



**Coimisiún na Scrúduithe Stáit
State Examinations Commission**

LEAVING CERTIFICATE EXAMINATION 2008

CHEMISTRY

**ORDINARY LEVEL CHIEF EXAMINER'S REPORT
HIGHER LEVEL CHIEF EXAMINER'S REPORT**

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1. General Introduction

The present Leaving Certificate syllabi for both Higher Level and Ordinary Level Chemistry were examined for the first time in 2002.

The structure and rubrics of both examination papers are the same. There is a total mark allocation of 400 marks. Each paper contains eleven questions and all questions are allocated 50 marks. The papers are divided into two sections. Section A has three questions on mandatory practical work. Section B contains eight questions on a range of topics across the syllabi. Candidates are required to answer eight questions, at least two of which must be from Section A.

1.1 Participation Rates in Chemistry

Table 1 Overall participation rates in Leaving Certificate Chemistry

Year	Candidates taking Chemistry	Percentage of total number of Leaving Certificate candidates
2003	6698	12.1
2004	7227	12.9
2005	7366	13.6
2006	7072	13.9
2007	6927	13.6
2008	7112	13.6

Table 2 Participation at Higher and Ordinary Levels

Year	Total no of Chemistry Candidates	Number of OL Candidates	Number of HL Candidates	Percentage OL Candidates	Percentage HL Candidates
2003	6698	967	5731	14.4	85.6
2004	7227	1022	6205	14.1	85.9
2005	7366	1333	6033	18.1	81.9
2006	7072	1358	5714	19.2	80.8
2007	6927	1197	5730	17.3	82.7
2008	7112	1210	5902	17.0	83.0

The increase in numbers taking Chemistry in 2008 is to be welcomed.

Table 3 Leaving Certificate Chemistry - participation by gender

Year	Number of Chemistry Candidates	Number of Females	Number of Males	Percentage Female	Percentage Male
2008	7112	3993	3119	56.1%	43.9%

2. Ordinary Level

2.1 Introduction

Overall statistical data for Ordinary Level Chemistry is presented in Section 2.2 together with some commentary on overall performance of candidates and gender differences. In Section 2.3, a detailed analysis of candidates' responses to this year's examination paper is presented including commentary on the quality of candidates' answering. Conclusions are presented in Section 2.4 and recommendations for students and teachers are presented in Section 2.5.

2.2 Performance of Candidates

Detailed statistics on the distribution of grades for Ordinary Level candidates are presented in Tables 4 to 6.

Table 4 Distribution of grades by ABC, D, and EFNG rate

Ordinary Level Chemistry			
Year	ABC %	D %	EFNG %
2003	78.7	14.6	6.6
2004	70.1	20.9	9.0
2005	63.7	24.5	12.0
2006	59.9	24.6	15.5
2007	58.5	24.7	16.8
2008	67.8	18.5	13.9

Table 5 Distribution of grades by percentage for Ordinary level candidates

Ordinary Level Chemistry – Grades by percentage					
Year	A	B	C	D	E, F & NG
2003	15.1	35.6	28.0	14.6	6.6
2004	9.2	29.7	31.2	20.9	9.0
2005	10.1	26.0	27.6	24.5	12.0
2006	7.0	25.4	27.5	24.6	15.5
2007	8.0	23.8	26.7	24.7	16.8
2008	11.7	30.5	25.6	18.5	13.9

Table 6 Detailed distribution of sub-grades by percentage for Ordinary level candidates

Ordinary Level Chemistry – Sub-grades by percentage														
Year	A1	A2	B1	B2	B3	C1	C2	C3	D1	D2	D3	E	F	NG
2003	5.9	9.2	10.8	12.4	12.4	9.7	9.8	8.5	6.7	3.7	4.2	5.1	1.4	0.1
2004	3.1	6.1	8.5	11.2	10.0	11.7	10.5	9.0	6.8	6.1	8.0	5.1	3.2	0.7
2005	4.0	6.1	7.7	8.6	9.7	9.7	9.1	8.8	8.9	8.3	7.3	7.8	3.7	0.5
2006	2.1	4.9	6.0	8.6	10.8	8.2	9.9	9.4	7.1	7.2	10.3	8.2	6.0	1.3
2007	3.3	4.7	5.0	8.4	10.4	9.0	9.0	8.7	8.0	5.7	11.0	10.4	5.3	1.1
2008	5.3	6.4	9.2	9.7	11.6	9.8	7.9	7.9	6.4	4.8	7.3	7.8	4.9	1.2

There was a significant improvement in candidate performance at Ordinary Level in 2008.

