NQ NATIONAL QUALIFICATIONS Review

SCOTTISH QUALIFICATIONS AUTHORITY

National Qualifications Review Report

Chemistry

Subject Review: Chemistry

1 Subject summary

Summary of Courses

Access 3 Chemistry
Intermediate 1 Chemistry
Intermediate 2 Chemistry
Higher Chemistry
Advanced Higher Chemistry

Summary of Recommendations

Recommendations which can be implemented this session (2001-2002)

1. Use of 20-hour Units in AH
The 20-hour Units should be retained (see section 2.1)

Recommendations which can be implemented for next session (starting August 2002)

2. Threshold scores in NABs at Advanced Higher
The threshold score for the NAB tests should be reduced from 18/30 to 15/30 for NABs at Advanced Higher (and 10/20 for the 20-hour Unit tests). This change is being made because of clear evidence from 2001 that candidates who narrowly failed NABs at their first attempt went on to pass the examination. (see section 2.3).

3. Outcome 3 — all Units at Intermediate 1– Advanced Higher (excluding Advanced Higher *Investigation* Unit)
Reduce the volume of internal assessment evidence required for assessment of Outcome 3 in Chemistry Courses at Intermediate 1 to Advanced Higher. This will be achieved by requiring candidates to produce evidence once for Outcome 3 in each Course, and using it for Outcome 3 in all three Units of the Course. This will replace the existing requirement to produce three distinct pieces of evidence. This will require some minor changes to the Units, as currently the Outcomes and evidence requirements make reference to the context of the Unit.

4. Use of grid questions in Higher and Advanced Higher examinations
Grid questions should be removed from Higher and Advanced Higher examinations, and replaced by additional multiple choice questions (see section 2.4).

5. Assessment load in AH — 2·5-hour Examination, Investigation Report of up to 2000 words, and 20-minute Visiting Examiner Interview
The Examination and Investigation Report should be retained, but the 20-minute interview with a Visiting Examiner should be dropped. Assessment guidelines for the Investigation Report should be revised to reflect this. (See section 2.4. Sections 2.5 and 2.6 also refer to this issue.)

Mid-long term recommendations

6. Review of Chemistry
SQA should begin a long-term project to update and revise Chemistry Courses to address the relative difficulty and decline in popularity of the subject (see section 2.4).

2 Course report

2.1 Summary of Courses

Component Units

Acc 3 Chemistry

- Chemistry in Action (40 hours)
- Everyday Chemistry (40 hours)
- Chemistry and Life (40 hours)

Int 1 Chemistry

- Chemistry in Action (40 hours)
- Everyday Chemistry (40 hours)
- Chemistry and Life (40 hours)

Int 2 Chemistry

- Building Blocks (40 hours)
- Carbon Compounds (40 hours)
- Acids, Bases and Metals (40 hours)

Higher Chemistry

- Energy Matters (40 hours)
- The World of Carbon (40 hours)
- Chemical Reactions (40 hours)

Advanced Higher Chemistry

- Electronic Structure and the Periodic Table (20 hours)
- Principles of Chemical Reactions (40 hours)
- Organic Chemistry (40 hours)
- Chemical Investigation (20 hours)

All Units are mandatory.

Uptake in 2001 (figures for 2000 are in brackets)

Intermediate 1	46 (11)
Intermediate 2	1587 (1218)
Higher	10050 (7479) - 25% of centres offered SCE Higher Grade in 2000
Advanced Higher	606 (CSYS 1071) - This is an increase on the usual CSYS figure of 1400

Do the Courses meet the design criteria (1 – 7)?

Yes, Acc 3 - H
No at AH - it uses 2 x 20-hour Units

Issues and recommendations

Issue: use of 20-hour Units in AH

The AH Chemistry Course was the result of changes to harmonise AH arrangements across the sciences and to achieve broad comparability with first year university courses.

