

CHEMISTRY

<p>Paper 9701/01 Multiple Choice</p>
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<i>Question Number</i>	<i>Key</i>	<i>Question Number</i>	<i>Key</i>
1	A	21	A
2	C	22	B
3	A	23	D
4	C	24	C
5	A	25	C
6	D	26	C
7	A	27	D
8	C	28	A
9	B	29	C
10	D	30	B
11	D	31	A
12	C	32	A
13	A	33	C
14	A	34	D
15	C	35	B
16	A	36	C
17	C	37	B
18	D	38	D
19	B	39	A
20	C	40	C

General Comments

For this paper, the mean score was 22.8 (57.0%), a little below the targeted value of 60%, and the standard deviation of the scores was 6.57 (16.4%), indicating that overall the paper performed satisfactorily.

The first 30 questions were simple completion items: **Questions 31 to 40** were three-statement multiple completion items.

Comments on Individual Questions

Four questions, **Questions 2, 3, 7 and 18**, had a high facility, representing areas of the syllabus that are widely understood.

Three questions had a low discrimination in distinguishing between more able and less able candidates.

- **Question 9** was an exercise in balancing two redox half equations: in the oxidation of a sulphite solution by a metal salt, a factor of 2 operated twice within the calculation, and some of the more able candidates omitted one of these, indicating a change of oxidation state of the metal by -2 and not -1, giving the distractor **A** as the answer and not the key **B**.
- **Question 28** exposed a widespread misunderstanding that NaBH_4 will reduce a carbon-carbon double bond as well as a carbonyl group, making the distractor **C** more popular than the key **A**.
- **Question 33** used a classic syringe experiment to examine the dissociation of PCl_5 to PCl_3 and Cl_2 . A surprising percentage of candidates believed that the internal pressure within the syringe would be different from the external, and that the dissociation would *not* lead to an increase in volume.

Examiners try to include questions that relate chemistry to its implications in everyday life, and **Question 12** asked about methods that could be used to deal with a spillage of sodium metal. The best method is to cover it with material that is inert – in this case, sand – and so prevent contact with the atmosphere containing both oxygen and water vapour, with which it would react (key **C**). A large proportion of the candidates chose to swamp it with ethanol (distractor **A**) which would involve a vigorous reaction and the evolution of hydrogen, which would then catch fire along with the ethanol itself and also any remaining sodium – a highly dangerous outcome.

Question 37 included three standard methods for the production of ammonia, but replaced all or some of the hydrogen atoms with deuterium. This question proved too difficult, and the result clearly indicates guessing or confusion among candidates.

Three other questions, while performing satisfactorily, deserve comment.

In **Question 19** candidates were asked to recognise any chiral centre in three compounds for which only the molecular formula was given. Many candidates failed to notice that $\text{C}_3\text{H}_6\text{I}_2$ could have the structure $\text{CH}_3\text{CHICH}_2\text{I}$.

Question 21 asked why the presence of $(\text{CH}_3)_4\text{Pb}$ enhances the rate of the substitution of methane by chlorine. A surprising number of candidates thought that it would be because metal ions would catalyse the reaction, rather than because $(\text{CH}_3)_4\text{Pb}$ would be a source of methyl radicals.

In **Question 32**, given that carbon monoxide burns readily to form carbon dioxide, many candidates recognised that this would be an exothermic reaction but not that this would also lead to a high value of K_c for the equilibrium $2\text{CO}(\text{g}) + \text{O}_2(\text{g}) = 2\text{CO}_2(\text{g})$.

CHEMISTRY

Paper 9701/02

AS Structured Questions

General comments

The paper tested candidates' knowledge and understanding of the required subject matter and the majority of candidates made good attempts to complete all of the questions. Chemistry is an experimental science which has a theoretical background and a number of questions on this paper related to some of the theoretical aspects of AS Level chemistry. While there were many good answers to these questions, there were also many candidates who struggled to explain clearly the relevant theory.

In addition, chemistry has a significant factual content and a number of questions asked candidates to recall knowledge. Again, there were many good answers to these questions but a number of candidates had not learned some basic chemistry and were penalised.

Overall, there were many good answers to this paper and most candidates were able to demonstrate some positive achievement. Candidates' knowledge of organic chemistry continues to improve in general, but a large number of candidates struggled with one or both of the calculations, often because they did not use a logical method of answering the questions.

The handwriting of some candidates continues to cause Examiners some concern. A specific example on this paper is in **Question 5 part (b)(ii)** for which the correct answer is 'ethanal'. In some answers it was impossible for Examiners to distinguish between 'ethanal' and 'ethanol' as the candidate's answer. In such cases, the candidate is the loser because a mark is only awarded when the Examiner is certain that the answer is correct.

Comments on specific questions

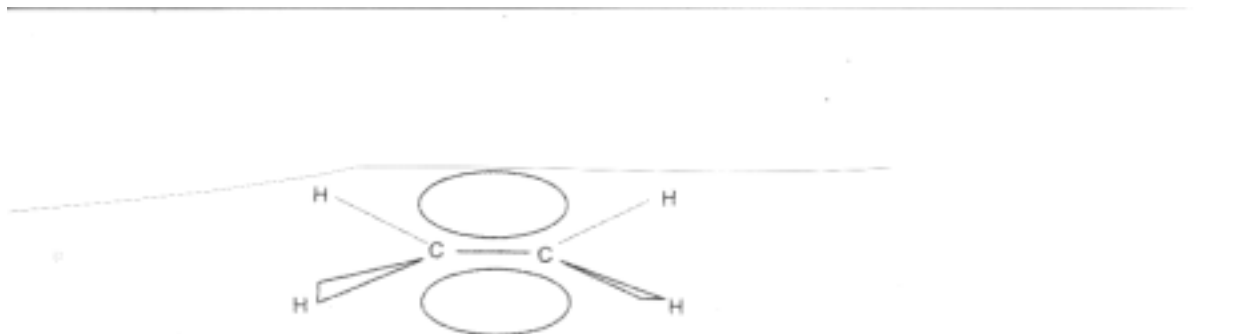
Question 1

This question tested candidates' understanding of orbitals and bonding. While there were many good answers to it, a surprising number of candidates struggled with the early parts of the question. In **parts (a), (b)(ii) and (d)**, allowance was made for the artistic ability – or otherwise – of candidates.