Table 7 Distribution of sub-grades by gender at Ordinary level

Ordinary Level Chemistry - Distribution of Sub-grade by gender													
Grade	A1	A2	B1	B2	B3	C1	C2	C3	D1	D2	D3	E, F & NG	
Overall (1210)	64	80	109	117	140	119	95	95	77	58	88	168	
Percentages	5.3	6.4	9.2	9.7	11.6	9.8	7.9	7.9	6.4	4.8	7.3	13.9	
Total Female (595)	44	53	51	71	61	52	43	47	37	30	38	68	
% Female	7.4	8.9	8.6	11.9	10.3	8.7	7.2	19.8	6.2	5.0	4.4	11.4	
Total Male (615)	20	27	58	46	79	67	52	48	40	28	50	100	
% Male	3.3	5.4	9.4	7.5	12.4	10.9	8.5	7.8	6.5	4.6	8.1	16.3	

As is evident from the table, female candidates at Ordinary Level outperform male candidates with a higher A grade return of 16.3% (the overall A grade rate was 11.7% and the A grade rate for male candidates was 8.7%). Similarly, the percentage of female candidates receiving A, B and C grades was 70.9% with the overall figure being 67.7% and the A, B and C grade return from male candidates being 64.6%. At the other end of the spectrum the E, F and NG return for female candidates was 11.4% compared with an overall figure of 13.9 % and 16.3% of male candidates.

2.3 Analysis of Candidate Performance

A detailed analysis of candidate performance across all questions on the examination paper is presented in Table 8.

Table 8 Statistical data on the answering of the Ordinary Level examination paper

Ordinary level Chemistry examination – analysis of questions*					
Question	Percentage of attempts	Rank order in terms of popularity	Average Mark with (%)	Rank order in terms of mark	Topic
1	74.1	8	26.9 (53.8)	9	Organic
2	88.3	2	35.4 (70.8)	2	Volumetric
3	87.5	3	33.5 (67.0)	5	Flame tests
4	90.8	1	38.3 (76.6)	1	Short items
5	58.3	11	29.5 (59.0)	8	Atom & Bonding
6	80.0	7	32.9 (65.8)	6	Organic
7	72.5	9	23.1 (46.2)	11	Acids
8	70.8	10	24.9 (49.8)	10	Water
9	85.8	5	34.3 (68.6)	3	Organic
10	85.0	6	32.3 (64.6)	7	General
11	87.5	3	34.3 (68.6)	3	General

* These statistics have been drawn from an analysis of approximately 10% of scripts which were selected at random.

Question 4 on the paper was the most popular followed by question 2 and question 11. All of the questions had significant response rates with only question 5 falling below an attempt rate of 60%. The observation is made that this year the questions that were based on organic chemistry (i.e. questions 1, 6, 9 and also one of the three parts in question 11) had at least mixed popularity. In 2005 the three and a half questions that were based on organic chemistry were amongst the least popular questions on the examination paper. The evidence for an improvement in the popularity of questions on organic chemistry seen this year is welcome and hopefully represents an increased engagement with this area of study.

The questions in Section A were on the topics of preparative organic chemistry, volumetric analysis and flame tests. Responses to Question 1 were disappointing and possibly suggestive that not all candidates had conducted this practical. Question 4, which contained short response questions from across the syllabus, was the most popular questions (91% attempt rate). It was also the best answered question on the examination paper.

Question 5, which was based on atomic structure and bonding, was the least popular question on the examination paper, and only ranked 8th in terms of mark awarded. This was somewhat surprising given that about one third of the marks in the question related to the completion of a table of properties of sub-atomic particles.

Question 7, which was a standard question on acids was 9th in terms of popularity and was also the least well answered question on the examination paper.

Question 8, which related to water and sewage treatment, was also low in popularity and the second poorest answered question on the examination paper.

Few candidates attempted less than eight questions and many candidates answered at least one extra question. However, the attempt made at the disregarded question often yielded few marks. It was also noticeable that many candidates performed poorly (getting less than 20 marks, 40%) on one or more of the questions included in their total mark. An examination of the scripts awarded marks in the range the 200 – 260 (D1 – C2) from the sample analysed showed that many of these candidates included one or more questions for which they received less than 20 marks (40%) as a contributor to their final result. This suggests that whilst many of these candidates know parts of the course reasonably well their overall mark was suppressed by a lack of knowledge across the course. A similar observation was made in 2005.

The overall standard of answering at Ordinary Level tends to be somewhat variable from year to year. This may be a feature of the relatively small cohort size (<3% of the total Leaving Certificate cohort). This year was characterised by a significant improvement in overall candidate performance on recent years, but the number of candidates not achieving a grade D or higher in the examination remains high. Examiners noted that many of these candidates displayed little evidence of having engaged with the subject.