The original consultation document for AH proposed 3 x 40-hour mandatory Units and the removal of the investigation. This proposal did not receive wide support from centres or end-users. The inclusion of a much-reduced 20 hour investigation in AH Biology, Chemistry and Physics was a compromise developed in response to the consultation findings in the sciences as a whole. In particular, it was not possible to retain a 40-hour Investigation in AH as it would have meant deletion of about one third of CSYS Chemistry content from the AH Course; this would not have been acceptable to end-users of the AH qualification.

There have been no adverse comments on the impact of the 20-hour Units. The NAB tests have been reduced proportionately. Assessment of Outcome 3 matches that in the 40-hour Units.

Recommendation: Use of 20-hour Units in AH

The 20-hour Units should be retained.

2.2 Assessment rationale

Assessment rationale

Internal assessment

Unit assessments assess all Outcomes and PCs at the minimum standard required for a pass, but do not address any of the additional requirements of the Course. The Units are designed for sequential delivery, with Unit assessment taking place immediately after completion of learning and teaching. Unit assessment therefore recognises achievement in a straightforward, familiar context. Unit assessments have been designed to be accessible.

Unit assessment includes assessment of practical work, which is essential in providing a context for the development of important scientific problem-solving and practical skills. It also underpins the development of knowledge and understanding. It is vital that candidates actively participate in experimental work and have opportunities to manipulate experimental data generated first-hand.

The emphasis is on the development and assessment of analytical and evaluative skills, with particular focus on report writing. This is intended to match what goes on in the scientific workplace, and should contribute to raised attainment in the external examination.

External assessment

The external Course examination samples across all of the Unit Outcomes, and achievement is graded on the basis of cut-off scores.

External assessment goes beyond internal assessment in focusing on the integration and application of knowledge and understanding, and problem-solving and practical abilities, in the content/contexts of the component Units. The Units are sampled equally in the Course examination, which includes familiar contexts as well as contexts which are less familiar and more complex than in the Unit assessments. Prescribed practical activities (PPAs) are defined for each Course, and candidates are expected to carry out all of these. Questions are set on these PPAs in the Course examination.

Relationship between internal and external assessment

The examination is designed to produce evidence against the Grade Descriptions. While similar questions to those that appear in the NABs may be used, in the exam they are testing the candidate's long term recall and understanding (grade C). Achievement at grade C goes beyond the sum of achievement in each of the component Units because the question papers are designed to test the candidate’s ability to

integrate knowledge and understanding, problem solving and practical skills across component Units. Candidates' responses to NABs alone cannot provide valid evidence of attainment against the Course Grade Descriptions.

Estimates and Appeals

Valid evidence for an Estimate could be generated through the use of a summative assessment instrument, such as a prelim-type examination based on work for at least **two** component Units, which emulates, as far as possible, the standard, security and format of the external examination.

Evidence collected for an Assessment Appeal should cover the content of **all** component Units. The evidence gathered for the Estimate should be combined with other evidence gathered towards the end of the Course for the remaining component Unit.

A high-scoring performance in a NAB, covering the content not assessed in the prelim, would lend weight to the appeal for a grade C award. For appeals for grade A, additional Course questions covering content not assessed in the prelim, and providing evidence of attainment against the Grade Description for grade A, should be included in the submission. Evidence produced from NABs alone (because of the lack of headroom for grade A) will not be sufficiently compelling for appeals at this grade.

Appendix 1 summarises the total assessment load for each Course.

Does the assessment approach meet the assessment criterion (8)?

Yes

Issues and recommendations

None

2.3 Internal assessment of Units

Description of the overall approach to internal assessment

A common approach was taken to internal assessment in the sciences, building on the experiences of Standard Grade. All Units have three Outcomes.

- Outcome 1 – knowledge and understanding
- Outcome 2 – problem-solving
- Outcome 3 – practical abilities

Approach for each Unit in Chemistry (Acc 3 – AH) (excluding the AH *Investigation* Unit)

At Int 1–AH, Outcomes 1 and 2 are assessed by a single holistic test worth 30 marks, which lasts 45 minutes (commonly referred to as a 'NAB test'). A specification for each Unit test ensures that it has the potential to generate evidence against each of the Performance Criteria (PC). A pass mark of 18 is applied for achievement of both Outcomes.

