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FOREWORD

This booklet contains reports written by Examiners on the work of candidates in certain papers. **Its contents are primarily for the information of the subject teachers concerned.**

CHEMISTRY

GCE Advanced Level and GCE Advanced Subsidiary Level

Paper 9701/01
Paper 1 - Multiple Choice

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

General comments

For this Paper, the mean score was 21.1 (52.7%), well below the targeted value of 60%, and the standard deviation of the scores was 7.12 (17.8%). In this respect the Paper has performed in a manner very similar to that of the corresponding Paper last year.

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

Comments on specific questions

Only five questions had statistics outside of the intended design limits.

Two had a high facility:

Question 7

Silicon(IV) oxide is readily recognised as having a giant covalent lattice.

Question 22

The initiation step of the free-radical chlorination of ethane is known to involve a homolytic fission of the $\text{C}-\text{Cl}$ bond.

Three questions led to a higher proportion of the more able candidates choosing a distractor rather than the key.

Question 19

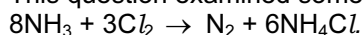
The responses indicated an uncertainty about the proportions of the constituents of vehicular exhaust gases – CO_2 , CO and N_2 – and a small proportion (9%), including some of the more able candidates, thought that H_2O vapour would be the major constituent, yet a consideration of the constituents of air and the sources of oxygen and nitrogen should have quickly eliminated the incorrect answers.

Question 25

This question was concerned with safe replacements for the CFCs that destroy the ozone layer. Only 13% of candidates chose the correct answer, butane, which is now widely used in aerosol propellants. Some 23% thought CHBr_3 would be satisfactory, apparently forgetting that the $\text{C}-\text{Br}$ bond is more readily broken than the $\text{C}-\text{Cl}$ bond, and that both halogen free radicals are capable of initiating the chain reaction that destroys ozone.

Question 36

This question examined some of the implications of the reaction between ammonia and chlorine:



It should be obvious that during this reaction an initial step is the generation of HCl , but 17% of candidates did not regard ammonia as behaving as a base in the formation of ammonium chloride.

Paper 9701/02

Theory 1

General comments

The standard of many of the candidates who took this Paper was commendably high but there were fewer candidates who scored very high marks. As in previous years, there were very few candidates who scored very low marks.

The majority of candidates followed specific instructions - such as that in **Question 1 (d)(i)** to draw a dotted line on a graph and label it $+\delta T$ -very carefully. There was, however, a significant number who did not do so and were penalised as a result.

There was also a significant number of candidates whose handwriting caused Examiners considerable problems. In extreme cases, illegible answers cannot be given any credit.

Comments on specific questions**Question 1**

- (a) Most candidates were able to draw the Boltzmann distribution curve but a surprising number were unable to state the units correctly. A significant number of candidates confused this diagram with a reaction pathway diagram and were penalised.
- (b) Many candidates struggled with this part. Examiners were expecting answers that either referred to the fact that the curve is not a normal distribution or explained that not all molecules have the same energy with the different energy values being distributed about a mean.

- (c) The majority of candidates answered both parts very well. Some candidates however, did not clearly show a definite line to represent activation energy, referring instead to an area below the curve.
- (d) This was generally well answered. The majority of candidates knew that at the higher temperature the peak of the curve is lower than and to the right of the original peak. Most candidates explained clearly that at the higher temperature, more molecules have energy greater than the activation energy and that there are more successful collisions as a result.

Question 2

- (a) This was generally very well answered. The most common error was to omit an equation in part (ii) - although one was specifically asked for in the question.
- (b) This too was well answered by the majority of candidates. A small number omitted to include (H₂O) in their expression for K_c . This was penalised because in this reaction, water is a product and not the solvent. It is therefore not present in great excess.
- (c) While there were many completely correct answers to this part, there was a significant number of candidates who were unable to deduce the correct numbers of moles present initially and at equilibrium. These are as follows:

	CH ₃ CO ₂ H	C ₂ H ₅ OH	CH ₃ CO ₂ C ₂ H ₅	H ₂ O
initially	0.10	0.13	0.05	0.00
at equilibrium	0.04	0.07	0.11	0.06

This gave the answer to part (c)(ii) as 2.36.

Most candidates were able to explain that units cancel in the K_c expression. Candidates who had omitted (H₂O) in their K_c expression should have realised their error at this stage.

Question 3

- (a) The vast majority of candidates answered this part correctly.
- (b) This too was generally well answered by most candidates.
- (c) This part was less well answered. A surprising number of candidates did not know what was formed in the reactions or were unable to balance the equations.
- (d) The first two parts were generally well done. The answers were as follows.
- (i) $2\text{Sb}_2\text{S}_3 + 9\text{O}_2 \rightarrow \text{Sb}_4\text{O}_6 + 6\text{SO}_2$.
- (ii) +3.

Many candidates found the calculation in part (iii) difficult. By linking the two equations given on the Question Paper it is possible to state that:

10 mol of Sb₂S₃ will produce 15 mol of CO₂ when reduced with carbon.

This means that the final volume will be $15 \times 24 = 360 \text{ dm}^3$.

Common errors were

- to fail to realise that 1 mol of Sb₄O₆ comes from 2 mol of Sb₂S₃;
- to use 22.4 dm³ rather than 24 dm³;
- to quote wrong units such as dm³ mol⁻¹.

Question 4

- (a) This was generally well answered although some candidates had difficulty in balancing their equation.
- (b) Knowledge of the Haber process is a clearly stated part of the syllabus which is often examined. This question went over the familiar material in a slightly different way and a surprising number of candidates struggled with it.

In part (i), Examiners expected the equation to be shown as an equilibrium.

In part (ii), what was expected was a diagram showing nitrogen and hydrogen passing through a reactor to produce a mixture of N_2 , H_2 , and NH_3 . This mixture would then pass through a heat exchanger - the reaction is exothermic - and then a condenser where any NH_3 formed would be cooled to a liquid. Finally, the unreacted gases would be passed back into the reactor. Examiners were simply looking for diagrammatic statements that showed these key processes but many candidates failed to identify them.