Question 1 [Ethanoic acid] Average mark 26.9 (53.8) Response 74%

This question was the least popular of the three practical-based questions and the least well answered of the questions on organic chemistry on the examination paper. Parts (b) and (h) were the better-attempted parts. This particular practical is one of the longer on the course. Examiners noted that from the evidence of the scripts, it appeared that many candidates may not have carried out or seen this experimental procedure. A similar observation was made a few years ago when the preparation of ethanal was examined.

Question 2 [Volumetric analysis] Average mark 35.4 (70.8%) Response 88%

This question was the second most popular and the second best answered on the paper. It was a traditional volumetric analysis question. All candidates recognised the equipment and made some attempt at describing how the solution was prepared. A significant number of candidates could not name a suitable indicator or give the colour change observed [part (e)]. The calculation was avoided or poorly answered by many

candidates [part (f)]. The overall quality of answering suggests that a significant amount of wet-chemistry is carried out in schools.

Question 3 [Flame tests] Average mark 33.5 (67%) Response 88%

This question ranked third in terms of popularity and slightly lower in terms of marks awarded (5th). Part (e) presented most difficulty with many candidates not knowing the required test. In part (b), a lack of detail in responses was the primary problem noted. From the overall quality of answering it appeared that the majority of candidates had carried out or at least seen this practical activity.

Question 4 [Short items] Average mark 38.3 (76.6%) Response 91%

This question was first in terms of popularity and highest in terms of average mark awarded. Definitions were well answered. One of the more common errors observed involved candidates entering a “+” between the two concentrations in the expression for the equilibrium constant in part (h). Otherwise, candidates scored reasonably well across all of the items.

Question 5 [Atom & Bonding] Average mark 29.5 (59%) Response 58%

This was the least popular question on the examination paper. It was also one of the least well answered questions. Part (a) was, for the most part, well answered. However, parts (b) and (c) were only answered well by a small number of candidates. The definition and application of electronegativity values presented a problem to most candidates, as did both elements of part (c) on fluorine.

Question 6 [Fuels] Average mark 32.9 (65.8%) Response 80%

The seventh most popular question on the examination paper figured marginally better (6th) in terms of average mark awarded. The most common areas where candidates lost marks here were some looseness in defining hydrocarbons and fuels [part (a)] and not providing the structural formula for ethyne [part (c)]. Bitumen was the most popular correct answer to part (d).

Question 7 [Acids] Average mark 23.1 (46.2%) Response 73%

This was the ninth most popular question on the examination paper and the least well answered question. Few candidates could give the name of a commonly used base or a use made of it [part (a) (ii)]. The calculations in parts (b) (ii) and (iii) were regularly not attempted.

Question 8 [Water] Average mark 24.9 (49.8%) Response 71%

This question was the second least popular and second lowest in terms of average marks awarded. In part (a) filtration and screening were regularly confused. “Fluorine” was regularly written down instead of “Fluoride”. In part (b), attempts at explaining

secondary sewage treatment were poor and a significant number of candidates stated incorrectly that tertiary treatment involves the addition of phosphates and nitrates.

Question 9 [Organic] Average mark 34.3 (68.6%) Response 86%

This was the fifth most popular question and ranked third in terms of average mark awarded. The most common error was to assign the name “ethanoic acid” to Z rather than “ethanal”. Examiners noted that questions on organic chemistry were answered well. Questions on ethane and ethyne tended to be answered well, whilst questions on the preparation of ethanal and ethanoic acid tended to be less successful.

Question 10 [Two parts from three] Average mark 32.3 (64.6%) Response 85%

This was a popular and reasonably well-answered question. Part (a) was most popular and well answered. Part (b) was least popular and when it was attempted the responses were generally poor. This was also the case in Part (c).

(a) [Rates]

This part was very well answered by the majority of candidates who attempted it. The quality of graph drawing and interpretation of the graph were excellent. Many candidates achieved full marks.

(b) [Instrumentation]

This was probably the least well answered part of the entire examination paper. The principles underpinning the techniques were, for the most part, not known.

(c) [Equilibria]

Many candidates performed well in (i) and (ii). However, very many candidates did not attempt part (iii) or when they did, the quality of responses was varied.

Question 11 [Two parts from three] Average mark 34.3 (68.6%) Response 88%

This was the third most popular question on the examination paper and was third in terms of mark awarded. Part (a) was the most popular and best answered part. Part (b) next most popular and it was also well answered. Part (c) was attempted by very few candidates. These tended towards sub-part A and answered it to a reasonable standard. Attempts at sub-part B were very rare.

(a) [History of elements and atomic structure]

This was well answered by many candidates.

(b) [Fuels]

Apart from difficulty with the second element of part (ii) where many candidates could offer no suitable word to describe the form of catalysis occurring, this question was well answered.

(c) [Options]

A Option 1

This was not popular and not very well answered. Most candidates confused “batch” and “continuous” processes.

