on the energy gap. Many candidates did not mention the d–d splitting and implied that it was the ligands that absorbed visible light. Good answers referred to $\Delta E = hf$.
- (c) Good answers gave an ionic equation for the disproportionation reaction and identified the products that gave the observations stated in the question. Some candidates complicated the equation by starting with a complex ion. This resulted in a number of mistakes. A common misconception was that the red–pink solid was Cu_2O or $\text{Cu}(\text{OH})_2$.
- (d) A significant proportion of the candidates were able to calculate the correct answer. The stages needed to obtain the correct answer were often very sketchy and difficult to follow. The most common error was not accounting for the change in volume from 25 cm^3 to 250 cm^3 and an answer of 7.62% was often seen. The stoichiometry between $\text{S}_2\text{O}_3^{2-}$ and Cu^{2+} was a problem for many candidates.

Question 4

The terms optical and geometric isomerism were well known but a significant proportion of candidates muddled the two terms. In part (b) the *cis* and *trans* isomers were well drawn. In part (c) a small fraction of candidates chose the *trans* isomer rather than the *cis* isomer but invariably these candidates still drew a mirror image and were awarded 1 mark. Common errors included isomers based on a tetrahedral structure with the ‘en’ ligand shown as monodentate. Other candidates used $[\text{Co}(\text{en})_3]^{3+}$ instead of the correct complex ion.

Question 5

Coordination number was defined correctly by most candidates but a common misconception was to quote the number of ligands, rather than the number of coordinate bonds, surrounding the central metal ion.

Almost all candidates gave examples of octahedral and tetrahedral complex ions but fewer included square planar complex ions. The bond angles for these different structures were less well-known and square planar complexes were often wrongly quoted as having a bond angle of 120° . Examples of the different complexes often did not include the charge and so were not given credit and a number of candidates used M, X and Y instead of actual metal ions and ligands.

The most popular octahedral complex ion described was $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ and the most popular tetrahedral complex was $[\text{CuCl}_4]^{2-}$. This was probably because candidates could remember the equation showing the ligand exchange reaction between $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ and Cl^- . The similar ligand exchange reaction involving $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ and Cl^- was also a popular equation given by candidates. Diagrams for the complex ions were usually excellent three-dimensional representations.

2816/01 Unifying Concepts in Chemistry

General Comments

The usual January entry for 2816/01 provided a few large and very good centres and very many very small centres, presumably mostly candidates re-sitting in an attempt to improve their grades.

The total entry of just over 500 was a significant increase in candidates and came from well over 100 centres. Significantly more centres seem to be preparing their candidates for the first sitting of this examination in January than in previous years.

There was a wide range of marks and there were no questions where candidates failed to score. The questions on equilibrium and reaction rates proved to be easiest for candidates.

Many candidates had obviously prepared extremely well for this exam and tackled stock questions on equilibrium, rates and acid–base chemistry to a very high standard. Some of these candidates then struggled when presented with unfamiliar application-type questions as those asked in Q1(e), Q3(e) and Q4(a), (b) and (d). Perhaps such candidates need more practice with synoptic questions.

The entry did include a not insignificant number of candidates who had not prepared for this examination. On such scripts, equilibrium and rate were confused, the methods to solve stock pH calculations were unknown and buffer responses were invented.