- (c) This was not well answered. The key word in the question is 'explain'. Many candidates made statements about the need for high pressure without explaining clearly that there are fewer moles of gas on the right hand side of the equilibrium than on the left hand side.
- (d) Many candidates struggled with this equation. A surprising number did not know the correct formula for nitric acid.
- (e) There were many correct answers to this part. The most common error was to omit to double the given value of ΔH_f^\ominus for $NH_3(aq)$.

The correct answer is $+31 \text{ kJ mol}^{-1}$.

Question 5

This was generally very well done with most candidates scoring high marks. The most common error was to state that acidified dichromate(VI) would oxidise an alkene.

Question 6

- (a) Although many candidates answered this correctly, there was a surprising number who gave either pentan-1-ol or a secondary alcohol as their answer.
- (b) Again many candidates answered this correctly but there were also many who struggled, particularly with part (ii). The most common error was for candidates to use the equation to determine how much alcohol is required for 100% yield and then to reduce this to 60% of its original value rather than multiplying it by $\frac{100}{60}$.

The correct answer is 14.57 g.

- (c) This was not well answered. Examiners were looking for evidence of a σ bond by orbital overlap and also the two portions of a π bond.
- (d) While most candidates knew the reagents fewer knew the correct conditions. In part (i), the alcohol must be heated under reflux with the oxidising agent. In part (ii), the alcohol must be esterified by heating it with ethanoic acid and concentrated sulphuric acid.

Paper 9701/03

Practical Test

General comments

The Examiners thank Supervisors who provided a full set of experimental results for **Question 1**. The dehydration of magnesium sulphate-7-water is a well tried experiment capable of providing very good and consistent results. Supervisor's results were used to check that pure magnesium sulphate had been available for the examination.

The majority of candidates were able to complete the Paper in the time allowed and there was no evidence of rushed answers to the latter sections of **Question 2**.

Comments on specific questions**Question 1**

Candidates were asked to *accurately weigh* the tube and its contents. It was pleasing to see that few candidates weighed to less than 2 decimal place accuracy and the majority used a mass of crystals between 2.00 g and 2.50 g as requested in the Paper.

- (c) Candidates were asked to show clearly by their results in Table 1.2 that all the water of crystallisation had been driven from the crystals. The Examiners were looking for evidence of any re-heating and re-weighing in Table 1.2 and also for two weighings within 0.05 g to show that all of the water had been driven off. Both of these points were awarded marks. Unfortunately many candidates did not perform any re-heating and consequently did not succeed in driving off all of the water. Some candidates did perform the extra heating and weighing and had a constant mass recorded in Table 1.2 but still had not driven off all of the water of crystallisation. It is possible that their heating was too cautious because of the warning in the question not to overheat the crystals.

Examiners checked and corrected all subtractions in the weighing tables before assessing the accuracy with which the experiment had been performed. Accuracy marks were awarded by comparing the value of $\frac{\text{mass lost on heating}}{\text{mass remaining after heating}}$ with the theoretical value of 1.05 obtained

from the formula $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$. Six marks were awarded for values within 0.03 of the theoretical value reducing by a sliding scale to 1 mark for values within 0.15 of 1.05.

Calculations

- (d) Most candidates correctly calculated the mass of anhydrous XSO_4 in (i) - a few recorded the initial mass of crystals at this point.
- (ii) The mass of water driven from the crystals was correctly calculated by the majority of candidates. If the mass of **FA 1** after heating had been incorrectly calculated in Table 1.2 an "error carried forward" was applied here and no further penalty applied.
- (e) The majority of candidates correctly divided the mass of water driven off by 18, the relative molecular mass of water. A significant number of candidates however divided by (7×18) at this point.
- (f) The answer to (e) was correctly divided by 7 in most cases - including those who had divided by (7×18) in (e).
- (g) This section, together with (h) was often left blank but most candidates were able to divide the mass of **FA 1** left after heating by their answer to (f).

(The answer for each section, whether correct or not, was used in subsequent sections so that candidates would only be penalised once for each mistake).

- (h) Those who obtained an answer to (g) were usually able to go on to subtract 96 to find the relative atomic mass of the element X. Some candidates, due to errors, obtained an answer to (g) that was less than 96 and decided that the relative atomic mass must be therefore be "96 - answer to (g)". It would have displayed better chemical understanding to show the answer as "(g) - 96" even if this gave a negative number (with the statement that there must be an error in some step).

A number of candidates included a unit of mass (g, g.mol^{-1}) in their answer(s) to (g)/(h). This was penalised once only.

Question 2

FA 2 contained the ions Mn^{2+} , Zn^{2+} , SO_4^{2-} and NO_3^- .

The Examiners would draw the attention of candidates to the rubric at the beginning of the observation/deduction question.

Deductions should be written alongside the observations on which they are based. Definite deductions may be made from tests where there appears to be no reaction.

The Qualitative Analysis notes should be used to consider *all* of the possible reactions that might occur when a particular reagent is used.

In many of the tests it was necessary to have a correct observation *and* deduction to obtain the mark for that test.

- (a) On adding sodium hydroxide an off-white precipitate should have been observed. This is the description of the manganese(II) hydroxide precipitate given in the notes. It does rapidly darken and the Examiners allowed a description of this precipitate as buff or light/pale brown. A white precipitate was not allowed. Manganese(II) or Mn^{2+} was the expected deduction for this precipitate.

On warming the tube the Examiners were expecting the candidates to test for ammonia gas, which should not have been detected - no ammonia evolved or no gas turning litmus paper blue - with the deduction of no ammonium salt.