B Option 2

This was not popular and was generally poorly answered.

2.4 Conclusions

- In general candidates followed the instructions on the examination paper correctly and attempted to answer the question that was being asked. In the vast majority of cases the manner in which candidates presented material was satisfactory.
- The standard of answering was disappointing in some cases, and Examiners noted that candidates who received E, F and NG grades did not demonstrate the required knowledge, detail and accuracy required to reach a grade D.
- Many candidates attempted one or more additional questions and many candidates attempted all three questions in Section A.
- Some of the responses to the question based on the preparation of ethanoic acid suggested that some candidates may not have carried out the experiment.
- It was noted that concerns raised in the 2005 Chief Examiner's Report had been addressed. These included, for example:
 - Improved knowledge of simple definitions
 - Improved candidate performance on the short questions
 - Some improvement in the number and quality of attempts at questions on organic chemistry
- A number of points raised in the 2005 Chief Examiner's Report remain a cause for concern. These included, for example:
 - Candidates not being able to name a suitable indicator in question 2 or describe the colour change at the end-point
 - Recognition that the combination of reduced choice and candidates having to answer eight questions requires good course coverage by the candidate.

2.5 Recommendations to Teachers and Students

- Further attention could be given to the following topics:
 - Volumetric analysis – in particular indicators and calculating concentrations
 - Organic chemistry – in particular mandatory experiments involving ethanal, ethanoic acid and soap.
 - Atomic structure and bonding – in particular the definition and application of electronegativity values.
 - Water and sewage treatment
- As organic chemistry is an important element of the syllabus and the examination, students should devote an appropriate amount of time to this area.
- The use of suitable reinforcement and revision material by Ordinary level candidates is recommended.
- Past examination papers, the sample papers, and the supplementary questions that were issued prior to the first examination in 2002 should be used as practice and as a guide to question lay-out and content.

3 Higher Level

3.1 Introduction

Overall statistical data for Higher Level Chemistry is presented in Section 3.2 together with commentary on overall performance and gender differences. In Section 3.3, a detailed analysis of candidates' responses to this year's examination paper is presented including commentary on the quality of candidates' answering. Conclusions are drawn in Section 3.4 and recommendations for candidates and teachers are presented in Section 3.5.

3.2 Performance of Candidates

Statistics on the distribution of grades for Higher Level candidates are presented in Tables 9 to 6.

Table 9 Distribution of grade by percentage in grade bands ABC, D, and EFNG for Higher level candidates

Higher Level Chemistry			
Year	Percentage A – C Grades	Percentage D Grades	Percentage E - NG Grades
2003	78.8	15.2	5.8
2004	76.0	16.3	7.8
2005	76.8	16.5	6.8
2006	75.7	17.0	7.2
2007	79.0	15.6	5.5
2008	79.1	15.5	5.8

Table 10 Distribution of grades by percentage for Higher Level candidates

Higher Level Chemistry – Grades by percentage					
Year	A	B	C	D	E, F & NG
2003	26.0	30.0	22.8	15.2	5.8
2004	23.0	30.1	22.9	16.3	7.8
2005	22.2	30.4	24.2	16.5	6.8
2006	22.1	28.9	24.7	17.0	7.2
2007	21.0	33.1	24.9	15.6	5.5
2008	23.7	31.0	24.0	15.6	5.7

Table 11 Distribution of sub-grades by percentage for Higher level Candidates

Higher Level Chemistry – Sub-grades by percentage														
Year	A1	A2	B1	B2	B3	C1	C2	C3	D1	D2	D3	E	F	NG
2003	15.1	10.9	10.2	10.0	9.8	7.8	7.8	7.2	5.2	4.9	5.1	4.2	1.2	0.4
2004	12.8	10.2	10.0	10.7	9.4	8.3	7.5	7.1	5.7	5.0	5.6	5.6	1.9	0.3
2005	11.4	10.8	10.9	9.9	9.6	9.2	7.4	7.6	5.4	5.6	5.5	4.8	1.6	0.4
2006	12.2	9.9	9.2	10.1	9.7	8.7	8.5	7.5	6.2	5.3	5.5	5.1	1.8	0.3
2007	9.9	11.0	10.7	11.6	10.8	9.2	8.3	7.4	5.4	4.9	5.3	3.6	1.6	0.3
2008	13.2	10.5	10.7	10.3	10.0	8.6	8.0	7.3	5.4	4.6	5.6	4.2	1.3	0.3

Table 12 Breakdown of sub-grades by gender (Higher Level)