Comments on Individual Questions

- 1(a) Most candidates showed this expression correctly with only the weakest inverting, omitting to square $[\text{HI}(\text{g})]$ or adding $\text{H}_2(\text{g})$ and $\text{I}_2(\text{g})$.
- 1(b) (i) Many candidates correctly identified that there would be 0.28 mol $\text{HI}(\text{g})$ and 0.11 mol $\text{I}_2(\text{g})$ at equilibrium. The commonest error was for candidates not to consider that 2 mol of HI are formed for every 1 mol of $\text{I}_2(\text{g})$ reacted. Consequently 0.39 mol $\text{HI}(\text{g})$ was seen on many occasions.
- 1(b)(ii) The calculation, marked consequentially on responses to (a) and (b)(i), scored two or three marks in the majority of cases. The commonest mark missed was allocated for calculating a value to an appropriate number of significant figures. As all figures had been supplied to two significant figures, the K_c value was also required to two significant figures and the correct response of 0.15 was often shown as 0.154. Candidates with 0.39 mol $\text{HI}(\text{g})$ from (i) often showed 0.796 or 0.8 whereas 0.80 was required consequentially.
- Most candidates identified that there are no units for this K_c expression. It should be stressed that candidates are required to make some response in the gap: 'no units' or '–' is sufficient. A gap was treated as no response and was not credited.
- 1(c) The majority of candidates correctly stated that both K_c and the composition of the equilibrium mixture would not change. The commonest mistake was to ignore the requirement for the composition.

- 1(d) As with (c), most candidates obtained both marks for this part. Weaker candidates sometimes just simply stated that the equilibrium would move to the right but most candidates went on to relate the forward reaction to being endothermic. It should be noted that there are two reactions, forward and reverse, and the phrase 'forward reaction' should be used.

- 1(e) For many candidates this part was more testing than the stock equilibrium questions in (a)–(d).

The weakest candidates often didn't seem able to interpret the information supplied and some omitted this part completely.

Better candidates were able to identify **A** as ICl and **B** as I_2Cl_6 . However, equations for their formation were then often given from I_2 and Cl_2 rather than from HI and Cl_2 as asked for in the question.

Strong candidates responded well with many collecting all 5 marks. Although the examiners expected to see HCl as the second product, H_2 was also accepted.

- 2(a) Almost all candidates identified the overall order as 3.

- 2(b) The answers for the calculation of rate constants continue to improve. More candidates seemed to be able to rearrange the rate equation and to obtain the correct units. The expected response was $6110 \text{ dm}^6 \text{ mol}^{-2} \text{ s}^{-1}$.

The commonest mistakes seen stemmed from careless working and calculator errors. Many candidates omitted to square the concentration of $\text{NO}(\text{g})$, obtaining an incorrect answer of 1.71. Others were unable to cope with the powers of 10 and obtained values of 6.11, 61.1, etc.

Mistakes with units were mostly with the signs of the indices.

- 2(c) (i) The sketch graph here provided more problems than expected. The expected downward curve, gradually levelling off was often replaced by an upward curve levelling off, other curves, or by straight lines usually through the origin. Candidates seem to be learning these shapes but then seem to be unable to apply them to a scenario.
- 2(c)(ii) The majority of candidates were aware that a tangent must be drawn at $t = 0$ and that the gradient gives the rate. The commonest omission was $t = 0$ or some reference to 'the start'.

The weakest candidates often referred to half-lives.

- 2(c)(iii) 'Constant half-life' was seen often with only the weakest confusing this with gradients.

- 2(d)(i) The expected curve was an upward slope, getting steeper. Many of comments in (d)(i) apply equally here.

- 2(d)(ii) The majority of candidates were able to work out that the rate would increase by nine times (3^2), with most justifying their answer by stating that the order with respect to NO is two. Some instead stated that 'the rate quadruples when the rate doubles' but this did not relate to the question.

