CHEMISTRY

GCE Advanced Level and GCE Advanced Subsidary Level

Paper 9701/01

Multiple Choice

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

General comments

For this paper, the mean score was 25.7 (64.3%), just above the targeted value, and the standard deviation of the scores was 7.11 (17.8%). This indicates that the paper discriminated satisfactorily among candidates, and the mean score has shown a marked increase on that from last year, probably reflecting that for the first time there were candidates who were taking this paper both at the end of their first year (Advanced Subsidiary) and the end of their second year (Advanced Level) studies.

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

Comments on specific questions

Seven questions had a facility above the design limit: **Questions 1**, **3**, **9**, **15**, **20**, **24** and **31**. A high facility is often coupled with a relatively low discrimination, but it is an encouragement to know that candidates are familiar with the use of bond dissociation energies to calculate an enthalpy change of formation (**Question 9**), and that environmental concern about the emission of carbon monoxide from car exhausts due to incomplete combustion is well known (**Question 24**).

Three questions did not discriminate well within the ability range of candidates, and these usually reflect misconceptions among the more able candidates.

In **Question 11** the variation of the rate of an autocatalysed reaction with time was given graphically. Whereas 34% of candidates chose the key **C**, 38% chose the distractor **B** in which the rate of the reaction was stated to increase to a maximum and not decrease thereafter: candidates should surely appreciate that when reactants are used up in a reaction there must inevitably be a diminution in rate.

Question 18 tested the understanding of the use of sulphur dioxide as a food preservative. The correct answer **B**, was given by 63%, that it is a reducing agent, but 19%, including some of the more able candidates, gave **D**, believing that its significant reaction was to form an acidic solution with water.

Question 38 the reaction of ethane with aqueous bromine in the presence of sodium bromide tests the understanding of the mechanism of electrophilic addition. An analysis of the answers yields the rather surprising fact that 52% of candidates thought that it is possible to obtain CH_2ClCH_2Cl, presumably by the generation of Cl_2 and its subsequent addition to $CH_2=CH_2$, and 24% believed it was not possible to get CH_2BrCH_2Br.

One question had a low facility: in **Question 21** candidates were asked the total number of different chloroethanes that are possible with the formula $C_2H_{6-n}Cl_n$. Only 19% gave the correct answer **C**, 9: by far the greater proportion, 59%, opted for **A**, 6, not allowing for the structural isomers when n is 2, 3 and 4.

Two other questions require comment. In **Question 8** a significant proportion of candidates, 33%, opted for the distractor **C** not appreciating that a 'standard enthalpy change of combustion' is estimated or measured at a standard temperature – in this case, not the high temperature of combustion of carbon. In **Question 36** 24% of candidates thought that strontium does not burn on being heated in oxygen.

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| **Paper 9701/02** |
| **Theory 1** |
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General comments

The general feeling was that the performance of candidates was better than last year, especially in some areas.

Comments on specific questions

Question 1

(a)   The image of a carbon atom as being like six bees buzzing around a space the size of a football stadium is a nice one. It reminds us that most of matter is space. This section was answered well; the chief omission was the electrostatic attraction of the protons in the nucleus for the electrons (the bees).

(c)   Some candidates gave NO_2^- or NO_3^- as the ions in binary compounds. Binary compounds contain two elements only.

Question 2

This question was well answered. Some poor diagrams in **(c)** failed to score marks.

Question 3

This question on aluminium is largely bookwork, on material which needs to be tested and understood.

Question 4

(a)(ii) Only a small percentage of candidates observed that more oxygen was required for the second stage of converting the SO_2 to SO_3.

(c)(i)(ii) These are equilibrium explanations answered in terms of Le Chatelier's principle. Catalysts are too
(iii) easily poisoned, which is why the air in **(iii)** needs to be clean or dust-free.

Question 5

Well answered. Some candidates lost marks by erroneously reducing the formula of cyclohexane to C_6H_{14} and cyclohexene to C_6H_{12}.

Question 6

This question was answered very well.

> **Paper 9701/03**
> **Practical Test**

General comments

The Examiners again thank Supervisors who provided experimental results for **Question 1** as requested in the Instructions to Supervisors. There were however, a number of Centres where no experimental information was provided by the Supervisor. This gives the possibility of candidates being disadvantaged as some of the accuracy marks for the question were awarded for the candidate's results compared to those of the Supervisor.

The Examiners expect to find in any packet of scripts opened:

- Session and Laboratory information for each candidate together with a seating plan for each laboratory in all sessions.