- (a) There were many very clear and correct answers to this part but a significant number of candidates gave wrong answers. Examiners expected candidates to represent the spherical shapes of the 1s and 2s orbitals with a circle, the 2s being larger than the 1s. A common error was drawings which showed 1s and 2s orbitals the same size. For the 2p_x orbital, candidates were expected to draw two symmetrical lobes along the x axis.
- (b)(i) This part received the fewest correct answers. Examiners expected a simple statement that there is an electrostatic attraction between the bonding pair of electrons and the protons in the nuclei of the two atoms involved.
- (ii) This part was less well done than **part (a)**. It was expected that candidates would draw two overlapping circles to represent the two 1s orbitals which overlap to form the σ bond in the H₂ molecule. Similarly, the σ bond in the HCl molecule would be shown by an overlap of a circle (representing the s orbital) and one lobe of the representation of the p orbital. Common errors were to show 'dot-and-cross' diagrams or, in the case of HCl, to show a small circle overlapping a larger one.
- (c) Many candidates knew that *bond polarity* referred to an unequal sharing of electrons by the two atoms concerned. Fewer were able to explain that HCl is polar because chlorine is much more electronegative than hydrogen.

- (d) As with **parts (a) and (b)(ii)**, there were many good attempts to draw the π bond in ethene. Examiners were looking for a representation of two p orbitals, one on each carbon atom, which had overlapped sideways to form a localised π bond above and below the C-C axis, as shown below.

A very good diagram of what is required is contained in the mark scheme for Singapore 9746/02 Specimen Paper **Question 1(c)(i)**. A poor copy of it is printed below.



- (e) While there were many fully correct answers to the calculation, there were also many candidates who made silly errors and were penalised as a result. This suggests a lack of checking of the answer before handing in the paper. A small number of candidates tried to use bond energy data from the *Data Booklet* rather than the data given in the question; this cannot be done and these candidates received no credit at all.

The correct answer is given by the following expression.

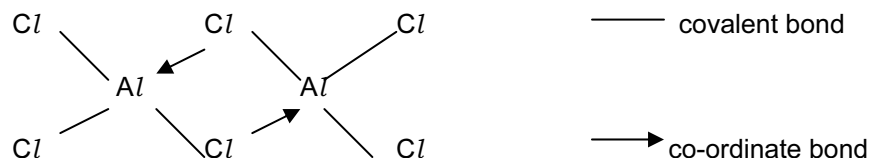
$$\Delta H_f^\ominus = 2(-393.7) + 2(-285.9) - (-1411) = + 51.8 \text{ kJ mol}^{-1}$$

Question 2

This question tested candidates' knowledge of the chemistry of some of the halides of the third period and their understanding of the bonding in these compounds. Many good answers were given but few candidates were able to answer the whole question correctly. The most common mistakes arose from candidates not keeping their answers simple and to the point. This was especially true in **part (b)** where there were many contradictory answers.

- (a) There were many very clear and correct answers to this part but a significant number of candidates thought that PCl_5 was a gas, despite the melting point being given in the question. Examiners accepted equations that contained P or P_4 but not those containing P_2 .
- (b)(i) While there were many clear explanations with good diagrams of the bonding in NaCl , there were still many contradictory statements such as 'sodium chloride has a giant ionic lattice ... with strong covalent bonds between the molecules'. Such answers are penalised.
- (ii) There were many muddled answers in this part as well. Examiners were looking for two clear and unambiguous statements such as the following. 'Silicon tetrachloride is a simple molecular compound. The forces between the molecules are weak van der Waals' forces.'
- (c) Many candidates gave fully correct equations. Examiners accepted SiO_2 or $\text{Si}(\text{OH})_4$ or $\text{SiO}_2 \cdot 2\text{H}_2\text{O}$ as the product. The most common mistake was for candidates to leave the equation unbalanced.
- (d) This was not so well answered. Candidates are expected to know that $\text{NaCl}(\text{aq})$ has a pH of 7 and that when PCl_5 is dissolved in water it will be hydrolysed to give a strongly acidic solution. Examiners accepted pH values of less than 5 for this solution.

- (e) (i) This was generally well answered with most candidates correctly giving Al_2Cl_6 as the low temperature form and $AlCl_3$ as the high temperature form.
- (ii) This was less well done. A surprising number of candidates thought that $AlCl_3$ is ionic. Another common error was to put a lone pair of electrons on the Al atom.
- (iii) This was badly answered by the majority of candidates, many of whom gave a 'dot-and-cross' diagram. Examiners expected a displayed structure, such as that printed below, which showed clearly the covalent and the co-ordinate bonds.



A number of those candidates who did include co-ordinate bonds in their answers showed them pointing **from Al to Cl** and were penalised.

Question 3

This question tested candidates' knowledge of the chemistry of some of the elements of the third period and their understanding of the molecular structures of phosphorus, sulphur and chlorine. Many good answers were given but few candidates were able to answer the whole question correctly. The calculation proved difficult for a significant number of candidates.

- (a) There were relatively few fully correct answers to this part with only small numbers of candidates correctly giving the molecular formulae of phosphorus, P_4 , and of sulphur, S_8 ; Examiners did not accept P_2 or S_2 . In contrast, the molecular formula of chlorine was very well known. A summary table of the structures of the first 36 elements of the Periodic Table is given on page 201 of AS and A Level Chemistry by Ratcliff et al, published by Cambridge University Press.
- (b) (i) This part attracted few correct answers. The sequence from highest melting point to lowest melting point is S_8 , P_4 and then Cl_2 .
- (ii) With so few correct answers to **part (i)**, it was not surprising that there were even fewer correct answers to this part. As can be seen from the correct sequence, the melting points decrease as the size of the molecules decreases. This is because, from S_8 to P_4 to Cl_2 there are fewer electrons in the molecule with the result that there are fewer induced dipoles and weaker van der Waals' forces.
- (c) (i) The majority of candidates answered this part successfully. The correct answer follows.

$$S_2Cl_2 = (2 \times 32.1) + (2 \times 35.5) = 135.2$$

$$n(S_2Cl_2) = \frac{2.7}{135.2} = 0.0199 = 0.02 \text{ mol}$$

There was a small number of candidates who used proton number rather than relative atomic mass and were penalised as a result.

- (ii) This was less well answered. The correct answer is given below.

$$0.02 \text{ mol } S_2Cl_2 \rightarrow \frac{0.96}{32.1} = 0.03 \text{ mol S}$$

$$1.0 \text{ mol } S_2Cl_2 \rightarrow \frac{0.03 \times 1.0}{0.02} = 1.5 \text{ mol S}$$

- (ii) The answer to **part (ii)** can be used to determine the stoichiometry of the equation. However, many candidates who gave a wrong answer to **part (ii)** were able to use the information in the question to construct the correct equation which is as follows.



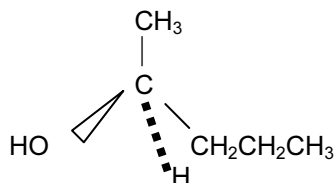
The most common error was to give a wrong formula for sulphurous acid.

- (d) This was generally well answered although a significant number of candidates failed to realise that the sulphur in S_2Cl_2 is both oxidised to H_2SO_3 and reduced to S. A commonly quoted product, both of oxidation and reduction, was HCl.

Question 4

This question tested candidates' ability to use displayed and structural formulae. There were many good answers with a pleasing number scoring full marks for this question.