- (b) Most candidates recorded a darkening of the precipitate in the filter paper.
- (c) Some manipulative skill was required in this test. If too much nitric acid was added at one time no precipitate was seen. The Examiners were expecting to see a white precipitate - $\text{Pb}(\text{OH})_2$, $\text{Zn}(\text{OH})_2$ or $\text{Al}(\text{OH})_3$ - which dissolved in excess of the acid. As this was a more difficult test only one of the ions needed to be quoted against the observation to gain the mark.
- (d) The majority of candidates correctly identified ammonia gas and deduced nitrate or nitrite in this test.
- (e) The Examiners were looking for a white precipitate, soluble in excess, when nitric acid was added to the filtrate. Only zinc ions could be present as lead and aluminium ions would not have been soluble in excess aqueous ammonia. This was a test in which many candidates did not keep their deductions alongside the appropriate observation.
- (f) Having deduced nitrate or nitrite in (d) the Examiners gave the opportunity in (f) (and in (g)) to eliminate or confirm nitrite. On adding acid in either test the Examiners were looking for "no brown gas" and a deduction of "no nitrite". Very few candidates gave this observation/deduction. Some did record "no reaction" on adding acid and eliminated nitrite along with carbonate and sulphite but the Examiners were looking for the specific elimination of nitrite.

The test for sulphate using barium chloride was generally successful.

- (g) The absence of nitrite was again missed but the majority of candidates were able to see no precipitate with silver nitrate and correctly deduce the absence of halides (not absence of halogens).

One mark was given in the Summary if all four ions had been correctly identified, providing there was observational evidence for the ions in the tests.

Paper 9701/04

Theory 2

General comments

This was the first winter session in which this new Advanced Level Paper has been set. Candidates seemed to have few problems either with the format of the Paper, or with the time allocated to it. Time should be even less of a problem next year, when $1\frac{1}{4}$ hours will be devoted to it (with no increase in the number of marks). Some candidates attempted to write at a greater length than space allowed. This practice should be discouraged, as it leads to illegibility and confusion in the answers.

The overall standard of answers was patchy – although many candidates scored in the 30s and 40s (and a good proportion even in the 50s), there seemed to be a larger proportion than usual scoring low marks of between 1 and 20.

Candidates are once again reminded of the need to include *all* atoms in an organic structural formula, as mentioned in the syllabus - carbon atoms with “bonds” sticking out of them are *not* taken to imply hydrogen atoms.

Comments on specific questions**Question 1**

This was a high-scoring question, with many candidates gaining full marks.

- (a) Either *voltmeter* or *potentiometer* were acceptable as correct answers to **A**. The most common errors were to refer to it as an ammeter or galvanometer, or even a battery. Most candidates recognised **B** as a salt bridge, and also appreciated that **C** was a solution of $\text{H}^+(\text{aq})$ ions although the necessity for the concentration to be 1.0 mol dm^{-3} was not appreciated by some. A few candidates who chose to use H_2SO_4 as the electrolyte forfeited this mark by giving its concentration as 1.0 mol dm^{-3} , rather than 0.5 mol dm^{-3} .
- (b) Many candidates correctly described the solution as containing 1.0 mol dm^{-3} of $\text{Fe}^{2+}(\text{aq})$ and 1.0 mol dm^{-3} of $\text{Fe}^{3+}(\text{aq})$. Some missed the mark by describing the solution as being composed of 1.0 mol dm^{-3} of each of FeSO_4 and $\text{Fe}_2(\text{SO}_4)_3$, not appreciating that a mole of $\text{Fe}_2(\text{SO}_4)_3$, does in fact contain 2 moles of Fe^{3+} ions. Far fewer candidates knew that the metal part of the electrode had to be inert (platinum or graphite) – most described it as an iron electrode.
- (c) Application of Le Chatelier provided the answers *increases* in (i) and *decreases* in (ii). A considerable number of candidates worked this out correctly.
- (d) The correct products are Fe^{2+} and Cu^{2+} . Allowance was made for candidates who chose to oxidise the copper metal to Cu^+ . The corresponding E°_{cell} values are +0.43V and +0.25V. Several candidates attempted to reduce the Fe^{3+} to Fe, despite the unfavourable E°_{cell} that would result.
- (e) Most candidate were able to calculate moles of Fe^{2+} correctly (7.5×10^{-3}), and use the correct Cu:Fe ratio from part (d) (1:2 or 1:1) to calculate the mass of copper to be 0.238g or 0.476g.

Answers: (d)(ii)+0.43 V or +0.25 V; (e)(i) $7.5 \times 10^{-3} \text{ mol}$, (ii) 0.238 g or 0.476 g.

Question 2

The drawing of the outline Born-Haber cycle on the Question Paper allowed even the weaker candidates to score a mark or two. The calculation of the lattice energy in part (c) still confused some, however.

- (a) Many scored here. The most common errors were to omit one or more state symbols, to quote the equation backwards, or to quote the equation for the enthalpy change of formation of $\text{Na}_2\text{O}(\text{s})$.

- (b) The species **A** and **B** were Na(g) and O(g) respectively. Weaker candidates either included ionic charges, or quoted oxygen as $\frac{1}{2}\text{O}_2(\text{g})$. Most candidates scored well on identifying the enthalpy changes. The most common error was not to realise that **2** was the *sum of* the first two electron affinities of oxygen. Some candidates also mixed up **3** and **4**, the lattice enthalpy and the enthalpy change of formation of Na₂O(s).
- (c) As might be expected, there were many different answers to this part – Examiners noted that over 20 different values had been calculated by various candidates! Only one was correct, of course, -2521 kJ mol⁻¹. Partial credit was able to be given for answers that were incorrect due to only one or two errors or omissions, but this had to rely upon the Examiner being able to read the candidate's answer, and to be able to follow the candidate's logic clearly. The most common errors/omissions were: not including the ionisation energy of Na; using the wrong bond energy for oxygen (O-O at 150 kJ mol⁻¹ rather than O=O at 496 kJ mol⁻¹); using the wrong multipliers (the correct ones were 2 x (107 + 494) and $\frac{1}{2}$ x 496); not using both electron affinities; and not using the correct signs for the various values.
- (d)(i) Many candidates correctly stated that the lattice energy would increase, but were less precise as to why – the Mg²⁺ cation has doubly the charge of Na⁺, and a smaller radius. Both factors increase the lattice energy. Mention of either factor would have gained the mark.
- (ii) Due to its *high melting point*, MgO is used as *furnace linings* (not just “in furnaces”), or as a *refractory material*.