- 2(d)(iii) Candidates found this part more difficult with only the best candidates realising that the rate would increase by a factor of 12 ($2^2 \times 3^1$). The commonest mistake was an increase of seven times, presumably from $2^2 + 3$ and this response was seen as often as the correct answer.
- 3(a) This was a very easy opening part with virtually all candidates obtaining a pK_a value of 2.82.
- 3(b)(i) Although most candidates obtained this mark with ease, some incorrectly showed the numerator as $[H^+(aq)]^2$. It was also common to see the negative charge on HSO_3^- omitted by carelessness.
- 3(b)(ii) Calculations of the pH values of weak acids are becoming easier as modern calculators now carry out much of the work for candidates. Consequently most candidates obtained the correct response of 2.20. The commonest mistake seen was 4.40, obtained by not taking a square root.
- 3(b)(iii) This part proved to be the most difficult on the whole paper. The examiners expected that candidates would realise that H_2SO_3 is dibasic and that HSO_3^- would dissociate slightly, producing a higher $[H^+(aq)]$. The examiners also credited a statement that the equilibrium $H_2SO_3(aq)$ concentration would be less than that before dissociation.
- 3(c)(i) This part was seen incorrect very often with many invented phrases being seen.
- 3(c)(ii) Although $[H^+(aq)][OH^-]$ was often seen, many candidates spoilt things by then dividing by the concentration of water.
- 3(c)(iii) Candidates seemed to be more confident with calculating the pH of a strong base than in previous sessions with the correct response of 12.42 being seen very often. The commonest error was to simply $-\log 0.0265$ and to obtain a pH value of 1.62, clearly impossible for a strong base. It was also common to see a zero in 0.0265 disappear resulting in an incorrect pH of 13.42.
- 3(d) This part proved to be more testing. Candidates needed to interpret the information to identify **C** and **D** and to construct equations for the reactions.
- It was common to see H_2SO_4 used instead of H_2SO_3 and many novel formulae were seen for either of the two salts, such as K_2SO_2 and KSO_3 . Candidates who did identify the two salts often fell down with the two equations, either omitting water entirely from the right-hand side, or being unable to balance the second equation.
- 4(a) There were mixed responses to this part. Surprisingly many candidates were unable to interpret the skeletal formula to obtain correctly 2 C atoms or 4 H atoms
- 4(b) Candidates found this part difficult. Very few candidates spotted that there were two reactions making up the first step: for the chloro and carboxyl functional groups. This often resulted in candidates struggling with the second step. It was also common to see unbalanced equations.
- 4(c) Most candidates could explain what is meant by a buffer solution. Although many could also write an equilibrium equation, this was often for a weak acid different from glycolic acid. It was also common to see an incorrect formula for glycolic acid, even after taking into account a formula already incorrect from (a) and (b).

Many candidates were well versed in explaining how a buffer solution works, although many then contradicted themselves by suggesting that the equilibrium restored the original concentration of hydrogen ions. Conversely, a poorly prepared candidate can often score no marks at all here.

The calculation of the relative amounts of salt and acid in the buffer proved to be much more difficult, although quite a few succeeded. Most candidates were able to calculate the hydrogen ion concentration correctly, but then assumed incorrectly that it was the same concentration as the anion from the acid (and salt!). Some candidates used variations of the Henderson–Hasselbalch equation successfully, with either the base or acid as numerator. Many produced a log ratio but failed to take the inverse log.

- 4(d) This part tested all candidates. Many candidates managed to calculate the amount in moles of carbon dioxide and water or carbon and hydrogen. The majority then went wrong as they did not consider the oxygen content and a large number of candidates ignored the information provided for compound **E** entirely. Many candidates did manage to make the jump to C_4H_6 and then to $C_4H_6O_6$, albeit sometimes by trial and error.

The examiners were often presented with a whole page of working for which little sense would be made. The weakest candidates had little idea of how to go about this problem and often tried mass ratios without considering moles at all.

The best candidates however showed flair in their solution and tackled this part with aplomb.

2816/03 Unifying Concepts in Chemistry (Practical Examination)

General Comments

The number of candidates entered for this paper was higher than usual in January.

Comments on Individual Questions

Plan 1

The Plan was well answered by most candidates. As usual the mark scheme had 19 marking points, so a large number of candidates were able to achieve the maximum mark of 16. Most candidates chose gas collection as the second method, though precipitation was also a popular. Since the latter method would be more difficult to carry out accurately, two marks fewer were made available to candidates who opted for this method.