- (a) There were many correct answers to this part. The most common error was to fail to draw a branched chain hydrocarbon. A few candidates included a non-displayed $-\text{CH}_3$ in their structures and were penalised. Details of how to represent structural, displayed and (from 2009) skeletal formulae are to be found in **Section 10.1** of the 2009 Syllabus.
- (b) The majority of candidates answered this correctly. A significant number failed to label their structures *cis* or *trans* as the question required and were penalised as a result.
- (c) In this part too there were many fully correct answers. A surprising number of candidates gave the same structure, usually that of pentan-2-ol, twice.
- (d) There were two aspects to this part: identifying the chiral alcohol, pentan-2-ol, and representing the three dimensional nature of the two isomers. More candidates were successful with the first of these processes. For the second, Examiners expected something like the following, with the mirror object and mirror image forms both being represented.



How candidates should represent optical isomers is also clarified in **Section 10.1** of the Syllabus.

- (e) Many candidates failed to realise that the compound must be cyclic, e.g. *cyclo*-pentane. Large numbers of answers contained structures with C=C bonds which would decolourise aqueous bromine.
- (f) This part was generally well answered.

Question 5

This question tested candidates' knowledge of some straightforward organic reactions. There were many good answers with a pleasing number scoring high marks for this question. Those candidates who scored low marks clearly had not learned the relevant material.

- (a) (i) Most candidates correctly used acidified potassium dichromate(VI) as the oxidising agent. Those who omitted to state that the solution must be acidified were penalised.
- (ii) Colour changes were usually accurately described. Examiners did not accept 'clear' as a colour when used with other oxidising agents.
- (b) (i) The oxidation of a primary alcohol can produce either an aldehyde or a carboxylic acid. Many candidates understood that in order to carry out the complete oxidation of ethanol, heating under reflux was necessary.
- (ii) Fewer knew that ethanal would be formed if immediate distillation were used. Examiners did not accept the word 'aldehyde' as an answer; they insisted on the compound being identified.

- (c) (i) In this part too, Examiners only accepted a positive identification of iodomethane by name or formula.
- (ii) This part was surprisingly badly answered. The reaction can be considered to be either hydrolysis or nucleophilic substitution. In the latter case, both words were necessary to gain credit.
- (d) This last part of the paper showed that many candidates had learned the chemistry involved and that many others had not. In each Step, Examiners only awarded the 'conditions' mark if a suitable reagent had been quoted. Common errors, which received no credit, were as follows.

Step I	the use of KI and concentrated sulphuric acid - which will not produce HI
	the use of PI_5 - which does not exist
Step II	the use of HCN – the reaction involves CN^- ions
	the failure to state that the reaction must be carried out in aqueous ethanol
Step III	the failure to state that the acid must be in aqueous solution – Examiners did not accept answers such as ' H_2SO_4 ' on its own
	the use of NaOH(aq) for hydrolysis – Examiners only accepted this if candidates stated that subsequent acidification was necessary

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Paper 9701/04

A2 Structured Questions

General comments

This was the second paper to be set on the new syllabus, which includes Applications of Chemistry, and for some parts of the world, the first time candidates had attempted the new questions.

In general terms the paper was accessible to most candidates with every single mark scored by someone however, for a number of individual candidates marks were lost because they failed to read the information provided in the question. Others failed to manage their time sufficiently well to fully answer all the questions, and so were unable to gain full marks.

Question 1

- (a) This part was well done on the whole, although some candidates did not use RCO_2H but just HA , and some confused $\text{p}K_{\text{a}}$ with pH .
- (b) In **part (i)**, there was some confusion between $\text{p}K_{\text{a}}$ and strength of acid (e.g. lower the $\text{p}K_{\text{a}}$, the weaker the acid). Some candidates simply described the trend in $\text{p}K_{\text{a}}$ without relating it to acidity. Although most knew Cl was electronegative, quite a few did not explain why that caused the acidity to increase (i.e. did not explain the weakening of the O-H bond or the stability of the anion). In **part (iii)**, many only scored one mark for changing $[\text{H}^+]$ of 0.01 into pH and did not go on to calculate the pH of $0.010 \text{ mol dm}^{-3}$ propanoic acid.
- (c) Many candidates recognised phosphorus was a catalyst in **(i)**, although some tried to incorporate it into the reaction (and equation). In **(iv)** far too many calculated the yield as 95% without considering the different RAMs of the two compounds.
- (d) This part was very well answered.

Question 2

- (a) This was generally well done, with only a few candidates confusing this explanation with that of the thermal stability of salts.
- (b) By contrast, this part was very poor. Some candidates did score full marks, but most did not keep to the sense of the question, and tried to convert the ethanedioate into carbonate.
- (c) **Part (i)** was generally well done, but several forgot to include units. **Part (ii)** showed up the usual errors of not including the $\times 4$ in the expression, or using $\times 2$ instead. The common ion effect in **part (iii)** was well known.

Question 3

- (a) An easy part, but surprisingly not all candidates scored both marks for this.
- (b) A surprising number had H_2O on the left hand side and $2\text{H}_2\text{O}$ on the right hand side. Quite a few also doubled up the empirical formula.
- (c) Answers to **part (i)** were disappointing – various alternatives were given. **Part (ii)** was often well answered, but some candidates wanted to include potassium in their redox reactions. The $\text{HOCl}/\text{Cl}_2 \text{ E}^\ominus$ was a common error. **Parts (iii)** and **(iv)** were more difficult with the most common error in **(iv)** relating Br_2/Br^- to Cl_2/Cl^- rather than to $\text{Cr}_2\text{O}_7^{2-}/\text{Cr}^{3+}$.

Question 4

- (a) This part was generally well answered.
- (b) **Parts (i) + (ii)** produced surprisingly few correct answers. Quite a few candidates got a sign wrong in **part (i)**, and felt they had to do something with the Cl_2 in **part (ii)**, such as break its bond.

Question 5

- (a) At most, around 20% of candidates scored a mark here, and this was also true for **part (b)**.
- (c) This generally gave better answers than the last time a similar question was set, but still many candidates were not clear as to the difference in the observation *during* the titration and at the end-point. By contrast, **part (ii)** was well answered and scored highly. Errors in the equation in **part (a)** were marked consequentially in this part.