Answers: (c) -2521 kJ mol⁻¹.

Question 3

- (a) Very few candidates scored 2 marks for the diagram in part (i). Although the general downward trend was known by many (= (1) mark) the structure within that trend was rarely shown. Carbon, in either macromolecular allotropic form, has a high melting point (ca. 3500°C); silicon and germanium, whilst still *macrocovalent*, have *longer and weaker interatomic bonds* than carbon, and hence lower melting points (1410°C and 940°C respectively). Tin and lead contain *metallic bonding*, which is not particularly strong, so these elements have even lower melting points (ca. 230°C and 330°C respectively). Mention of the points in italics would have scored full marks in part (ii).
- (b) This was well answered by many candidates, who were aware that CCl₄ does not react with water due to the absence of *available d-orbitals*. Equations showing the *complete* hydrolysis of SiCl₄ could have ended up with SiO₂, H₂SiO₃, Si(OH)₄ (+ 4HCl) etc.

Question 4

- (a) Candidates lost marks by not *describing* the differences in melting point and density, or by describing only one of them. Compared to calcium, iron has a higher melting point due to a *more strongly bonded lattice*, which in turn is due to *more delocalised electrons*. The density of iron is larger than that of calcium due to its atoms having a *greater relative atomic mass*, and a *smaller atomic radius* than calcium atoms.
- (b) Most candidates scored a mark here for stating that the 3d and 4s electrons have about the same energy. This makes the third ionisation energy for iron not much greater than the second, in contrast to the calcium situation.
- (c)(i) Most candidates knew this O Level/IGCSE equation, although some attempted to incorporate O₂ from the air into their reaction!
- (ii) The first hurdle to overcome was the correct formula for siderite (FeCO₃). The formulae of all three of the other “possible” iron carbonates, Fe₂CO₃, Fe₂(CO₃)₃ and Fe(CO₃)₂, were seen. Most candidates appreciated that O₂ was required to balance this equation.

- (iii) This calculation was well done by many candidates. Most worked in “megamoles”, so no unit conversion problems had to be tackled. Marks for incorrect answers arising through the correct working from wrong equations were given full credit.

Answers: (c)(iii) 6.89 tonnes.

Question 5

- (a) Many candidates knew the correct reagents and conditions for nitration (*concentrated* $\text{HNO}_3 + \text{H}_2\text{SO}_4$, at 55°C).
- (b) Candidates were less good at identifying the correct mechanism type – electrophilic addition and nucleophilic substitution were two popular answers.
- (c) Most candidates correctly identified X^+ as NO_2^+ and Z^+ as H^+ , but very few indeed scored a mark for the intermediate Y. The most common error was to attach a + charge to either the X^+ (NO_2^+) or Z^+ (H^+), or to both, in addition to a + sign being on the “horseshoe” showing the delocalised π bond around the remaining 5 atoms of the ring. In part (iv) 2 marks could be gained for the full equation ($2\text{H}_2\text{SO}_4 + \text{HNO}_3 \longrightarrow \text{NO}_2^+ + \text{H}_3\text{O}^+ + 2\text{HSO}_4^-$), although 1 mark was available for the incomplete $\text{H}_2\text{SO}_4 + \text{HNO}_3 \longrightarrow \text{NO}_2^+ + \text{H}_2\text{O} + \text{HSO}_4^-$.
- (d) Although (i) was answered well, part (ii) produced all sorts of strange tin- or chlorine-containing organic compounds, rather than the correct triamine.

Question 6

- (a) Although the *type of reaction* could be described as condensation or acylation, the *reaction mechanism* shown here is *nucleophilic substitution* (or nucleophilic addition-elimination).
- (b) Several candidates called the acid required *ethanoic acid*, but then were magnanimously given credit for writing the correct formula of propanoic acid. HCl was the most common (incorrect) alternative to PCl_5 or SOCl_2 .
- (c) The intermediate propanenitrile was known by many. Fewer know that step II required reduction with $\text{H}_2 + \text{Ni}$ or Pt , or LiAlH_4 , and fewer still scored a mark in (ii) for stating that NaCN (*not* with HCN or acid) was used with heating (in ethanol-water).
- (d) Many candidates correctly identified this as an example of *condensation* polymerisation in part (i), although a significant number wrote *addition* polymerisation. Candidates were less good in (ii) at identifying the monomers as 1,4-diaminobenzene and benzene-1,4-dicarboxylic acid. Part (iii), as an application of the ideas of intermolecular bonding, was not picked up by most candidates. Because the question asked for a comparison between Kevlar and *other polyamides*, hydrogen bonding between the amide groups on adjacent chains was not accepted as a reason for its greater strength. Stronger van der Waals forces between the chains, due to the large number of benzene rings, or the greater rigidity and linearity of the chains, due to the 1,4-substitution pattern, were the points looked for. Many candidates merely stated *hydrolysis* in (iv). Heating with an aqueous acid or alkali were the conditions required for the mark.

Paper 9701/05

Practical Test

General comments

The Examiners thank Supervisors who provided a full set of experimental results for **Question 1**. As times of reaction are temperature dependent, the Supervisor's values were not used on this occasion in awarding accuracy marks but did enable the Examiners to see that the experiments worked well within a Centre.

Comments on specific questions**Question 1**

The experiment in **Question 1** generated good practical results from the majority of candidates - a very small number appeared to be unable to follow the instructions and had four widely differing times with no connection between them.

Candidates were asked to record their times to the nearest second but the Examiners saw, and worked with, many times recorded to one hundredth of a second. A number of candidates also recorded times such as "1.12" in Table 1.1 when the majority of candidates in the Centre were obtaining times of about 70 seconds for the same experiment. In assessing accuracy marks for these candidates the Examiners assumed the "1.12" to be a "clock display" in min.sec and converted the value to 72 seconds.