- The full results of the experiment performed at the same time as the examination, under the same conditions and using the same materials for **each Laboratory and Session**. The results should be fully recorded in the same way they will be recorded by the candidates.

When this information is provided, the Examiners are able to make allowances where problems occur within a Session or Laboratory. It is not unknown for solutions in a particular area of a Laboratory to have deteriorated owing to adverse conditions. Where the seating plan and experimental results were provided the Examiners were able to make any necessary adjustments to accuracy marks.

The paper performed well and gave the majority of candidates the opportunity to display their practical skills. Marks were distributed over the upper part of the 25 mark range with comparatively few candidates scoring below 10 marks.

Comments on specific questions

Question 1

It was expected that candidates would record all weighings to two decimal places (or better). There were still a number of candidates who, using balances capable of weighing to 2 decimal places, omitted the second decimal place where this was a zero. One mark was given if all four recorded weighings were recorded with this required precision but was lost where the second decimal place was omitted.

Candidates were asked to perform and then repeat the same experiment – weighing between 3.30 g and 3.50 g of **FA 1**. The Examiners were surprised to see the number of candidates who spent time in ensuring they had weighed exactly the same amount of **FA 1** for each experiment. One mark was given if each amount weighed, shown by correct subtraction in Table 1.1, was between 3.20 g and 3.50 g. The lower limit of 3.20 g allowed for some residual solid in the weighing bottle.

Thermometers with graduations every $0.2^{o}C$ were specified. The Examiners were looking for all thermometer readings to be recorded to the nearest $0.1^{o}C$. (Where thermometers graduated in whole degrees were supplied by Centres the Examiners were still looking for one decimal place as these should be read and recorded to the nearest $0.5^{o}C$.) As with the weighings, some candidates recorded a temperature such as $25.0^{o}C$ as $25^{o}C$ and lost the mark for precision in using their thermometers.

Accuracy marks

For each experiment the ratio of $\dfrac{\text{temperature rise}}{\text{amount weighed}}$ was calculated.

Four marks were available by **comparing the ratios from the candidate's experiments**.

Average Temperature Rise is Closest to	$5^{o}C$ (or higher)	$4^{o}C$	$3^{o}C$	$2^{o}C$	$1^{o}C$ (or lower)
Mark	**Difference in Ratio**				
4	Up to 0.05	Up to 0.04	Up to 0.03	Up to 0.02	Up to 0.01
3	0.05+ to 0.10	0.04+ to 0.08	0.03+ to 0.06	0.02+ to 0.04	0.01+ to 0.02
2	0.10+ to 0.15	0.08+ to 0.12	0.06+ to 0.09	0.04+ to 0.06	0.02+ to 0.03
1	0.15+ to 0.20	0.12+ to 0.16	0.09+ to 0.12	0.06+ to 0.08	0.03+ to 0.04
0	> 0.20	> 0.16	> 0.12	> 0.08	> 0.04

A further four marks were available by comparing **one of the candidate's ratios with the ratio calculated from the Supervisor's Results**. The candidate ratio closer to that obtained by the Supervisor was used in this case. Marks were again awarded as in the Table above.

A large number of candidates showed very good consistency in their practical work and scored the first four marks for accuracy but some obtained results that showed large differences between the two ratios.

It was generally found that candidates who scored zero for accuracy when their own results were compared obtained a reasonable mark (from 4) when one of their ratios was compared to the Supervisor's result.

Calculations

(f) The majority of candidates were able to multiply the volume of solution (50 cm^3) by 4.3 and by the temperature rise. There were still a significant number of candidates who added the mass of **FA 1** to the 50 cm^3/50 g of solution or who simply included the mass of **FA 1** in their expression. It was expected that units would be correct: Joules or Joules converted to kiloJoules, (mol^{-1} was ignored).

(g) The majority of candidates were able to divide their answer to **(f)** by the value of ΔH to obtain the number of moles reacting. Some candidates mixed their units (J and kJ) and because of this even inverted the expression.

(h) The majority of candidates were again able to divide their average mass by the answer to **(g)** to obtain the molar mass of XCO_3. Some left the calculation at this stage thinking they had obtained the atomic mass of X. The Examiners were looking for an attempt to subtract 60 from the molar mass already calculated (arithmetical errors ignored) and an evaluated answer that had no units. Candidates who had made an error in an early part of the calculation often calculated a molar mass that was less than 60. This should have alerted them to a mistake.