Question 6

- (a) Most candidates managed to identify **C** in **part (i)**. In **part (ii)** many also identified amide and ester functional groups, but quite a few suggested amine or carbonyl or carboxyl. In **part (iii)** quite a few identified naphthol, but then gave the urethane CH_3NHCO_2H as the other product. If they did hydrolyse this, they usually suggested HCO_2H as a product rather than H_2CO_3 .
- (b) A pleasing number scored both marks here, for the aqueous reagents. The usual $AlCl_3$ or concentrated H_2SO_4 were seen, however, in many scripts.
- (c) The identity of **D** was correctly shown by most candidates in **part (i)**. **Part (ii)** was also generally answered well. In **part (iii)** many candidates just gave the mono-ethanoate.
- (d) This was fairly well answered by the more able candidates. Common errors were to imagine that the ligands in **(i)** were NH_3 or " $C_{10}H_6(OH)NH_2$ " or even " $C_{10}H_6ON$ ". A few candidates gave $[Cu(NH_3)_6]^{2+}$ formulae in **part (ii)**. Nucleophilic substitution was a common incorrect answer in **part (iii)** instead of *ligand* substitution.)

Question 7

- (a) This was generally well answered.
- (b) Most candidates gave the equation with just one H_2SO_4 , but then spoiled it by writing H_3O^+ on the RHS.
- (c) This part seemed to cause considerable confusion. Good candidates scored full marks, but weaker candidates chose inappropriate oxidising agents or conditions for chlorination.

Question 8

- (a) On the whole this part was well answered, although quite a number of candidates lost a mark in **part (i)** by simply repeating the word 'helix' from the question rather than describing the structure. Many also did not say where the H-bonds were between in **part (ii)**.
- (b) There were often some vague descriptions here, however: e.g. describing the mRNA as having *copied* the code from the DNA, rather than forming a *complementary* strand. Many candidates seemed to have little idea of the sequence of events.
- (c) **Part (i)** also suffered from inadequate descriptions. Few candidates specified that it was the 2°, 3° or 4° structure that was being disrupted. Many just wrote "denatured", which was not sufficient for the mark. **Part (ii)** was answered better.
- (d) Most candidates were able to give good descriptions of the exothermic hydrolysis of ATP, but quite a few did not explain how the ATP was produced.

Question 9

- (a) This part was poorly answered. Quite a number scored the first mark, but very few mentioned radio frequency, and the descriptions of splitting and/or chemical shift were usually absent. A surprisingly large number seemed to confuse NMR with MS.
- (b) The first mark was scored by most, but many seemed to be convinced that the use of X-rays was an invasive technique whereas NMR was not. The idea of *tuning* the NMR frequency to identify different tissues was not well known.
- (c) Many candidates scored the first mark, but the interpretation of the NMR spectrum was not well done. Too many candidates simply looked up chemical shift values from the *Data Booklet* without using the integration values or splitting patterns from the spectrum.

Question 10

There was evidence that a small proportion of candidates ran out of time giving patchy or no answers to this question.

- (a) This part was fairly well answered, although several candidates incorrectly used Fe^{2+} instead of Fe(s) as the reducing agent.
- (b) and (c) These “application” parts were surprisingly poorly done. Reference was often made to economics with no detail in **part (b)** and candidates referred to the dangers of letting bacteria loose in the environment in **part (c)**. Candidates clearly know of the ubiquitous nature of bacteria, but they seem to think that all bacteria are pathogenic.
- (d) This part was generally better done, but only a minority of candidates managed to get **part (i)** right. Very few scored a mark in **part (ii)** and the main reason for dropped marks was failure to read the question carefully enough.
- (e) This was surprisingly poorly answered. Some candidates knew that aluminium ores were not likely to be sulphides, but most who scored here did so for stating that aluminium was too reactive.
- (f) Only a small proportion of candidates were able to make a suitable suggestion here. Some knew about “bioremediation” whilst others described “precipitation methods”.

CHEMISTRY

Paper 9701/05

Planning, Analysis and Evaluation

General comments

This was the first of the new format A2 practical skills papers set in an October/November examination session. As in June 2007, many candidates had been well prepared for the examination but many others lacked the basic skills of graph plotting, drawing tangents, calculating gradients and evaluating the graphical evidence. The skills required in planning an experimental method remain a weakness for many candidates. Examiners would emphasise that such skills can only be adequately developed by practice in planning and implementing experiments in the laboratory.

Comments on specific questions

Question 1

In preparation for the planning exercise in this paper candidates should have practice at preparing instructions for the conduct of an experiment, such as might be issued on an experiment sheet – specifying the chemicals to be used, the apparatus (including its capacity), and masses/volumes/concentrations to be prepared and used. Candidates needed to read carefully the information provided at the beginning of the question. It was found that many candidates did not use all of the information provided or ignored instructions in the rubric of the question.

- (a) “By considering trends in the size and charge of the ions, predict the likely trend in ΔH_{soln} from LiOH to CsOH”.
- The Examiners expected reference to the increasing ionic radius of the cation and to the constant charge on Group I cations, leading to a prediction that ΔH_{soln} would decrease in magnitude from LiOH to CsOH. A large number of candidates correctly described the trend in ionic radius (although some incorrectly referred to atomic radius) but omitted any reference to ionic charge (or referred to increasing nuclear charge). The prediction was often omitted. The trend shown in the sketch was marked consequentially to the prediction. Where no prediction was given the Examiners expected to see decreasing magnitude for ΔH_{soln} from LiOH to CsOH.
- (b) It was encouraging to note that many candidates were familiar with the terms independent and dependent variables. The Examiners accepted the metal hydroxide used or the mass of metal hydroxide used as the independent variable. A common error throughout this question for some candidates was to refer to metals rather than metal hydroxides. Temperature rise, heat/energy produced or ΔH_{soln} were accepted as dependent variables. Temperature was often given as the dependent variable rather than temperature rise. The volume or mass of water used was the expected answer for the other variable to be controlled.
- (c) Most candidates were able to draw apparatus in which the solid hydroxide was mixed with water and the temperature change measured. Two sources of error eluded many candidates; one acceptable source was common although the way of minimising its effect was less well answered. The Examiners expected to see heat loss to the surroundings as one source of error. Many candidates who gave this as their answer had drawn diagrams in which the heat loss was already minimised and were unable to add further ways of improving the apparatus. The second expected source of error, from the information given in the question, was the absorption of water vapour from the air. The Examiners were looking for weighing the hydroxide in a sealed container and minimising contact with air. Many answers involved a vacuum or storing the hydroxide under oil (the metal confusion again?).

- (d) Many candidates knew or noted from the first sentence of the question that Group I hydroxides are highly corrosive. The wearing of gloves was accepted as a suitable way to minimise risk. The use of eye-protection was not credited as the Examiners consider the use of eye-protection to be a normal requirement of practical work.
Some candidates commented on the highly exothermic reaction between the metal hydroxides and water with the risk of material spraying out of the apparatus or boiling over. One mark was given to these candidates for two of the following precautions - eye-protection, gloves, laboratory coats.
- (e) A section of the question that produced some very weak answers. Too many candidates were vague in their answers – weigh a sample; measure some water; measure the temperature rise. A set of instructions (in the form of bullet points) for the conduct of the experiment would have been ideal.
The Examiners expected to see the following.
a named hydroxide being used
at least two weighings described and the mass to be used falling in the range of 0.05 to 0.25 mol for the selected hydroxide
between 50 cm³ and 200 cm³ of water measured – and the apparatus used for measuring the volume of water stated
initial and highest temperatures measured
Few candidates adequately described the weighings and measurement of water volume.
- (f) The Examiners expected to see a table containing columns for the different hydroxides, two weighings and two temperature measurements. Candidates who had been penalised in (e) for lack of weighings or temperature measurements were not penalised again if the table contained a column for the mass of solid used or the temperature rise.
- (g) Most candidates gave the correct expression for calculating the heat energy produced in the experiment. A small number of candidates used the mass of solid or combined mass of (solid + water) instead of the mass of water in the calculation. Comparatively few candidates continued the calculation to calculate the molar change.