Candidates were allowed two runs (experiments 1 and 2) for the first mixture and should have achieved a time that was very similar for each run. The mixtures in experiments 3 and 4 should have produced times that were half of those achieved in experiment 2.

In assessing accuracy, experiment 2 was compared with experiment 3 (5 marks) and with experiment 4 (5 marks).

Volume of FA 1 (=FA 3) x time in seconds was calculated for experiment 2.

Volume of FA 1 x time in seconds was calculated for experiment 3.

Volume of FA 3 x time in seconds was calculated for experiment 4.

The V_t values for experiment 2 and experiment 3 were compared and the following ratio calculated:

$$\frac{\text{Larger } (V_{xt}) - \text{Smaller } (V_{xt})}{\text{Larger } (V_{xt})} \times 100$$

5 marks were awarded for a difference up to 5%, 4 marks up to 10%, 3 marks up to 15%, 2 marks up to 20% and 1 mark up to 30%.

A similar five marks were awarded for a comparison of experiments 2 and 4.

Where there was a difference greater than 10% between the times in experiments 1 and 2, the V_t giving a greater number of accuracy marks was used when comparing experiment 1 or 2 with experiments 3 and 4.

Comparing experiments 2 and 3

- (b)(i)** Most candidates correctly stated **FA 2** (X) and **FA 3** (iodine) as the reagents with fixed concentration.
- (ii)** **FA 1** was correctly given as the reagent with a different concentration. Some candidates lost this mark by including water.
- (iii)** Three marks were available:
- The first for any qualitative statement that showed a decreased rate with a decreased concentration.
 - If 3 or more marks had been scored for accuracy, a second mark was available for a semi-quantitative statement; e.g. doubling concentration/volume doubled the rate.
 - The third mark was given for a precise statement: reaction is first-order (with respect to **FA 1**) or rate is directly proportional to concentration.

Where a candidate scored less than three marks for accuracy the second and third marks were available for comparing the changes in concentration and numerical values of rates as calculated in Table 1.1. Full marks were occasionally awarded for answers, matching experimental results, that showed the reaction to be second-order or zero-order.

Comparing experiments 2 and 4

- (c)(i) Most candidates correctly stated **FA 1** (sulphuric acid) and **FA 3** (iodine) as the reagents with fixed concentration.
- (ii) **FA 2** was correctly given as the reagent with a different concentration. Some candidates again lost this mark by including water.
- (iii) Three marks were available and were awarded in the same way as the three marks in (b)(i).
- (d) It was disappointing that only a few candidates were able to suggest the volumes of reagents that were to be mixed. Many changed the volumes of **FA 1** and **FA 2** as well as the volume of **FA 3**. The total volume of solution was often greater than 44.0 cm^3 . (Correct multiples of appropriate volumes were accepted). A large number of candidates repeated the volumes in experiment 1.

Question 2*Assessment of planning skills*

It was clear from the plans seen that many candidates did not understand the problem posed - that "washing soda" crystals lose water of crystallisation *on exposure to air* and the % of water so lost on standing in the air had to be determined.

Five marks were allocated for the method and four marks for the processing of results. It was anticipated that the majority of candidates would obtain the five method marks:

- weighing a container suitable for heating (tube, crucible or evaporating basin);
- weighing the/any container plus solid;
- heating and re-weighing after heating;
- re-heating and re-weighing,
- reference to heating to constant mass.

Many candidates weighed hydrated crystals $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ rather than crystals that had been exposed to the air and lost water of crystallisation.

Beakers or flasks were often used for the heating - beakers are not suitable as the sharp bend between base and side is liable to crack on heating without liquid contents and flasks are not suitable as water vapour is less likely to be expelled from the flask.

Candidates commonly weighed a sample of solid into a tube that had not been weighed empty and then weighed the tube and residue after heating or weighed the solid in one container and transferred it to another before heating.

Any reference to constant mass was rewarded.

Many candidates were unable to make much progress with the processing of results beyond calculating the mass of water driven off in the experiment. The inclusion of relative atomic masses should have indicated that a calculation should be shown either in algebraic form or using invented specimen results. Those candidates who included specimen values generally made better progress than those who attempted algebraic expressions.

The Examiners identified four major ways of tackling the processing of results (and a number of other variations). Working for the four methods is shown below.

In each of these methods it is assumed that 10.00 g of the solid $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$ remaining after exposure to the atmosphere is heated and that 5.00 g of water is driven off, leaving 5.00 g of anhydrous sodium carbonate, Na_2CO_3 .

Method 1

$$\frac{5.0}{106.0} = 0.0472 \text{ moles of anhydrous sodium carbonate, } \frac{5.00}{18.0} = 0.2778 \text{ moles of water}$$

$$\frac{0.2778}{0.0472} = 5.89 \text{ moles of water/mole of sodium carbonate}$$

$$\% \text{ water lost on standing} = \frac{10 - 5.89}{10} \times 100 = 41.1\%$$

Method 2

5.0 g of Na_2CO_3 left after heating

$$\text{This came from } \frac{286}{106} \times 5.0 = 13.49 \text{ g of } \text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$$

$$\text{Mass of water} = (13.49 - 5.0) = 8.49 \text{ g}$$

$$\% \text{ water lost on standing} = \frac{(8.49 - 5.00)}{8.49} \times 100 = 41.1\%$$

Method 3

$$\% \text{ water in } \text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O} = \frac{5.0}{10.0} = 50\%$$

$$\% \text{ water in } \text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O} = \frac{180.0}{286.0} = 62.9\%$$

Moles of water/mole of sodium carbonate

$$\text{In } \text{Na}_2\text{CO}_3 \cdot x \text{H}_2\text{O} = \frac{\frac{50}{18}}{\frac{50}{106}} = 5.89$$

$$\% \text{ Water lost on standing} = \frac{(10 - 5.89)}{10} \times 100 = 41.1\%$$

Method 4

$$\text{Moles of } \text{Na}_2\text{CO}_3 \text{ and hence } \text{Na}_2\text{CO}_3 \cdot x \text{H}_2\text{O} = \frac{5.0}{106} = 0.0472 \text{ moles}$$

$$M_r \text{ of } \text{Na}_2\text{CO}_3 \cdot x \text{H}_2\text{O} = \frac{10.0}{0.0472} = 212$$

$$\text{Moles of water lost on standing} = \frac{286 - 212}{18} = 4.11 \text{ moles}$$

$$\% \text{ of water lost on standing} = \frac{4.11}{10} \times 100 = 41.1\%$$

Paper 9701/06

Options

Comments on specific questions***Biochemistry***

This remains a popular option and candidates were, on the whole, well prepared.