Higher Level Chemistry - Distribution of Sub-grade by gender													
Grade	A1	A2	B1	B2	B3	C1	C2	C3	D1	D2	D3	E, F & NG	
Overall (5902)	779	621	631	610	589	517	473	429	317	273	329	334	
Percentages	13.2	10.5	10.7	10.3	10.0	8.6	8.0	7.3	5.4	4.6	5.6	5.7	
Total Female (3398)	422	371	376	384	368	314	283	239	166	154	162	159	
% Female	12.4	10.9	11.1	11.3	10.8	9.2	8.3	7.0	4.9	4.5	4.8	4.7	
Total Male (2504)	357	250	255	226	221	203	190	190	151	119	167	175	
% Male	14.3	10.0	10.2	9.0	8.8	8.1	7.6	7.6	6.0	4.8	6.7	7.0	

Examiners noted that the overall standard of responses of Chemistry candidates remains good. Year-on-year variations in grade distribution is relatively small with an average return of A grades around 23% and a combined A+B+C grade return of around 78% in recent years. Lower than expected average scores were obtained by candidates on questions on recrystallisation, relative molecular mass determination and soap preparation.

In the period 1998 to 2002 the percentage of candidates receiving grades A to C at Higher Level increased from 69.9% to 77.1%. The percentage of candidates a Grade A increased from 15.7% to 23.0%. Over the same period the percentage of candidates awarded E, F or NG grades fell from 9.9% to 6.9%. The overall standard candidate responses remains very good with many excellent candidates in evidence.

As is evident from the table, male candidates slightly outperformed female candidates with a higher A grade return of 24.3% (the overall A grade rate was 23.7% and the A grade rate for female candidates was 23.3%). This is an exact reversal of the situation observed in the Chief Examiner's Reports of 2002 and 2005. The percentage of female candidates receiving A, B and C grades was 80.1%. The overall ABC combined figure was 78.7% and the A, B and C grade return from male candidates was 75.5%. The E, F and NG returns for female candidates was 4.7% compared with an overall average of 5.7%, and 7.0% for male candidates.

3.3 Analysis of Candidate Performance

A detailed analysis of candidate performance across all questions on the examination paper is presented in Table 13.

Table 13 Statistical data on the answering of the Higher Level examination paper

Higher level Chemistry examination – analysis of questions*					
Question	Percentage of attempts	Rank order in terms of popularity	Average Mark with (%)	Rank order in terms of mark	Topic
1	95.8	1	36.7 (73.4)	1	Volumetric
2	72.0	6	35.4 (70.8)	3	Organic
3	80.0	4	31.1 (62.2)	10	Rates
4	90.8	3	35.2 (70.4)	4	Short items
5	68.8	8	35.2 (70.4)	4	Atom
6	94.0	2	34.6 (69.2)	6	Organic
7	78.8	5	36.0 (72.0)	2	Organic
8	42.5	11	31.4 (62.8)	9	Acids/Water
9	48.3	10	25.2 (50.4)	11	Equilibria
10	69.0	7	33.7 (67.4)	7	General
11	55.3	9	32.7 (65.4)	8	General

* These statistics have been drawn from an analysis of approximately 8% of scripts which were selected at random.

Question 1 on the paper was the most popular followed by question, 6, 4, 3 and 7. Question 1 on the analysis of vinegar was also the best-answered question followed by questions 7, 2, 4 and 5. An increase in popularity and in the average mark awarded in the organic chemistry questions (questions 2, 6 and 7) was observed compared with that seen three years ago. Examiners commented on the quality of some of the answering of the questions on organic chemistry. However, the standard of responses on organic theory in question 9 was more varied. Questions 9, 10 and 11 were the least popular questions and were also least well answered. One of these three questions was regularly attempted as an extra question.

Examiners noted an increase in the number of candidates showing molecular formulae and the addition of atomic masses when working out even simple relative molecular masses.

Very few candidates (~2%) attempted less than eight questions. Over 60% of all candidates attempted at least one extra question and 24% of candidates answered two or more extra questions. Nearly 50% of candidates attempted all three questions from Section A. These observations are suggestive of three things. Firstly, time does not appear to be an issue in respect of completing the examination. Secondly, since

candidates have the information to attempt extra questions it suggests that there is good coverage of the syllabus by many candidates and, thirdly, the fact that nearly half of all candidates attempt all the questions in Section A suggests that good attention is being paid to practical work in many schools. However, the number of candidates attempting question 11 (c) B this year was exceedingly small.