Question 2

It was disappointing to note that many candidates were unable to process simple experimental results – many of the basic skills in dealing with graphical information were missing.

- (a) Most candidates were able to plot the volume of hydrogen on the y-axis against time on the x-axis. A few candidates gave the unit of time as seconds rather than minutes. Attention is drawn to the section of the practical syllabus, which deals with the recording of units, what is acceptable and what is not acceptable. The Examiners used this information when marking graphs and tables. Some candidates persist in joining all points. Each of the volumes of gas recorded at 5 minutes and at 7.5 minutes were intentionally low and it was hoped that candidates would draw a smooth curve passing by these points.
Continuation of the curve back from 0.5 minutes would have produced an intersection on the y-axis. Many candidates chose to “bend” their curve to 0,0.
- (b) Most candidates identified the anomalous points referred to above but few, even those who had noted that the volumes were lower than expected, were able to suggest either of the acceptable explanations – a “sticking” syringe or the reading taken too early.
Parallax error, reaction slowing down, human error or impurities in the magnesium were frequently seen as explanations. Loss of gas before the bung was put in was often given as the reason – as though each reading represented a separate experiment. It would be a worthwhile exercise to discuss what would happen to the curve if gas was lost at a particular point in the experiment – to encourage candidates to evaluate given data.
- (c) The initial rate of reaction was constant between 0.5 and 2 minutes. The Examiners accepted a straight line drawn through these four points or an attempt at an initial tangent at t=0 minutes where a more curved initial line had been drawn.
Many candidates drew tangents at odd places on the graph. The mark for calculating the gradient was given consequentially if points were correctly read from any tangent and used in a correct expression for the gradient.

- (d) The majority of candidates did not take notice of the sequence of events at the start of the experiment as described in the question. The magnesium was dropped into the acid in the flask. The flask was then stoppered and finally the stop-clock was started. Gas was being collected in the syringe before the clock was started, hence the intercept on the y-axis at $t=0$ minutes. Common answers given described no reaction on dropping the magnesium into the acid, a slow starting reaction or loss of gas before the stopper was inserted.
- (e) Loss of gas before the stopper was inserted was often described in this section without a suitable change to the method being suggested. The better candidates used a divided flask or other way of keeping the reactants apart within the sealed flask prior to mixing. Adding the acid from a tap-funnel was not acceptable.
- (f) Most candidates correctly calculated the relative concentration of the acid for each student. Some inevitably calculated incorrect values where the total volume was not 100 cm^3 . Incorrect values from this table were marked consequentially in following sections.
- (g) Most candidates were able to plot the initial rate against the relative concentration of the acid. Scales were often poorly chosen – the plotted points should cover at least half the length of each axis. Some candidates included units for relative concentration. More care should be taken with the placement of points on the graph. Examiners frequently see points plotted on a line when they are clearly between two lines and vice-versa.
- (h) Again a substantial number of candidates did not read the question, which asked if the prediction made by student 1 was consistent with the graph drawn. The points for students 2 to 8 were very close to a straight line. Where candidates had drawn a straight line through the first 4 points in (a) they obtained a further point which was also close to this straight line. Where the curve had been drawn to 0.0 and an initial tangent drawn (or a tangent constructed to any other point on the curve) an initial rate for student 1 was obtained that rarely fitted with the values from the other students. Many candidates commented on the experimental result for student 1 – not the 2nd order prediction that had been made.
The Examiners were looking (i) for some statement about the shape of the line drawn in (g) – straight line or curve and (ii) the relationship between relative concentration and initial rate shown by the graph drawn by the candidate. If a curve had been drawn the Examiners allowed a conclusion that the prediction was supported, as a 2nd order graph would be a curve. The majority of candidates drew straight lines but did not always comment on the significance of a straight line.
- (i) This section was marked consequentially. The emphasis was on the confidence placed in the plotted points. Candidates with one or more plotted points a long way from the straight line were at an advantage in highlighting these points.
Some candidates who had drawn straight lines through points very close to the best-fit line expressed a lack of confidence as the points were not actually on the line, indicating a lack of experience of such practical work. An appreciation of likely and acceptable experimental error should be included in any practice of analysis and evaluation.

CHEMISTRY

Paper 9701/31

Advanced Practical Skills 1

General comments

The Examiners thank Supervisors at Centres who supplied, as requested, experimental data for each session/laboratory and seating plans. If candidates are not to be disadvantaged it is important that every candidate can be linked, by the Examiner, to a particular session/laboratory and a corresponding set of Supervisor results. Regrettably a number of Centres continue to provide no Supervisor information. Examiners take steps to obtain the missing data through CIE but it is often unobtainable and candidates may be disadvantaged as a consequence. Some other Centres do provide Supervisor data for multiple sessions/laboratories but there is insufficient data to place candidates within each session and candidates may again be disadvantaged.

The Examiners anticipated that both AS and A2 candidates would be able to convert volumes and times into log values and this was the case for a large majority of candidates. Candidates who calculated $1/t_{\text{time}}$ as a representation of rate and volume as a representation of concentration rather than their log values were not penalised. Care was taken to ensure that no candidate was disadvantaged however they approached this question.

Every mark on the paper was awarded but a few marks were not awarded very often.

There was some evidence from the scripts of incomplete sections. This may have been due to a pressure of time but it was noted that many candidates who completed all sections of the paper also gave comprehensive answers and performed more than the minimum experiments required in **Question 1**.

Comments on specific questions

Question 1

This question differed from that set in the June 2007 Paper 31 in having no titration but an extended physical chemistry experiment involving some decision making as to the number of experiments to be performed and the display of results in a graphical form.