Question 1

- (a) Most candidates could draw the two disaccharides in (a)(i), but fewer gave the presence of a chiral centre as explanation in (a)(ii).
- (b) Almost all candidates knew that glucose forms hydrogen bonds with water, and could draw a suitable diagram showing this.
- (c)(i) A number of candidates omitted either ATP or ADP from their equation.
- (ii) The diagrams showing the displayed formula of glucose-6-phosphate were often well drawn, although some candidates lost marks through carelessness. The main difficulty for even good candidates was in explaining what controlled the reaction in cells.

Question 2

- (a) This part was well answered by most candidates with well-drawn graphs and correctly positioned lines. Most candidates were able to explain how K_m was obtained, and what it represented.
- (b) The sketch lines were often correct, but the explanations were often weak, particularly for a co-factor.

Environmental Chemistry

This option varies in its popularity in different parts of the world. The rather wordy nature of questions this year seemed to be rather off-putting for some candidates and marks for this option were rather lower.

Question 3

Candidates who read the text thoroughly had significantly fewer problems than those who 'skimmed' it. Basic environmental knowledge coupled with the information provided in the text led good candidates to gain some high marks. The parts that required some knowledge, parts (c) and (e) were generally only answered well by good candidates. There was also some evidence of 'guessed' answers with information that was not relevant to the data provided.

Question 4

- (a) This was a standard question, and few candidates had trouble with it.
- (b) It was expected that this part would be fairly routine, but some candidates had clearly not learned the important reactions of CFCs in the upper atmosphere.
- (c) This was designed to be a data analysis exercise, yet a number of candidates ignored the data provided, and scored few marks.
- (d) Candidates were expected to compare the structure of the two compounds, recognizing that the HCFC compound would be more easily destroyed, and contained one fewer chlorine atom.

Phase Equilibria

This remains a very popular option and produced some very good answers.

Question 5

This question gave candidates some unfamiliar data and required them to analyse it, many did so very successfully.

- (a) It was expected that candidates would be able to describe the change in forces between molecules on evaporation, and to link this change as being proportional to ΔH_{vap} .
- (b) In this part it was hoped that candidates would relate the data to the intermolecular forces in the different compounds, with water standing out as the only one showing hydrogen bonding. Some detailed analysis of the data was needed to score full marks.
- (c) This was generally well answered with few candidates unable to state Raoult's Law or apply it to the examples given.

Question 6

Candidates in general found this question more taxing than **Question 5**.

- (a) Although almost all could define partition coefficient, many struggled with the calculation. This is perhaps a little surprising since calculations like this have been set on previous Papers.
- (b) By contrast, almost all candidates could state Henry's law, and many used it to successfully calculate the solubility of the components of dissolved air and its percentage composition.

Spectroscopy

Although one of the less popular options, there were some very well prepared candidates who scored good marks.

Question 7

Parts (a), (b) and (c) were relatively straightforward for those candidates prepared for this option, although some failed to take notice of the bold text in (b).

- (c) There was still some confusion about the fact that *shorter* wavelength means *higher* energy.
- (d) This part required candidates to interpret some information and sketch the absorption peaks of two compounds relative to that of haemoglobin. Again, there was some confusion over the position of the peaks and over the fact that this was absorption rather than emission.

Question 8

- (a) This was relatively straightforward recall, and few slipped up here. The interpretation of spectra always proves to be a good discriminator, and parts (b) and (c) were no exception, with only the best candidates scoring full marks.
- (c) Some candidates lost marks by failing to read in part (ii) that U was formed from T.

Transition Metals

As with **Phase Equilibria**, this remains a popular option, with this year being no exception.

Question 9

- (a) It was expected that this part would prove relatively straightforward, but a surprising number of candidates confused anode and cathode, and which of the impurities dissolved and which formed the anode sludge. Most candidates could name an alloy of copper, although some candidates could not correctly identify the alloying metal.

- (b)(ii) The calculation proved surprisingly taxing for some candidates who had scored full marks up to that point.

Question 10

This question proved to be rather more straightforward for good candidates, with many scoring 8 marks or more. Weak candidates could not work out the electronic configuration of the Mn^{3+} ion, and did not know the colours of the ions of manganese.

- (c) The best candidates successfully used the Data Booklet, but even here some chose the wrong reactions. Nonetheless, a pleasing number of candidates scored 9 or 10 marks on this question

Paper 9701/08

Practical Test

(Mauritius Only)

General comments

The Examiners thank Supervisors who provided a full set of experimental results for the Experiments in **Question 1**. Supervisor's results were not used directly in awarding accuracy marks but were a useful guide to the correct conduct of the experiment and were available as a standard value where there was any doubt about the results obtained at a Centre. The eight accuracy marks available were divided into two parts – four marks being available for the consistency of working shown by the candidate and a further four marks for a comparison of the candidate's results with a value calculated from the equation for the decomposition.

Question 2 was in a slightly different form to past questions. Deductions were not expected for individual tests but were made at the end and based on the "whole" picture obtained from the tests. By asking the question in this way more individual points could be awarded and repetition of deductions was eliminated.

Comments on specific questions

Question 1

In the weighing tables marks were awarded if all weighings were to 2 decimal places or better and if there was any evidence of re-heating in Table 1.2.