Question 1 [Volumetric analysis] Average mark 36.7 (73.4%) Response 96%

This was the most popular and best-answered question on the paper. Familiarity with volumetric techniques was generally quite good. Some candidates had difficulty in giving an adequate answer to part (a). "To avoid wastage of chemicals" was a common response. Part (b) was generally well-answered. In part (c) the indicator (mostly *phenolphthalein*) and colour change were generally known. A small number of candidates gave the colour change in reverse. A small number of candidates incorrectly chose *methyl orange*. The use of the term "clear" instead of "colourless" was occasionally noted. Many candidates failed to give an adequate justification for the choice of indicator. The calculations in part (d) showed up the usual errors. Many candidates filled in the volumetric analysis formula incorrectly; quite a few used all three titration figures to find the average titre; and there was the usual problem in some cases of multiplying, or in some cases dividing the molarity by 4, presumably to allow for the 250 cm³ volumetric flask. The remaining parts of the calculation were reasonably well answered. Some candidates gave the old name "formic acid" as the answer to part (e).

Question 2 [Organic practicals] Average mark 35.4 (70.8%) Response 72%

This question was the least popular question in Section A. It was, however, one of the better-answered questions on the paper as a whole. Paper chromatography was chosen by most candidates in part (a). The answering was generally quite good, but many candidates did not describe the application of the mixture to the paper and/or the movement of the eluent on the paper. Part (b) was very poorly attempted, and most candidates gave an explanation in terms of different solubilities. The answer to part (c) and part (d) were generally known. Clove oil/cloves was almost universally offered as the answer to the latter part. Most candidates were able to answer to part (e). Part (f) was also well-answered though "emulsion" was regularly given as the description. Most candidates were able to deal with the calculation in part (g).

Question 3 [Rate of reaction] Average mark 31.1 (62.2%) Response 80%

This was one of the more popular questions on the examination paper. However, the answering was the poorest in Section A and the second poorest on the paper as a whole. In part (a), few candidates drew or described the hazard symbol. The symbol for corrosive was a common incorrect answer; the symbols for explosive and poison were also encountered. Part (b) was reasonably well-answered, but H₂ was often given as a product. The inclusion of MnO₂ as a reactant was seldom seen. Part (c) was well-answered but some diagrams did not show the arrangement for mixing at a precise time. Many candidates also failed to show a device for measuring the gas produced, and test tubes and gas jars were commonly suggested for the collection of the gas. The graphs

drawn for part (d) were generally good though some candidates plotted 50.5 cm^3 at the 55 cm^3 mark and sometimes the axes were poorly set up. A small number of candidates did not use graph paper. Many candidates had difficulty explaining why the graph is steepest at the beginning. In part (e) (i), a considerable number of candidates did not appear to know how to get the instantaneous rate from the graph but got some marks for drawing a correct tangent. Some candidates drew the tangent in the wrong position. An unexpectedly large number of candidates could not do the calculation in part (e) (ii), and many, who did know how to do the calculation used 22.4 l as the molar volume.

Question 4 [Short items] Average mark 35.2 (70.4%) Response 91%

Part (a) was generally correctly answered. Some candidates gave the configuration for the aluminium atom. Most candidates obtained full marks for part (b), though some candidates answered in terms of “arranging” rather than “discovering” atomic number. Part (c) was poorly answered. Many candidates seemed unable to distinguish between ‘what an entity is’ and ‘what its properties are’. Part (d) was poorly answered. “Atomic absorption spectrometry” was a very common incorrect answer. Attempts at part (e) were generally poor especially part (i) where CaCO_3 , Ca^{2+} , Mg^{2+} were commonly given. Answers to part (f) were generally correct. Attempts to part (g) were nearly always correct, with most candidates referring to the “two lone pairs in water”. Attempts at part (h) were poor and the item was regularly not attempted. Virtually all candidates could answer part (i) correctly. The number of candidates who could complete and balance the equation in part (j) was small. The first element of part (k) was reasonably well answered. Attempts at the second element were few and generally poor. This is consistent with the poor uptake of this option as evidenced by the attempt rate of question 11 (c) B.

Question 5 [Atomic theory] Average mark 35.2 (70.4%) Response 69%

Candidates had difficulties with the use of electronegativity values to predict whether a bond is non-polar or slightly polar. Part (a) was very well answered. “Relative” or “measure of” was occasionally omitted from the definition. Part (b) was answered well by almost all candidates. The prediction of polarity from electronegativity difference led to methane being frequently described as polar covalent in part (c). The poor answering in part (d) was widespread. Most candidates had correctly identified in part (c) that the bonding in MgCl_2 is ionic; yet in part (d) many described it with covalent bonds. In part (e) most candidates knew the meaning of intermolecular but quite a few stated or described it as “bonding within the molecule”. In part (g), most candidates accounted correctly for the effect of the positively charged rod on water and cyclohexane. However, many thought that the thin stream of water would be “repelled” by the negatively charged rod.