- (a) Both marks in this section were marks for the collection of data. The first mark was for simply performing each of the first two experiments and recording a time for that experiment. The second mark was for following instructions – candidates were assumed to have followed the written instructions if, for experiment 2, they recorded a time within 20% of the time recorded by the Supervisor for the same experiment. Most candidates were awarded both of these marks.
- (b) In this section the candidates had to include in a table the results from the previous page and make decisions as to how many additional experiments were required and the quantities to be used in those experiments.
Marks were awarded for the following.
- (i) All experimental data, including that for experiments 1 and 2, included in a single table. A mark awarded to the majority of candidates.
- (ii) The table of results drawn up in advance of carrying out the experiment. This is the second of the bullet points in the presentation of data and observations section of the practical syllabus. The criterion used to judge this point was to look for a sequential listing of volume of **FA 1** in the table, e.g, (50,40,30,20,10 cm³). The results of experiments 1 and 2, transferred from the previous page could be at the beginning or end of the table or in the sequence of volumes as shown above. This mark was also commonly awarded.

- (iii) The inclusion in the table of columns for volume of **FA 1** or $\log(\text{volume of FA 1})$; $1/t_{\text{time}}$ or $\log(1/t_{\text{time}})$ and time. Most candidates included these columns but a few candidates omitted time – going straight to $1/t_{\text{time}}$ or $\log(1/t_{\text{time}})$. When assessing “accuracy” for points (viii) and (ix) the Examiners calculated the experimental time associated with the recorded values for this small number of candidates.
- (iv) All columns, excluding log columns, were inspected for correct headings and units. Attention is drawn to the practical section of the syllabus where acceptable and non-acceptable units are described. The mark for correct headings and units was based on this section of the syllabus. Centres should note that T or t should not be used as a heading for time as it can lead to confusion with temperature. A significant number of candidates gave incorrect units.
- (v) Candidates were instructed to record times for experiments to the nearest second. A significant number of candidates recorded the time to 0.01 s as shown on a stop-watch. Other candidates recorded all times in the form 15.0 s, 21.0 s etc. This represents a time recorded to 0.1 s and was not credited for this marking point.
- (vi) The first of the decision marks – awarded to candidates who did three (or more) additional experiments.
- (vii) The second decision mark – awarded if the chosen mixtures showed uniform spacing for the volume of **FA 1** used (e.g. 50,40,30,20,10 cm³, or 50,37,24,10 cm³). Most candidates were awarded this mark if the mark for (vi) had also been awarded.
- (viii) and (ix). The Examiners calculated (volume of **FA 1** x time) for experiment 1 and the two experiments using the next largest volumes of **FA 1**. The difference between the closest pair of these three values was expressed as a % of the higher value of that pair. Both marks were awarded for a difference up to 10% and one of these two marks for a difference greater than 10% but within 20%. Most candidates scored both marks and nearly all candidates scored at least one mark.
- (x) and (xi) The Examiners calculated the difference between the time for experiment 1 on page 3 and the time obtained by the Supervisor for the same experiment. Both marks were awarded for a difference within 10%, one mark for 10+ to 20% as above.
- (c) The first mark for the graph was given for plotting $\log(1/t_{\text{time}})$ or $1/t_{\text{time}}$ on the y axis against $\log(\text{volume of FA 1})$ or volume of **FA 1** on the x axis. The Examiners were concerned with numerical values and ignored omission of the –ve sign for $\log(1/t_{\text{time}})$ or the plotting of negative numbers in a positive direction.
 Many candidates made a poor selection of scales. Starting each scale at zero resulted in the bunching of the plotted points in a small area of the graph paper. The Examiners expected to see points plotted over at least half the length of each axis. Scales should always be easy to use and not involve the use of a calculator to determine the number of “small” squares when placing a point on the graph.
 The Examiners expected to see, and checked, the point plotted for each of the experiments performed. Points were accepted if within ½ of a small square in either direction of the point determined by the Examiner but it was often observed that points, which should have been exactly plotted on a line of the grid were between lines and vice versa. Greater care is needed in placing points on a graph – many candidates sacrificed this mark.

- (d) Many candidates failed to draw any construction lines on their graph. Other candidates drew very small triangles. The Examiners expected to see construction lines to two points on the graph that represented a triangle whose hypotenuse extended for more than 50% of the length of the straight line drawn on the graph.
Co-ordinates of two points on the line were often misread (particularly where a difficult scale had been selected) or by many candidates taken from the table – i.e. the plotted values (even if the straight line did not pass through these points).
The Examiners would encourage the selection of two points on the line that are **not** plotted points – emphasising the reason for plotting the graph from the experimental data.
Most candidates were able to calculate a gradient from the data obtained although a few candidates inverted the ratio. The final mark in this section was for calculation of the gradient to at least 1 decimal place. No marks were awarded for deducing the order of reaction.
- (e) Few candidates read this question and understood the error that was being considered. They were told that the uncertainty in experiment 2 was greater than that in experiment 1 but a considerable number of candidates gave answers that supported the opposite. The question was about judging the point at which the printed material became obscured – Examiners were looking for answers that said the printed material disappeared rapidly in experiment 1 but was gradually obscured in experiment 2 making it difficult to judge the precise moment when the printing just disappeared.
The estimate of uncertainty for each experiment was answered incorrectly by the majority of candidates who often recorded an uncertainty related to the timing apparatus, e.g. 0.005 s, for each experiment. The Examiners were looking for an estimate of 1-3 seconds for experiment 1 and an estimate larger than that for experiment 1 and between 3-10 seconds for experiment 2.
Incorrect answers for uncertainty were carried forward into the calculation of % error and this mark was awarded to many candidates.
- (f) This section was often left blank but it was not clear if this was a time constraint or an inability to complete the table. The mixtures for experiments (i) and (ii) needed a total volume of 55 cm³ and a constant volume of **FA 1**. Many candidates failed to meet these two conditions and were not awarded the mark in this section. The experiments did not have to be performed to gain this mark.
- (g) If the mark had been awarded in (f) and the experiments performed, one mark was available for any comment that fitted the observed results for all three experiments. It was expected that increasing acid concentration would produce a slight increase in the rate of reaction. Many candidates observed this slight increase in rate and decided that the reaction was first order with respect to acid concentration or decided that it was zero order when times for reaction had been steadily decreasing as the acid concentration increased.

Question 2

The Examiners were very disappointed with the general response to this question which is more demanding than the familiar form of carrying out the tests described and recording the observation made. The selection of appropriate reagents can be expected to feature in future questions. The number of reagents and ions listed in the Qualitative Analysis Notes is relatively small and candidates should be familiar with all of these reagents and reactions.

- (a) The Examiners were looking for a single reagent to identify the solution containing nitrite ions. Any named acid would have been suitable. Many candidates selected sodium hydroxide and aluminium metal – not a single reagent and a combination that would not have separated nitrite and nitrate ions.
- (b) To identify the sulphite and sulphate ions the Examiners expected to see barium chloride (or nitrate) and a named strong acid other than sulphuric acid. Many candidates had not thought through the consequences of adding sulphuric acid after adding the barium salt and many still claimed that one of the two white precipitates formed with the barium ion was soluble in the sulphuric acid. Candidates should appreciate that a reagent is a chemical available in a bottle; e.g. barium nitrate, barium chloride, sulphuric acid, nitric acid; and not a single ion such as Ba²⁺. In this paper Examiners did accept Ba²⁺(aq) or a solution containing Ba²⁺ as a reagent but this is no guarantee that such “reagents” will be accepted in the future.