Many candidates who obtained a molar mass of less than 60 proceeded to subtract the molar mass from 60 in the second part of the section.

Question 2

The solution **FA 2** contained the ions Al^{3+}, Br^- and SO_4^{2-}.

The Examiners would draw the attention of candidates to the Rubric for an Observation/Deduction question:

"You should indicate clearly at what stage in a test a change occurs, writing any deductions you make alongside the observations on which they are based".

This is particularly important where a second reagent is added. Examiners awarded marks where possible but on occasions it was impossible to know which reagent had produced the recorded observation so no mark was awarded. Deduction marks are only awarded following a valid observation.

A good range of marks was produced in this question with a significant number of candidates having excess marks cancelled to the maximum 10.

(a) Candidates were asked to add sodium carbonate to the solution and it was anticipated they would see effervescence and identify carbon dioxide as the gas given off with a deduction that the solution was acidic.

The observation mark was given for the gas evolved turning lime water milky, cloudy etc. This mark was not given very often. The deduction mark (for acid/acidic solution) was also given from an observation of effervescence or naming carbon dioxide as the gas given off.

A surprising number of candidates deduced carbonate as the ion present!

Salts of highly charged ions such as Al^{3+}, Fe^{3+} or Cr^{3+} did not obtain the deduction mark.

Fe^{3+} or Cr^{3+} were considered to be incorrect ions as their solutions are coloured. As incorrect ions they cancel a correct deduction such as acid or acidic solution.

(b) Most candidates scored two marks here – white precipitate with the barium salt and sulphate as deduction. This was one test where the white precipitate was often written against the added acid. Some candidates did not realise the significance of adding the acid as they left sulphite in the deduction.

(c) The observation for a bromide on adding silver nitrate is difficult unless chloride, bromide and iodide are tested side by side. In deciding the observations that would be allowed, the Examiners took into consideration the analysis notes printed on page 7. The precipitate should have been cream but not yellow.

For the observation mark; cream, cream/off-white, cream/white, white/cream, off-white/cream were allowed as colours with the precipitate insoluble or partially soluble in dilute aqueous ammonia. Bromide was the deduction from a correct observation.

(d) A white precipitate, soluble in excess sodium hydroxide was required for the observation mark. All three ions, Al^{3+}, Pb^{2+} and Zn^{2+} were required for the deduction mark.

(e) A white precipitate, insoluble in excess ammonia solution was required for the observation mark. The two ions, Al^{3+} and Pb^{2+} were required for the deduction mark. If the deduction mark had been given in **(d)** a candidate could score the deduction mark here for the absence of Zn^{2+}. The deduction mark could also be scored for concluding the presence of Al^{3+} providing it had already been mentioned when effervescence was seen in **(a)**.

(f) One mark only was available for this test and was given for no reaction/no precipitate as the observation together with the presence of Al^{3+} or absence of Pb^{2+} as deduction.

One mark was given for listing the correct ions in the Summary. A small number of candidates continue to confuse cations and anions.

A small number of candidates did not understand that fresh samples of **FA 3** should be used in the tests **(b)** to **(f)** and from their recorded observations it was clear that they had added further reagents to some of the mixture from **(a)**.

Where acid was added in **(b)**, **(c)** and **(f)** candidates observed that *"the precipitate dissolved to form a clear/colourless solution"*.

As this did not interfere with subsequent reagents full marks could be gained in these tests. No marks were possible however on addition of sodium hydroxide or ammonia, as the precipitate left in **(a)** remained insoluble in these reagents.

> **Paper 9701/04**
>
> **Paper 4**

General comments

This was the first year of the new format of A level papers. Inevitably, because this paper concentrated solely on the A2 part of the syllabus, it was likely to seem quite demanding for candidates. Those who took Papers 1 and 2 alongside Paper 4 would have found the first two much more straightforward than this Paper. This is as it is designed to be. In the event, candidates seemed well prepared for this Paper, although it was noted that several candidates had not spent enough time on the Organic Chemistry sections of the syllabus.

There was no real evidence of candidates running out of time, and in the main their answers were full enough. There were one or two places on the paper where candidates felt the need to expand their answers, (e.g. **Questions 2(a)**, **4(b)**, and **(c)**)) but where necessary candidates used other available space. In general candidate's answers were succinct and to the point. Calculations were usually set out clearly, and several error-carried-forward marks could be awarded for correct working after an erroneous beginning to a calculation. For this to occur, the candidate's working must be clearly laid out at every stage.