Question 6 [Organic] Average mark 34.6 (69.2%) Response 94%

This question was reasonably well answered. In part (a) (i), almost all candidates knew the definition. Likewise element (ii) was well answered. Most of the errors observed were in the structure of heptane, with quite a few candidates giving the molecule a chain

of six or sometimes eight carbon atoms. In element (iii), many candidates could only identify one correct fraction. LPG, diesel and kerosene were commonly encountered incorrect answers. Naphtha was the usual fraction omitted. Element (iv) was well answered, but quite a few candidates gave only one acceptable change when two were required. In element (v), most candidates were able to identify an oxygenate, usually MTBE. However, as in (iv), many candidates could only give one reason why oxygenates are added to petrol. In part (b) some candidates encountered difficulty with balancing the equation. The most common error was having $3\frac{1}{2}\text{O}_2$ in the equation, presumably due to not taking into account the presence of the oxygen atom in ethanol. The calculation was handled well by most candidates.

Question 7 [Organic] Average mark 36.0 (72.0%) Response 79%

This was very well answered and a very large number of candidates scored full marks on this question. Part (a) was generally well answered. Most definitions of chemical equilibrium were good but some candidates failed to answer yes/no to the question as to whether or not the reaction had ceased. Some also found it difficult to give an adequate explanation for the fact that the reaction had not ceased. In part (b), the correct equilibrium constant expression was given in most cases. In the calculation, some candidates had difficulty in correctly working out the molar quantities at equilibrium. In part (c), most candidates knew Le Chatelier's principle though some did not indicate that it refers to a reaction at equilibrium. The predictions and explanation in (i) and (ii) were reasonably well answered. Some, however, correctly explained that the reaction would shift in the backward (exothermic) direction in order to raise the temperature, but failed to state the effect on the yield of HI or on the colour intensity. Almost all candidates knew that pressure change would have no effect because the reaction has the same number of molecules on both sides of the equation.

Question 8 [Acids-bases/water] Average mark 31.4 (62.8%) Response 43%

This was quite a poorly answered question. Many candidates were unable to write an expression for the self-ionisation of water in part (a) (i). Part (a) (ii) was not answered well and many candidates confused K_w with K_c . Attempts to derive the pH of pure water from the value of K_w were very often inadequate. In element (iii), the pH calculations were often correct but quite a few candidates subtracted their initial answer from 14. Part (b) (i) was very well answered. Many included screening but often omitted filtration from their attempt. Many candidates described all stages of the water purification process. Element (ii) was generally well answered, but very many candidates gave "fluorine" instead of "fluoride" as one of their chosen chemicals.

Question 9 [Equilibrium] Average mark 25.2 (50.4%) Response 48%

This question was not very well answered. The unpopularity and poor answering may be partly due to the reaction mechanism in (d) which accounted for more than one-third of the marks. Attempts at part (a) were generally very good. A few candidates omitted the heat source or placed it incorrectly. In part (b), the majority of candidates drew the

structure of propene, the second member of the series and not butene the third as was asked. These candidates were, however, able to correctly identify planar and tetrahedral carbon atoms. In part (c), virtually all candidates could explain the term “unsaturated”. Part (d) was generally poorly answered. The bridged intermediate or a localised carbonium ion were rarely encountered. Candidates often attempted to draw a carbonium ion and omitted the positive charge. Very few candidates could make a reasonable attempt at their names or structural formulae. Only a small minority of candidates could adequately explain how the formation of these compounds supports the reaction mechanism. In part (e), the majority of candidates were able to name the polymer. The drawing of two repeating units, however, presented problems for many. Some candidates showed double bonds between the carbon atoms. Others did not seem to understand what is meant by ‘the repeating unit of a polymer’.

Question 10 [Two parts from three] Average mark 33.7 (67.4%) Response 69%

The quality of answering in this question was moderate. Within the question, parts (a) and (b) were the popular choices with part (b) the slightly more popular of the two. A number of candidates also attempted part (c) with some candidates, as usual, attempting all three parts.

(a) [Water]

Parts (i) & (ii) were well answered. “Known volume” was often omitted. Conversion to ppm appeared not to be well understood in some cases. Part (iii) was generally well answered. A large majority of candidates gave the white precipitate with silver nitrate and also the solubility of the precipitate in ammonia solution. A small number of candidates gave the test for free chlorine in swimming pool water

(b) [Redox]

Definitions in parts (i) & (ii) were generally well known. In part (iii), some candidates failed to identify clearly that the iodide ion was the species oxidised in the first equation. Also, some candidates gave the iodine molecule as the species reduced in the second equation but did not identify it as the oxidising reagent. Attempts at part (iii) were reasonably good. However, a number of candidates failed to correctly balance one or other of the two equations, the second equation being the more often incorrect.