One observation mark was given for any reference to a brown gas formed between **FA 4** and an acid. The deduction of **FA 4** containing the nitrite was given from this observation or from effervescence with an acid.

Where sulphuric acid was added after barium chloride (or nitrate) the only mark available for observation or deduction was for a white precipitate with barium chloride (or nitrate) for each of **FA 3** and **FA 6**.

Candidates who used the correct reagents but obtained reversed observations for **FA 3** and **FA 6** were awarded no observation marks but subsequent deduction marks (error carried forward).

- (c) The specified tests in this section should have been quick and easy to perform – results being obtained almost immediately. A great deal of time should not have been spent on each separate test.

Many candidates missed the observation mark in (i) as they failed to state that it was the gas formed that turned red litmus blue – the solution contained an alkali. Some candidates reported a gas turning litmus blue in more than one test with sodium hydroxide, a contradictory observation. A significant number of candidates wasted time by heating the solution in (i) when a precipitate had formed with sodium hydroxide.

In (iv) many candidates reported the white precipitate with sodium sulphite but stated that it was insoluble in hydrochloric acid.

As has been found previously, there was very poor reporting of observations when sodium hydroxide and when ammonia solution were added to a solution containing the manganese(II) ion, **FA 6**. Many candidates failed to see the initial off-white precipitate or failed to record the solubility/insolubility in excess of the reagent. Many candidate recorded brown precipitates at this stage.

- (d) Deductions and supporting evidence were marked consequentially from the observations. A brown precipitate when sodium hydroxide or aqueous ammonia was added to **FA 6** allowed a deduction of Fe^{3+} as the cation present.

In general the criteria for supporting evidence was set lower than that for the observation mark. The observation mark for **FA 6** needed an off-white precipitate insoluble in excess reagent for sodium hydroxide and for aqueous ammonia. The insolubility in excess of each reagent was not required for the supporting evidence.

Some candidates identified anions in this section rather than the required cations.

- (e) Fewer than half of the candidates were able to suggest a soluble metal chromate (or dichromate) or chromate/dichromate (Stock notation not required) as the suitable reagent.

CHEMISTRY

Paper 9701/32

Advanced Practical Skills 2

General comments

The Examiners thank Supervisors at Centres who supplied, as requested, experimental data for each session/laboratory and seating plans. If candidates are not to be disadvantaged it is important that every candidate can be linked, by the Examiner, to a particular session/laboratory and a corresponding set of Supervisor results. Regrettably a number of Centres continue to provide no Supervisor information. Examiners take steps to obtain the missing data through CIE but it is often unobtainable and candidates may be disadvantaged as a consequence. Some other Centres do provide Supervisor data for multiple sessions/laboratories but there is insufficient data to place candidates within each session and candidates may again be disadvantaged.

The Examiners anticipated that both AS and A2 candidates would be able to convert volumes and times into log values and this was the case for a large majority of candidates. Candidates who calculated $1/t_{\text{time}}$ as a representation of rate and volume as a representation of concentration rather than their log values were not penalised. Care was taken to ensure that no candidate was disadvantaged however they approached this question.

Every mark on the paper was awarded but a few marks were not awarded very often.

There was some evidence from the scripts of incomplete sections. This may have been due to a pressure of time but it was noted that many candidates who completed all sections of the paper also gave comprehensive answers and performed more than the minimum experiments required in **Question 1**.

Comments on specific questions

Question 1

This question differed from that set in the June 2007 Paper 32 in having no titration but an extended physical chemistry experiment involving some decision making as to the number of experiments to be performed and the display of results in a graphical form.

- (a) Both marks in this section were marks for the collection of data. The first mark was for simply performing each of the first two experiments and recording a time for that experiment. The second mark was for following instructions – candidates were assumed to have followed the written instructions if, for experiment 2, they recorded a time within 20% of the time recorded by the Supervisor for the same experiment. Most candidates were awarded both of these marks.
- (b) In this section the candidates had to include in a table the results from the previous page and make decisions as to how many additional experiments were required and the quantities to be used in those experiments. Marks were awarded for the following.
- (i) All experimental data, including that for experiments 1 and 2, included in a single table. A mark awarded to the majority of candidates.
- (ii) The table of results drawn up in advance of carrying out the experiment. This is the second of the bullet points in the presentation of data and observations section of the practical syllabus. The criterion used to judge this point was to look for a sequential listing of volume of **FA 1** in the table, e.g, (20,15,10,5 cm³). The results of experiments 1 and 2, transferred from the previous page could be at the beginning or end of the table or in the sequence of volumes as shown above. This mark was also commonly awarded.

- (iii) The inclusion in the table of columns for volume of **FB 4** or $\log(\text{volume of FB 4})$; $1/t_{\text{time}}$ or $\log(1/t_{\text{time}})$ and time. Most candidates included these columns but a few candidates omitted time – going straight to $1/t_{\text{time}}$ or $\log(1/t_{\text{time}})$. When assessing “accuracy” for points (viii) and (ix) the Examiners calculated the experimental time associated with the recorded values for this small number of candidates.
- (iv) All columns, excluding log columns, were inspected for correct headings and units. Attention is drawn to the practical section of the syllabus where acceptable and non-acceptable units are described. The mark for correct headings and units was based on this section of the syllabus. Centres should note that T or t should not be used as a heading for time as it can lead to confusion with temperature. A significant number of candidates gave incorrect units.
- (v) Candidates were instructed to record times for experiments to the nearest second. A significant number of candidates recorded the time to 0.01 s as shown on a stop-watch. Other candidates recorded all times in the form 15.0 s, 21.0 s etc. This represents a time recorded to 0.1 s and was not credited for this marking point.
- (vi) The first of the decision marks – awarded to candidates who did three (or more) additional experiments.
- (vii) The second decision mark – awarded if the chosen mixtures showed uniform spacing for the volume of **FB 4** used (e.g. 20,16.25,12.5,8.75,5 cm³, or 20,15,10,5 cm³). Most candidates were awarded this mark if the mark for (vi) had also been awarded.
- (viii) and (ix). The Examiners calculated (volume of **FB 4** x time) for experiment 1 and the two experiments using the next largest volumes of **FB 4**. The difference between the closest pair of these three values was expressed as a % of the higher value of that pair. Both marks were awarded for a difference up to 10% and one of these two marks for a difference greater than 10% but within 20%. Most candidates scored both marks and nearly all candidates scored at least one mark.
- (x) and (xi) The Examiners calculated the difference between the time for experiment 1 on page 3 and the time obtained by the Supervisor for the same experiment. Both marks were awarded for a difference within 10%, one mark for 10+ to 20% as above.
- (c) The first mark for the graph was given for plotting $\log(1/t_{\text{time}})$ or $1/t_{\text{time}}$ on the y axis against $\log(\text{volume of FB 4})$ or volume of **FB 4** on the x axis. The Examiners were concerned with numerical values and ignored omission of the –ve sign for $\log(1/t_{\text{time}})$ or the plotting of negative numbers in a positive direction.
 Many candidates made a poor selection of scales. Starting each scale at zero resulted in the bunching of the plotted points in a small area of the graph paper. The Examiners expected to see points plotted over at least half the length of each axis. Scales should always be easy to use and not involve the use of a calculator to determine the number of “small” squares when placing a point on the graph.
 The Examiners expected to see, and checked, the point plotted for each of the experiments performed. Points were accepted if within ½ of a small square in either direction of the point determined by the Examiner but it was often observed that points, which should have been exactly plotted on a line of the grid were between lines and vice versa. Greater care is needed in placing points on a graph – many candidates sacrificed this mark.
- (d) Many candidates failed to draw any construction lines on their graph. Other candidates drew very small triangles. The Examiners expected to see construction lines to two points on the graph that represented a triangle whose hypotenuse extended for more than 50% of the length of the straight line drawn on the graph.
 Co-ordinates of two points on the line were often misread (particularly where a difficult scale had been selected) or by many candidates taken from the table – i.e. the plotted values (even if the straight line did not pass through these points).