Answer to Numerical Problems

Question 1

(b)   pH = 13.3

Question 2

(b)(i)   rate(A) = 4.6 (±0.8) x 10^{-5} mol dm^{-3} min^{-1}

rate(B) = 11 (±3) x 10^{-5} mol dm^{-3} min^{-1}

   (vi)   k = 0.2 (±0.05) mol^{-1} dm^3 min^{-1}

Question 3

(c)(ii) A_r = 85.3

Question 4

(c)(ii) $E^{\ominus}_{cell}$ = +0.75 V

   (iii) $E^{\ominus}_{cell}$ = +0.95 V

Comments on specific questions

Question 1

(a)   Most candidates knew this definition $K_w = [H^+][OH^-]$. The most common incorrect answers were $K_w = pH + pOH$; $K_w = K_a x K_b$; $K_w = [H^+] + [OH^-]$.

(b)   This calculation was well done by those candidates who had written the correct expression in **(a)**.

(c) The idea that ammonia was a *weaker base* or *less ionised* than NaOH was expressed by many candidates. Some stated incorrectly that ammonia was a *stronger acid*, and some put the difference down to "experimental error".

(d) Both this part and part **(e)** were taken straight from the syllabus (sections 7l and 7m) but Examiners were disappointed to see so many incorrect answers. Many candidates did not read the question carefully enough, and drew curves showing the titration of a fixed amount of HC*l* with NH_3 in the burette, rather than vice versa. The curve should have started at pH 11.3 (not 13.3 as some indicated), fallen gently to about pH 7, and then fallen sharply to about pH 2 at the end point, which occurs at a volume added of 40 cm^3. Thereafter a gentle slope downwards to about pH 1.

(e) Only a minority of candidates chose the correct indicator, methyl orange. Several forfeited their mark by placing a tick in more than one box.

(f) Equations were necessary to gain full marks here. The most appropriate were the following:

$$NH_3 + H^+ \longrightarrow NH_4^+ \text{ and}$$
$$NH_4^+ + OH^- \longrightarrow NH_3 + H_2O$$

The most common errors were to suggest that ammonium chloride and "ammonium hydroxide", NH_4Cl and NH_4OH, occurred as un-ionised species, that ionised, when needed, to $NH_4^+ + Cl$ or OH^-.

Question 2

(a) This part was designed to test the ability of candidates to devise a suitable experimental technique, from given information (syllabus section 8j). Several candidates mentioned the use of a colorimeter, but fewer described how to use it effectively. Many applied the "thiosulphate cross obscuring" method. This could score [3] out of [4] if well described. A few candidates described the extraction of samples and the titration of remaining OH^- with HC*l* - a good reliable method. The main weaknesses in most candidates' answers were the lack of detail in the use of a stopclock; the mixing of solutions of the two reagents *of known concentration* ; and the measurement of the "end" of the reaction ("take the time when the mixture turns yellow" was a common example of this). The "ideal" answers would have included the following steps:

(i) mix a known volume of each solution, of known concentration, and start the stopclock.

(ii) place in a colorimeter (fitted with a suitable filter) and measure the increase in absorbance over time *or* take out samples at known time intervals and titrate against standard acid.

(b)(i) Many candidates have clearly never drawn tangents at T = zero to find initial rates. The majority chose random times at which to draw their tangents, and even then did not calculate the slopes accurately. Some did not read the graph carefully enough, and quoted their rates in mol dm^{-3} sec^{-1}, rather than mol dm^{-3} min^{-1} (some converted the rate in min^{-1} into a rate in sec^{-1} - this unnecessary extra step was perfectly acceptable, of course).

(ii) Those whose tangents in **(a)** were drawn incorrectly often came up with a curious answer here. Many assumed the order was first order, even without attempting a calculation. From this stage onwards the error-carried-forward principle was applied, so full credit could be obtained in parts **(iii)** - **(vi)** even if parts **(i)** and **(ii)** were incorrect.

(iii)(iv) Since the first two half-lives were the same (construction lines on the graph were needed to ensure the mark), the order was one.

(v) The rate equation had to fit with the candidate's answers to **(ii)** and **(iii)**.

(vi) Examiners checked that the candidate's answer, including the units, was consistent with their answers to parts (**i**)and **(v)**.

Question 3

Examiners were in general pleased with candidates' answers to **(a)** and **(b)**. In **(c)** candidates used a variety of methods - some strictly algebraic, and some via moles - to obtain their answers. A significant minority (mostly grade A/B candidates) scored full marks.