Examiners checked and corrected all subtractions in the tables and calculated the % mass loss for *Experiment 1* and for *Experiment 2*. There was no penalty at this stage for incorrect subtraction. The % mass loss for each of the candidate's experiments were compared and 4 accuracy marks awarded for a difference up to 1.0% decreasing by a sliding scale to 1 mark for a difference up to 10.0%.

The theoretical mass loss on heating was 33.47% but preliminary work by the Examiners which was also confirmed by the candidates' results showed that about 31% was the expected practical value. A further 4 accuracy marks were awarded for comparing 31.0% with the value obtained by the candidate that was closer to 31.0% and using the same sliding scale as used in comparing the candidate's two results.

Many candidates scored highly in both sections but some had very inconsistent results for their own two experiments. It was generally found that candidates who scored poor marks for the comparison of their own experiments had one result which was close to the "standard" value of 31.0%. The practical work therefore produced a range of accuracy marks.

- (d) Most candidates gained the mark for calculating the relative molecular mass of $\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2 \cdot \text{H}_2\text{O}$.
- (e) The correct theoretical mass loss on heating was obtained by most candidates but some failed to realise that 2 mole of H_2O and 1 mole of CO_2 were driven off. The mass of some other combination of H_2O and CO_2 was divided by the molecular mass calculated in (d).

Another error seen from time to time was to divide 79.5 by 239 rather than 80 divided by 239. At first sight 79.5 might have been an arithmetical error in the mass of water and carbon dioxide but 79.5 was the molecular mass of CuO and therefore *chemically* incorrect.

A few candidates did obtain the correct value by calculating $\frac{2 \times 79.5}{239}$ and subtracting it from 100.

- (f) Candidates were asked to calculate the % loss in mass for each of their experiments. To gain the mark they had to have answers correct to 1 decimal place (or better) when compared to the Examiner calculated values used in assessing accuracy. Candidate errors in subtraction were consequently penalised here.
- (g) The first part of (g) carried no marks. One mark was available for each possible source of error. Insufficient heating was not allowed as candidates had been asked to ensure that decomposition of the carbonate was complete and constant mass should have been obtained in the experiments. Loss of solid from the tube during reaction and water condensed inside the tube were also not acceptable answers as they had been covered in the instructions for the conduct of the experiment. Acceptable reasons were:
- loss of water/decomposition of sample before heating
 - presence of impurities in the sample
 - moisture absorbed by the solid before or after heating
 - too low a temperature in Bunsen flame to bring about complete decomposition or too high a temperature causing further decomposition of the remaining CuO.

“Acceptable” reasons were awarded marks even if the error would have been in the opposite direction to that obtained by the candidate. A considerable number of candidates gained 1 mark in this section but a disappointingly large number scored zero. Very few candidates scored the full two marks.

Question 2

The solid supplied was a mixture of sodium nitrite and lead(II) oxide.

Tests on Filtrate (NaNO_2)

- (a) To gain the observation mark a candidate had to record “no change” on adding potassium iodide and a “brown colour/formation of iodine” on adding the sulphuric acid. Many candidates obtained the brown solution but did not gain this mark as they did not make it clear when the changes took place.
- (b) To gain the observation mark a candidate had to record the purple solution on adding potassium manganate(VII) and subsequent loss of the purple colour *or* state that the purple colour was lost on adding sulphuric acid. Many candidates did not gain this mark as they just stated that the colour of manganate(VII) was lost.
- (c) The observation mark was given for a yellow or brown gas or for stating that NO_2 had been seen.

To gain the deduction mark for nitrite, the candidate had to have at least two pieces of supporting evidence in the tests (a) to (c).

A brown/black colour in (a); a loss of colour in (b) or a brown gas in (c) was sufficient.

One mark was given for stating that **FD 3** acts as an oxidant with acidified iodide ions providing a brown/black colour had been recorded in (a).

One mark was given for stating that **FD 3** acts as a reductant with acidified manganate(VII) ions providing decolourisation of the solution or a final colourless solution had been recorded in (b).

The criteria for the deduction marks were a little easier than those for the observation marks and most candidates were able to score deduction marks – a few however confused oxidant and reductant.

Tests on Residue (PbO)

- (d) "A white precipitate soluble in excess sodium hydroxide" was needed for the observation mark.
- (e) "A white precipitate insoluble in excess aqueous ammonia" was needed for the observation mark.

The majority of candidates gained these marks.

- (f) "A yellow precipitate" (PbI_2) was needed for the observation mark. The precipitate must not be soluble but any subsequent change in the colour of the precipitate was ignored.

For the deduction mark to be awarded, the mark for "yellow precipitate" in (f) and one of the marks in (d) or (e) were required.

<p>Paper 9701/09</p> <p>Paper 9 - Practical Test</p> <p>(Mauritius Only)</p>

General comments

The Examiners thank Supervisors who provided a full set of results for the experiments in **Question 1**.

Experiments 2 and 3 used exactly the same quantities of reagents as experiment 1 and if conducted well should have produced identical results.

The times of reaction in rate of reaction experiments are temperature dependent, therefore the Examiners based the majority of the accuracy marks on the consistency of results obtained by individual candidates. It was assumed that the experiment would have been repeated over a fairly short period of time with little variance in temperature during that time. Further accuracy marks were awarded against a "standard" value derived from the Supervisor's results. In a few Centres where the Supervisor and candidate values were clearly at variance, a new "standard" was derived from the candidate results.

Comments on specific questions**Question 1***Accuracy marks comparing experiments 1,2 and 3*

All times were converted to seconds – some candidates recorded their times in the form displayed on a stop-clock, i.e. "min.sec". A time recorded as "1.34" was converted to 94 seconds.

For each candidate the difference between the highest and lowest time was calculated and the difference calculated as a % of the higher value.

- 5 marks were given if all times were within 5% of the largest
- 4 marks were given if two times were within 5% of the larger and the other within 10% of the further of the 5% pair

As the differences increased the marks decreased.