The manganate(VII) titration was described reasonably well. Some chose an unsuitable concentration of KMnO_4 in the burette, one that would not give a titre of the order of 25 cm^3 . Some omitted to acidify or to heat to speed up for this slow titration reaction. A number of candidates do not understand how the manganate(VII) ion is able to self-indicate and so give the wrong end-point colour change. The calculation of the concentration of ethanedioic acid from specimen data was answered well.

The gas collection experiment was also described well by most candidates, who were able to justify clearly the quantities of materials they had chosen. Those who chose the precipitation method fared less well, because insufficient accuracy precautions (such as washing the residue from the reaction flask into the filter paper with distilled water and then drying to constant mass) were included in the descriptions. Those who chose barium ions to effect the precipitation were allowed to work on the basis that barium ethanedioate was either soluble or insoluble, provided that their thinking was clearly explained.

Test B Part 1

The standard of accuracy of most candidates in this double titration was very variable, partly because of the indistinct nature of the colour changes at both end-points. Centres are reminded that it is important that the Supervisor's results submitted should be accurate and reliable.

Test B Part 2

The calculation was generally done well by all but the weakest candidates. Some did not give answers to three significant figures as requested, especially in (a). Part (d) was not always well answered: some candidates did not refer specifically enough to the number of moles shown in the chemical equation given.

Test B Part 4

The Evaluation proved to be very challenging.

Parts (a) and (b) were generally answered well. Candidates confuse 'accuracy' and 'reliability', but answers in part (b) were much better than is usual. However, it was expected that candidates' answers would relate appropriately to the results that they had actually obtained in their titration.

In (c), many candidates wrote sensibly about extra burette readings resulting in increased percentage/cumulative error. However, comments related to the indistinct colour changes of both indicators during the procedure were generally unfocused.

In part (d), the majority of candidates paraded their lack of understanding of pH. Despite having titrated sodium carbonate with HCl during the examination, many candidates asserted that sodium carbonate is an acid and would therefore react with the NaOH.

Grade Thresholds

Advanced GCE Chemistry (3882/7882)
January 2009 Examination Series

Unit Threshold Marks

Unit		Maximum Mark	a	b	c	d	e	u
2811	Raw	60	51	45	40	35	30	0
	UMS	90	72	63	54	45	36	0
2812	Raw	60	49	44	39	34	29	0
	UMS	90	72	63	54	45	36	0
2813A	Raw	120	98	88	78	69	60	0
	UMS	120	96	84	72	60	48	0
2813B	Raw	120	98	88	78	69	60	0
	UMS	120	96	84	72	60	48	0
2813C	Raw	120	94	84	74	64	55	0
	UMS	120	96	84	72	60	48	0
2814	Raw	90	73	65	57	49	42	0
	UMS	90	72	63	54	45	36	0
2815A	Raw	90	74	68	62	56	50	0
	UMS	90	72	63	54	45	36	0
2815C	Raw	90	75	68	61	54	47	0
	UMS	90	72	63	54	45	36	0
2815E	Raw	90	77	70	63	56	49	0
	UMS	90	72	63	54	45	36	0
2816A	Raw	120	100	90	80	70	61	0
	UMS	120	96	84	72	60	48	0
2816B	Raw	120	100	90	80	70	61	0
	UMS	120	96	84	72	60	48	0
2816C	Raw	120	92	82	72	62	53	0
	UMS	120	96	84	72	60	48	0

Specification Aggregation Results

Overall threshold marks in UMS (ie after conversion of raw marks to uniform marks)

	Maximum Mark	A	B	C	D	E	U
3882	300	240	210	180	150	120	0
7882	600	480	420	360	300	240	0

The cumulative percentage of candidates awarded each grade was as follows:

	A	B	C	D	E	U	Total Number of Candidates
3882	10.0	35.9	60.7	84.1	98.4	100	1206
7882	14.9	49.3	78.0	92.9	98.1	100	288

1694 candidates aggregated this series

For a description of how UMS marks are calculated see:

http://www.ocr.org.uk/learners/ums_results.html

Statistics are correct at the time of publication.

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