(a)   Several candidates tried to incorporate O_2 on the left hand side of the equation. Very few confused this decomposition with that of a Group I nitrate, so most ended up with the oxide. What happened to the N and O was the subject of much speculation on the part of some, however!

(b)   The main slip in candidates' descriptions was to refer to sizes of Group II *atoms*, rather than *cations*. The cations polarised the bonds in the nitrate *anion*. Several candidates thought that stability *decreased* down the Group, as the lattice energies decreased.

(c)   The most chemically logical way of approaching this calculation was to calculate the number of moles of oxygen evolved (10.85g of oxygen is 0.678 moles), and to equate this with the number of moles of MNO_3 in 100g. Hence the M_r of MNO_3 = 100/0.678 = 147.5. Hence A_r(M) = 85.5 approximately, and thus M = Rb. Many other correct alternative methods were given full credit.

Question 4

(a)   A surprisingly large number of candidates got this part wrong. The most common error was to write $3d^3 4s^2$.

(b)(i)   Suitable $E^\ominus$ values needed to be quoted (+1.36 V, 1.07 V and 0.54 V in this case). Most, but not all, candidates knew that chlorine is the strongest oxidiser, and iodine the weakest. There was some confusion shown between oxidising agents and reducing agents.

(ii)   Some candidates quoted the M^{3+}/M $E^\ominus$ rather than the M^{3+}/M^{2+} $E^\ominus$ for Cr and Fe. This was allowed, although not intended! Quoting the $E^\ominus$ for $Cr_2O_7^{2-}$/Cr^{3+} showed a lack of understanding as to whether oxidising or reducing agents were being compared.

(c)   Correct calculations using the correct $E^\ominus$ values would have shown that there would be no reaction in **(i)**, but there would be reactions in **(ii)** and **(iii)**. Candidates still find $E^\ominus$ calculations challenging. Some multiply the $E^\ominus$ value by the number of electrons, some change the sign of an $E^\ominus$ for no apparent reason, and some add together $E^\ominus$ values rather than take them away.

Question 5

(a)   The descriptions of functional groups were often not specific enough. Phenol (or phenolic hydroxy) was accepted, alcohol or hydroxyl was not. Amide was acceptable, but peptide was not. Other common errors included amine; hydroxide and ketone (!).

(b)(i)   At least 2 bromines were needed in the ring to score the mark. Orientation was not critical. Common errors included brominating the CH_3 group and the NH group.

(ii)   The sodium phenate needed to be shown in an ionic form (either as Ar-O$^-$Na$^+$ or just as Ar-O$^-$).

(iii)   Only the more able hydrolysed the amide to $CH_3CO_2^-$ and Ar-O$^-$. Many candidates substituted H atoms in the ring with OH groups, or added OH to the C=O in the amide group.

(c)(i)   This proved a surprisingly difficult part. Many candidates did not look back at the formula of paracetamol and recognise that it was an amide of ethanoic acid. Most who scored a mark here chose to use ethanoyl chloride rather than the anhydride, which was an acceptable alternative. Those who just stated "acyl chloride" did not score - perhaps they were confused between acyl and acetyl?

(ii)   Acceptable reagents included PCl_3, PCl_5 and $SOCl_2$.

Question 6

This was in general a high scoring question.

(a)(i)(ii) Some candidates confused these two reaction with each other. Reaction I needs a halogen carrier (e.g. AlCl_3, Fe, I$_2$) and *non-aqueous* chlorine. Reaction II requires light as a catalyst, again with non-aqueous chlorine.

(b)(i) Most correctly identified A as the unreactive compound, but did not explain their reasons clearly. The effect of chlorine on the reactivity of the aromatic ring is irrelevant. The point looked for was the extra strengthening of the C-Cl bond due to the delocalisation of chlorine's electrons into the ring (*or* the inability of the C-Cl bond to undergo nucleophilic attack due to the ring electrons getting in the way).

(ii) The most common error was to omit the inorganic product (OH$^-$ or NaOH) from the balanced equation

Question 7

(a) The identification of **Y** as nitrobenzene was successfully accomplished by only a minority of candidates. Many suggested chlorobenzene (even though they had written that chloromethylbenzene was unreactive in **Question 6**). The correct reagent and conditions for reaction I are conc HNO$_3$ + conc H$_2$SO$_4$ at 50-60°C. For reaction II candidates could have used *either* LiAlH$_4$ (**not** NaBH$_4$) *or* H$_2$ + Ni (**not** Pt, which would hydrogenate the ring). The most common reagent, Sn (*or* Fe) with conc HCl, was chosen by many.