The Examiners would encourage the selection of two points on the line that are **not** plotted points – emphasising the reason for plotting the graph from the experimental data.

Most candidates were able to calculate a gradient from the data obtained although a few candidates inverted the ratio. The final mark in this section was for calculation of the gradient to at least 1 decimal place. No marks were awarded for deducing order of reaction.

- (e) The Examiners were very surprised by the number of candidates who were unable to state that the error in reading a volume of 20 cm^3 in a 25 cm^3 measuring cylinder was 0.25 cm^3 (half of the smallest scale division). There is a single reading of the volume of liquid in a measuring cylinder. An error in this measurement could be carried forward into the table without penalty for the next mark but the majority of candidates gave a different value in the table. The Examiners checked the calculated % error for each error in the table. Many candidates ignored their calculated % error and stated that a measuring cylinder gave the most significant source of error in the experiment when the calculated % error showed clearly that a burette measuring 1.00 cm^3 of **FB 3** gave the most significant error. Some candidates recognised the significance of their calculated % errors but merely stated that the burette gave the most significant error without linking it to the measurement of a small volume of **FB 3**. The final mark in this section was marked consequentially to the calculated % errors.
- (f) This section was often left blank but it was not clear if this was a time constraint or an inability to complete the table. The mixtures for experiments (i) and (ii) needed a combined volume of 40 cm^3 of **FB 2** and water. The volume of **FB 2** needed to be less than 20 cm^3 in each of experiments (i) and (ii) as candidates had been asked to investigate the effect of **reducing** the concentration of iodide ions. Many candidates failed to meet these two conditions and were not awarded the mark in this section. The experiments did not have to be performed to gain this mark.
- (g) If the mark had been awarded in (f) and the experiments performed, one mark was available for any comment that fitted the observed results for all three experiments. It was expected that decreasing the concentration of iodide ions would decrease the rate of reaction.

Question 2

The Examiners were very disappointed with the general response to this question which is more demanding than the familiar form of carrying out the tests described and recording the observation made. The selection of appropriate reagents can be expected to be a permanent feature of future questions. The number of reagents and ions listed in the Qualitative Analysis Notes is relatively small and candidates should be familiar with all of these reagents and reactions. The inclusion of an organic unknown clearly caused problems for many candidates.

- (a) The Examiners were looking for a pair of reagents to identify which solution contained the sulphate ions. The expected pair of reagents was barium chloride (or nitrate) followed by a strong acid other than sulphuric acid. The Examiners also accepted silver nitrate followed by aqueous ammonia to identify the two solutions containing a chloride and hence the sulphate by elimination. Candidates who selected these reagents generally scored 2 or 3 marks in this section. Many candidates selected a soluble barium salt and a soluble lead(II) salt. This was an inappropriate choice as lead(II) salts give white precipitates with sulphates and chlorides. The conclusion of **FB 5** containing the sulphate was allowed from a white precipitate with Ba^{2+} .
- (b) This section suffered from extremely poor reporting of precipitate colours and the solubility/insolubility of any precipitate formed in an excess of sodium hydroxide or aqueous ammonia. Many candidates missed the formation of precipitates on first addition of the reagent – presumably adding too much reagent at the start of the test. Few candidates scored either observation mark in this section. One mark was given for correct observations when the reagents were not in excess and one mark for correct observations when the reagents were in excess.

Candidates lost marks for reporting blue precipitates instead of green precipitates with the nickel(II) ions in **FB 5**.

The initial precipitates formed when aqueous ammonia reacts with copper(II) and with nickel(II) ions were often missed.

Chromium(III) ions produced the poor reporting seen previously – precipitates are not green but grey-green (as described in the Qualitative Analysis Notes).

Despite the poor reporting in the first part of **(b)** many candidates had sufficient observations in the table pointing in the correct direction to allow marks to be given for correctly identifying Cu^{2+} in **FB 6** and Cr^{3+} in **FB 7**.

The criteria for supporting evidence were less demanding than those for the observation marks.

Copper(II) was allowed from blue precipitates with each reagent or from the dark blue solution formed with excess aqueous ammonia.

Chromium(III) was allowed from grey-green precipitates with each reagent or from a dark green solution with excess sodium hydroxide.

(c) In part **(i)** very many candidates reported effervescence when magnesium was dropped into a warm solution of **FB 8** in water. Of these, few candidates tested the gas formed – despite the rubric immediately above the table. Had hydrogen been identified, the acidic nature of **FB 8** would have been established in this first test.

The Examiners were surprised that this elementary test and its significance were missed.

In part **(ii)** many candidates did observe the insolubility of **FB 8** in dilute acid and its subsequent solubility in aqueous sodium hydroxide. (Evidence of a weak organic acid).

The Examiners anticipated that the test involving addition of **FB 8** to ethanol and a few drops of concentrated sulphuric acid followed by heating and pouring the product into cold water would have indicated the likely formation of an ester.

Very few candidates recorded any smell – were their mixtures insufficiently heated? Those candidates who did notice a distinctive smell recorded it as sweet or fruity. The ester formed in this reaction should have had a smell reminiscent of liniment, of antiseptic or of hospitals.

Very few candidates scored well in this section.

Three marks were available for conclusions as to the type of compound present in **FB 8**.

- It was an acid or formed an acidic solution.
- It was an organic acid.
- Reference to one piece of supporting evidence for the conclusion of an organic acid, such as ester formation (allowed from sweet or fruity smell). Some candidates concluded incorrectly that **FB 8** was an ester.