(c) [Energy levels/spectra]

Part (i) was well answered. In part (ii), the definition of “ground state” created some problems; “excited state” was well defined. In part (ii), most candidates knew the name given to the series of lines but names other than Balmer were occasionally encountered. Very few candidates did well in part (iii). Many candidates simply gave a set of points designed to fit most questions of this type without showing much understanding of what was being asked.

Question 11 [Two parts from three] Average mark 32.7 (65.4%) Response 55%

The answering was reasonably good. Part (a) was the most popular part followed by part (b) and then part (c) A; part (c) B was extremely rarely chosen. As in Question 10, quite a few candidates attempted all three parts.

(a) [Reduction of alcohols]

This was generally well answered. “Sodium dichromate” was an occasional incorrect answer. Part (ii) was reasonably well answered but “propanol” was commonly offered instead of the required “propan-1-ol” or “1-propanol”. Part (iii) was well answered. Some candidates had problems with the structure, but the fact that the alcohol is a “secondary alcohol” was widely known. In part (iv), most candidates knew that “propanal” would be the compound oxidised, but a small number of candidates gave an inorganic product (e.g. Cu^+) of the reaction. Virtually all candidates who attempted part (v) of this part of the question answered it correctly.

(b) [Carbon dioxide emissions calculations]

This question was successfully answered by virtually all who attempted it. The only error commonly seen was in the volume calculation in (iii) where many candidates used 22.4 l as the molar volume.

(c) [Options]

A [Carbon dioxide/greenhouse effect]

The definitions required in part (i) were not well known. Some candidates confused the “greenhouse effect” with “damage to the ozone layer”. The trapping of “ultra-violet” rather than “infra-red” radiation was a fairly common error. The definitions given for “acidic oxide” were generally poor. Part (ii) generally well answered, while part (iii) was poorly answered. “Carbonic acid” was fairly commonly given as one of the species produced, but the other two species were rarely identified correctly. “Calcium carbonate” and “calcium hydrogencarbonate” were common incorrect answers. Part (iv) was well answered. “Limestone”, “lime” and “sodium hydroxide” were the popular, and correct, choices.

B [Aluminium]

There were few attempts at this part of the question.

3.4 Conclusions

- In general, candidates followed the instructions on the examination paper correctly and attempted to answer the question that was being asked. In the vast majority of cases, the manner in which candidates presented material was satisfactory.
- Examiners noted that candidates who received E, F and NG grades tended to lack the knowledge, detail and accuracy required. It would appear that some of these candidates would have been better suited to the Ordinary Level examination.
- Knowledge of definitions demonstrated by candidates was an improvement on the last two years. However, some candidates occasionally reworded definitions without fully appreciating that accuracy was being lost. The number of mathematical problems has decreased in recent years. The application of “consequential marking” has removed the problem of candidates who make an error early in answering a mathematical problem losing large quantities of marks.
- Many candidates attempted additional questions. However, Examiners noted that it appeared that some candidates may not have studied all practicals in preparation for the examination.
- A number of positive points noted in respect of concerns raised in the 2005 Chief Examiner’s Report appear to be showing signs of resolution. These included:
 - Improved knowledge of definitions
 - Improved performance on the short questions
 - Some improvement in the number of attempts and quality of attempts at questions on organic chemistry
- A number of points raised in 2005 and/or in 2002 which remain a cause for concern included:
 - Limited engagement with some of the practicals in organic chemistry e.g. preparation of ethanal, preparation of ethanoic acid and the preparation of soap
 - Limited understanding of the mechanism of addition involved in the halogenation of alkanes and the mechanism for the ionic addition to alkenes, and the experimental evidence that exists for both mechanisms.
 - Limited understanding of the links between atomic structure and spectra.
- Examiners noted that candidate performance in the following topics could improve:
 - The principle on which all chromatographic techniques are based

- Describing how to start a rate of reaction experiment and a volume measurement simultaneously
- The use of electronegativity values to predict the polarity in bonds
- The self-ionisation of water and simple pH calculations
- The options question 11 (c) A & B

3.5 Recommendations to Teachers and Students

- Accuracy of language, particularly in relation to the statement of laws and definitions, should be further emphasised.
- Students should be encouraged to practise short-answer type questions.
- The three mandatory experiments in Section A should be comprehensively covered.
- Further practice is recommended in stoichiometry-related questions.
- Students should be encouraged to develop an understanding of atomic theory and its link to spectra.
- As organic chemistry is a significant element of the syllabus and the examination, an appropriate amount of time should be devoted to it.
- Emphasis should be placed on the evidence underpinning reaction mechanisms as is given to reproducing the steps in a reaction mechanism.
- Students are advised to develop examination technique. In particular, they should attempt the required number of questions and check that they have answered them fully before attempting additional questions.
- Past examination papers, the sample papers, and supplementary questions that were issued prior to the first examination in 2002 should be used as practice and as a guide to question layout and content.