(b)(i) The reaction of phenylamine with either H$^+$, H$_2$O or HCl was acceptable. The product had to show the ionic C$_6$H$_5$NH$_3^+$.

(ii)(iii) Phenylamine is *less* basic than ammonia because the *lone pair on nitrogen* is delocalised over the aromatic ring.

(c)(i) Either HNO$_2$ or NaNO$_2$ + HCl was accepted as the reagent. The temperature conditions need to be less than 10°C.

(ii) Many candidates knew the NaOH was needed, but far fewer appreciated that it needs to be in *aqueous solution* .

(iii) Common errors in the formula of the dye were to draw -N≡N- rather than -N=N-; to omit the CH$_3$ group on the phenolic ring; or to join the N=N to the CH$_3$ rather than to the ring. Although the CH$_3$ and OH groups had to be adjacent in the product, any orientation of the =N=N- was acceptable.

> **Paper 9701/05**
>
> **Practical Test**

General comments

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When this information is provided, the Examiners are able to make allowances where problems occur within a Session or Laboratory. It is not unknown for solutions in a particular area of a Laboratory to have deteriorated owing to adverse conditions. Where the seating plan and experimental results were provided the Examiners were able to make any necessary adjustments to accuracy marks.

The paper performed well and gave the majority of candidates the opportunity to display their practical skills. Marks were distributed over the upper part of the 30 mark range with comparatively few candidates scoring below 13 marks.

Comments on specific questions

Question 1

This paper followed normal practice in awarding three marks for the recording of results in the titration table:

One mark for recording all final burette readings to two decimal places (to nearest 0.05 cm^3).

A significant minority of candidates still record burette readings to only 1 decimal place.

One mark for two titres within 0.10 cm^3.

Time is often wasted by candidates who perform three or four accurate titrations and average all of them when the first two are within the 0.10 cm^3 tolerance.

One mark for obtaining a suitable average value **and showing how it is obtained** either by ticking the titres selected (as per rubric) or showing the calculation.

A number of candidates fail to indicate which values they used in obtaining the average or just tick one value. In the latter case the closest titre to that selected is noted by the Examiner to assess if a "spread penalty" is to be applied.

Accuracy marks

The "average" selected by the candidate (or by the Examiner where there was an error in subtraction in the titration table) was compared with the titre obtained by the Supervisor and 5 accuracy marks were available for differences:

Accuracy marks		Spread Penalty	
Mark	Difference from Supervisor/cm^3	Range used/cm^3	Deduction
5	up to 0.20	0.20+ to 0.25	1
4	0.20+ to 0.25	0.25+ to 0.30	2
3	0.25+ to 0.30	0.30+ to 0.35	3
2	0.30+ to 0.50	0.35+ to 0.40	4
1	0.50+ to 1.00	greater than 0.40	5
0	Greater than 1.00		

The spread penalty is applied where candidates have not shown good judgement in considering the titres to be used in calculating the "average". Candidates are expected to use results within a 0.20 cm^3 spread when calculating the average.

The Examiners observed good precision in the titres recorded in this examination resulting in consistent values. High accuracy marks were awarded to many candidates.

Calculations

(b) Nearly all candidates were able to calculate $\dfrac{\text{titre}}{1000} \times 0.02$.

(c) The majority of candidates were able to use the half equations to establish the ratio $MnO_4^- \equiv 5Fe^{2+}$. Most went on to correctly multiply the answer to **(b)** by 5 and gain the first mark but some divided by 5 after writing down the correct ratio. A few 1:1 and 1:2 ratios were seen.

Some candidates failed to convert their moles of Fe^{2+} into a concentration but the majority correctly multiplied by 40 and obtained the second mark.

(d) *Experiment 2*

Table 1.2 confused a small number of candidates whose final and initial burette readings were for the **FB 3** added. The Examiners accepted the volume of **FB 1** given by the candidate without the benefit of the subtraction being checked.

Some candidates did not transfer their titre figure from Experiment 1 and consequently did not plot this figure onto the graph.

The titrations were performed well – accuracy being assessed on the graph. **FB 3** was a solution of hydrogen peroxide which under acid conditions oxidised some of the Fe^{2+} leaving the remaining Fe^{2+} to react with the manganate(VII). The majority of candidates obtained very good straight lines with all four points lying close to the best-fit line.

(e) *Graph*

One mark was given for plotting **FB 1** on the *y axis* and **FB 3** on the *x axis.* The majority of candidates scored this mark but a few plotted **FB 3** against **FB 1**.