An additional 5 accuracy marks were awarded if at least one value in the candidate's results was within 5% of the "standard" value obtained from the Supervisor's results. 4 marks were awarded if the closest candidate value was within 10% of the Supervisor's value etc.

Processing of results

- (d) The majority of candidates were able to calculate an average of all three times from their experiments or an average of the two closer values. In many cases two or three times (if recorded to the nearest second) were identical and that value was selected.

- (e) The intention, in this section, was that the candidates would use their results to obtain the “error” around their timings. For example with times of 65, 67, 68 seconds recorded.

Suitable averages would be 66.7s (average of all three) or 67.5 s (average of closer pair).

For an average of 66.7 s the error would be $66.7 \pm(1.7)$ s or $66.7 \pm(2)$ s to nearest second.

For an average of 67.5 s the error would be $67.5 \pm(0.5)$ s or $67.5 \pm(1)$ s to nearest second if working with the pair used to calculate the average, or $67.5 \pm(2.5)$ s or $67.5 \pm(3)$ s to nearest second if including all the times recorded.

Candidates were allowed to use:

- the difference between the average and the value furthest from the average to the nearest second above;
- half the range covered by the readings;
- $\frac{\Sigma \text{ individual differences to average}}{3}$

Accuracy marks comparing experiments 4,5 and 6

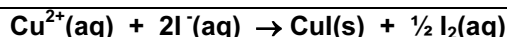
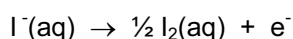
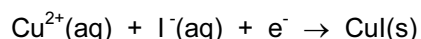
Three accuracy marks were awarded in a similar way to those for experiments 1-3. As much smaller times were recorded the range was increase to all readings within 10% for the full three marks.

- (i) Marks were awarded as in (d).
- (j) Marks were awarded as in (e).
- (k) One mark was awarded to any candidate who commented on the shorter time for experiments where the Cu^{2+} ion was present.

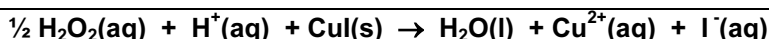
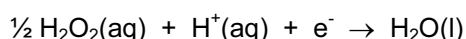
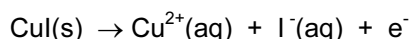
The second mark was seldom given. Candidates were expected to consider the average times and errors calculated for each set of experiments and state that the errors in experiments 4-6 would not increase the time to that in experiments 1-3 (or vice versa). With no “overlap” of values Cu^{2+} was clearly a catalyst.

- (l) It was disappointing to see the large number of candidates who were unable to handle the E^θ data provided. The equations were listed in order of oxidising power of the substance on the left-hand side – as in the subject syllabus.

Examiners were hoping to see candidates picking the second and third equations listed and stating **that Cu^{2+} is able to oxidise iodide to iodine**, the copper ion being reduced to CuI. (One mark)



The Cu^{2+} catalyst could be regenerated, as CuI can be oxidised by $\text{H}_2\text{O}_2/\text{H}^+$ (Second mark)



Equations were not essential – the statements in bold above were sufficient.

Many candidates attempted to combine three equations and often all three of them had electrons only on the left or on the right hand side of each equation. No marks were awarded.

The first mark was awarded for any combination of equations having Cu^{2+} and iodide on the left-hand side of the equation and iodine on the right, regardless of "correct" Chemistry.

A small number of candidates gained the second mark but not the first and a small number were able to give both parts of the alternative route.

Question 2

Assessment of Planning Skills

Method

The problem was clearly laid out in the introduction to the question:

- Nitrite ions can be titrated with acidified manganate(VII) ions, *but* Nitrite ions react with acid on its own
- The solution of sodium nitrite provided was impure.

The Examiners were disappointed that the colours of the ions were not better known. A full range of colours was seen for each of the ions.

It was anticipated that candidates would realise that the "normal" method of titration using standard manganate(VII) solution in the burette with acidified nitrite in the flask could not be used because of the reaction between the acid and the nitrite.

The majority of candidates did, however, use this method. Potassium manganate(VII) solution was placed in the burette, nitrite solution pipetted into the flask and acid added. The solution was then titrated until the end-point was reached. These candidates could have scored one mark (point c) if they had stated the end-point would be at the first appearance of a (permanent) pink colour.

A few candidates realised the problem and placed acidified manganate(VII) solution in the burette. Had they stated a precise dilution of the standard manganate(VII) with acid the first mark (point a) would have been awarded. The second mark (point b) could now be obtained for pipetting the nitrite solution (and not adding additional acid). The third mark was again for a pink colour at the end-point.

A minority of candidates correctly placed the nitrite solution in the burette (point a), pipetted manganate(VII) solution into the flask and added acid to the flask (point b). They then titrated the solutions until the solution in the flask turned colourless at the end-point (point c).

Processing of results

As the concentration of the solutions had been given in the introduction to the problem and relative atomic masses were given at the start of the processing section it was expected that candidates would show calculations using the reacting quantities given - $x \text{ cm}^3$ of sodium nitrite reacts with $y \text{ cm}^3$ of aqueous potassium manganate(VII).

Many candidates were able to use the data provided to calculate the moles of potassium manganate(VII) in $y \text{ cm}^3$ of solution and to apply the correct mole ratio to convert this into moles of nitrite.

Some candidates successfully went on to multiply the moles of nitrite by $\frac{1000}{x}$ to find the concentration in mol dm^{-3} before multiplying by 69 to find the mass of pure sodium nitrite dissolved but some went straight to the $(x69)$ step and omitted scaling up to 1 dm^3 .

Candidates who got this far were generally able to complete the calculation with $\frac{\text{mass of pure NaNO}_2}{4.00} \times 100$

Common errors in the calculation were:

- to calculate moles of nitrite as $\frac{4.00}{69}$,
- to use 85 (NaNO_3) instead of 69 (NaNO_2)
- to end the calculation with $\frac{(4.00 - \text{mass of pure NaNO}_2)}{4.00} \times 100$

A significant number of candidates did not attempt the processing of the results.