One mark was given for labelling the axes – including units (the latter were missed by many candidates)

One mark was given for linear scales and for the **FB 1** values being plotted over more than half the length of the available axis. Most candidates scored this mark – very few non-linear scales were seen but some unsuitable scales were selected.

Two marks were given for correctly plotting (to within $\frac{1}{2}$ small square in either direction) the four titres. One mark was given for three points correctly plotted, zero for less than three.

Examiners corrected the plotting of points where necessary. For candidates who selected "difficult" scales no plotting marks were available but the Examiner plotted their points onto a graph with a normal scale selection.

Accuracy marks were awarded for the fit of the correctly plotted points to the Examiner selected best-fit line.

	Mark
All four plotted points are within 1 horizontal or vertical square on either side of the line.	3
Three of the plotted points are within 1 horizontal or vertical square on either side of the line and the fourth point is within 2 horizontal squares.	2
Three of the plotted points are within 2 horizontal or vertical squares on either side of the line.	1

Three marks for accuracy were awarded to the majority of candidates.

(f)   One mark was given if the candidate had plotted a best-fit line for **their plotted points**. A line that passed through three points but missed the fourth point was considered to be a best-fit line.

(g)   A large number of candidates did not realise that the volume of **FB 3** required was the intercept on the **FB 3** axis when the volume of **FB 1** was 0.00 cm^3.

A number of candidates had ignored the instruction that the **FB 3** axis should extend to 30.00 cm^3 and chose a scale of 2,4,6,8,10,12 cm^3 on the *x axis*. The mark in **(g)** was lost by these candidates as there was no intercept on the *x axis*. A very small number of these candidates determined a gradient and obtained the mark for calculating the volume of **FB 3** where the intercept should be.

Question 2

(a)   Many varying pieces of apparatus were seen – some straight forward, others very fanciful! In assessing whether the first mark was to be given Examiners asked two questions.

- *Was the apparatus used for heating the caesium nitrate suitable*? Apparatus with "sharp" corners such as conical or flat-bottomed flasks were not considered to be suitable.

- *Would the apparatus successfully collect and measure the gas given off*? The second mark was for clearly labelling the apparatus used to collect the gas and giving a sensible capacity – likely to be found in a laboratory. 25 dm^3 gas syringes were considered to be unlikely.

(b)   If the gas had "encountered" water in the apparatus (even if it had not actually been bubbled through water) oxygen was accepted as the gas to be collected. If no water was included oxygen/nitrogen dioxide was accepted. A few of the better candidates gave oxygen/nitrogen or oxygen depending on the equation.

(c)   This was the most demanding part of the plan and for the majority of candidates only 1 mark (M_r of $CsNO_3$ =195) was awarded. Most candidates failed to see that the **maximum** volume of gas to be collected depended on which was the correct equation. The Examiners were looking for a statement such as: (if oxygen alone to be collected) – More gas produced in second equation. (if oxygen/nitrogen dioxide to be collected) – More gas produced in first equation. One mark was given for such a statement or for a calculation showing this information. The third mark was for calculating a mass of caesium nitrate to be used, using the correct equation, that would not produce more gas than could be held in the capacity apparatus drawn.

(d)   The Examiners were expecting that candidates would convert the mass of caesium nitrate and volume of gas(es) collected to moles (one mark) and calculate the mole ratio.

4 mole $CsNO_3 \equiv$ 5 mole gas   Equation 1
2 mole $CsNO_3 \equiv$ 1 mole gas   Equation 2

For the second mark to be awarded numbers had to be involved in the explanation. The question had asked how you would use your results – reference to brown gas was not given credit.

(e)   Most candidates picked up the toxic description of NO_2. Many stated that the experiment should be carried out in sealed apparatus to prevent loss of the NO_2. This was not awarded the mark as the candidates did not realise that if gas is lost from the apparatus the point of the experiment is lost. Dissolving the NO_2 in water was not allowed as a safety point. This left the use of a fume-cupboard or adequate ventilation in the laboratory. Use of a gas mask or respirator was allowed but not use of a face mask.

Comments on specific questions

Biochemistry

This remains a popular option and answers to the two questions were, on the whole, pleasing.

Question 1

In part **(a)** most candidates knew that tertiary structure referred to the overall 3-dimensional structure of the protein involving folding or coiling of the chains. Part **(b)** produced some very good answers, although sometimes the choices of examples were incorrect e.g. NaC*l* for electrostatic bonding. Most candidates could identify the bond types, but examples of R group interactions were again often not well chosen.

Question 2

The structure of DNA was generally well described in part **(a)**, with many candidates producing accurate, clearly-labelled diagrams. Part **(b)** was rather less well answered by some candidates whose answers lacked detail. The questions posed were quite specific and candidates need to address these to score well.

Environmental Chemistry

This option varies in its popularity in different parts of the world. The questions this year proved a little more testing and marks for this option were rather lower.

Question 3

Part **(a)** of this question hinged on candidates recognising that sulphur dioxide would absorb in the infra-red region of the spectrum. As a result it could re-emit energy back to the Earth's surface. In part **(b)**, despite the fact that the question asked about the formation of sulphate ions, candidates wrote equations for the formation of sulphuric acid from sulphur dioxide! Part **(c)** was answered rather better, with many candidates feeling on more familiar territory. A surprisingly few candidates knew very much about fluidised beds as a means of removing sulphur from coal during combustion.

Question 4

Part **(a)** of this question was answered very poorly on the whole, with few candidates showing that they knew anything about the weathering of limestone. Answers to part **(b)** were rather patchy with some good answers, but others in which candidates seemed to write down anything they thought might be vaguely relevant. Clearly a significant number of candidates do not know enough about the chemistry of soils.

Phase Equilibria

This remains a very popular option and one which produces some very good answers.

Question 5

The graph in part **(a)** caused few problems, except for those candidates who reversed the axes and were penalised one mark. Answers to **(a)(ii)** and **(b)(i)** and **(ii)** which were based on the graph were usually successful. The calculation of mole fraction in part **(c)** caused problems for weaker candidates, with many of them forgetting to add the potassium chloride and water. Part **(d)** was straightforward for good candidates, but a number of candidates simply drew the phase diagram of water and scored no marks.

Question 6

Lots of candidates scored both marks for the diagram in part **(a)**, with those losing marks failing to show the correct flow direction of the water in the condenser or omitting the thermometer or fractionating column. Part **(b)** was well attempted, although some candidates included an azeotrope. The explanation of theoretical plates was usually satisfactory. In part **(c)** many candidates showed good understanding of hydrogen bonding and the effects of chain length.

Spectroscopy

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

Question 7

Although a good number of candidates could describe two ways of preparing a solid for infra-red analysis, a significant number did not provide sufficient detail to score more than 2 of the 4 marks. In part **(b)(i)** candidates seemed to stop reading when they got to 'functional group' and did not look for those which would absorb in the infra-red region. In part **(b)(ii)** most candidates correctly identified –N-H. Part (c) produced some good answers, but too often they did not highlight specific absorptions.

Question 8

This question was answered rather better than **Question 7** on the whole. Most candidates correctly explained the origin of M+1 and M+2 peaks as ^{13}C and ^{37}Cl or ^{81}Br respectively. Any valid means of calculating *n* was accepted in part **(b)**, although the use of the M and (M+1) data was expected. Some candidates struggled to identify the two fragment ions in part **(c)**, partly because they did not think of what fragment could be lost to give *m/e* 57 (M-15). In part **(d)**, however, many candidates scored both marks.

Transition Metals

As with Phase Equilibria, this remains a popular and well answered option, with this year being no exception.

Question 9

Part **(a)** caused some confusion, for although almost all candidates knew that the 3d orbitals were split, many did not seem to know what caused two of these to be raised in energy. The Examiners were looking for an explanation based on the repulsion of the electrons due to approaching lone-pairs or negative charges on ligands. In part **(b)** a significant number of candidates showed incorrectly the loss of two 3d electrons rather than the 4s electrons. Most candidates did however know the reason for paramagnetism in **(b)(ii)**. Part **(c)** was a very good discriminator, with good candidates scoring full marks, and weaker candidate only picking up 1 or 2 marks. The key was to realise that only two of the three Cl ions were co-ordinated. The diagrams in part **(c)(iii)** were often two-dimensional which lost a further mark.

Question 10

Despite the fact that part **(a)** of this question dealt with a very familiar topic – the rusting of iron – answers were not always good, with a significant number getting the half-equations the wrong way round. Others referred to the protective oxide coat on magnesium instead of it acting as a sacrificial anode. In part **(b)**, most candidates knew of the reaction, but those who could use half-equations to explain why Fe^{2+} was a homogeneous catalyst were far fewer in number. The use of $E^{\ominus}$ values is a common area of questioning in this option and candidates need to be confident in their use.