At Access 3, a similar approach is adopted, but each test is broken down into three sub-sections, each worth 10 marks, with a pass mark of 6.

Outcome 3 is assessed by a report on a piece of experimental work (one report per Unit) This is not a separate assessment event — the evidence for assessment is generated during learning and teaching time. Typically an experiment would take about one hour of class time to generate the data, and a further hour would be required to write up the report. The experimental activity is likely to be performed by a small group of candidates together.

After collection of the data, each candidate must complete a report individually. There is a widely accepted structure to a scientific report, which comprises of a number of different aspects, all of which must be present — these are defined by the Performance Criteria for Outcome 3. Supportive criticism of

the reports is encouraged as part of this process and to produce evidence for assessment. Re-drafting of the report after this criticism is also to be encouraged as part of the learning and teaching process. Re-drafting should focus on the Performance Criteria concerned. The Outcome is achieved when there is evidence for each PC in the report. At Access 3–Higher there is a pro-forma with structured questions which help the candidates develop the report. At Advanced Higher candidates do not have this support.

AH Unit: *Electronic Structure and the Periodic Table* (20 hours)

This Unit is assessed in a similar way to the 40-hour Units. The holistic test for Outcomes 1 and 2 has been reduced proportionately. The test is likely to take around 30 minutes to complete.

Outcome 3 is assessed by a report. As a scientific report has a well-defined structure, this could not be reduced for a 20-hour Unit (as in other Units, the practical work is likely to take one hour, and the write-up one hour).

There have been no adverse comments about this 20-hour Unit.

AH Unit: *Chemistry Investigation*

This Unit has two Outcomes, which are assessed holistically through a lab record (log/diary) which gives brief summaries of the planning stage and records the collection and analysis of data.

A formal report on this activity contributes to the external assessment of the Course (see next section).

Note on comparability with other Courses in the same broad subject area

The approach taken at Intermediate 1 – Advanced Higher in Chemistry is broadly similar to that taken in the others sciences. The main difference is in relation to Outcome 3 in Chemistry when compared to Biology and Physics. All subjects require a report as evidence for Outcome 3 but Chemistry (Intermediate 1 – Higher) uses a pro-forma for the report.

Does the internal assessment of the Units meet the assessment criterion (9)?

No, approximate assessment loads are:

- Acc 3, Int 1, Int 2, Higher — all Units: two hours 45 minutes, including one hour of prescribed practical activities
- AH — mandatory Units: two hours 45 minutes, including one hour of prescribed practical activities
- AH — 20 hour Unit: two hours 30 minutes
- AH — 20 hour *Investigation* Unit: lab notebook completed as part of on-going activity (report and interview completed for external assessment)

(Totals are per Unit)

Issues and recommendations

1. Issue: Outcome 3, Int 2–AH

There has been some concern about the time taken up on practical work for the assessment of Outcome 3. In September 2000, centres were informed that the completion and subsequent re-drafting of the report could be done outwith class time, provided the teacher/lecturer could ensure authenticity of the work produced. This clarification has led to significant improvements in this area, although a few comments submitted to the review have indicated that this move has not been popular with all teachers.

Members of the examining teams and Assessment Panel tend to feel that difficulties with Outcome 3 stem from the fact that many teachers/ lecturers have been too demanding in terms of the amount of detail required, and in re-drafting requirements — much of the workload stems from re-assessment rather than assessment. Some centres have thought, incorrectly, that a report that did not meet all the PCs had to be completely re-written; when, in fact, only those parts which do not meet the PCs need to be re-drafted or modified. Other

centres have required candidates to correct every minor imperfection before they have judged the report to be satisfactory. This could be addressed by staff development and exemplification of standards.

Comments submitted to the review suggest that there is a clear feeling among significant numbers of subject specialists that Outcome 3 places undue burdens on assessors and candidates, although there is no consensus on how this issue should be addressed (a collation of comments is available on SQA's website).

Recommendation: Outcome 3 — all Units at Intermediate 1 – Advanced Higher (excluding Advanced Higher *Investigation* Unit)

Reduce the volume of internal assessment evidence required for Outcome 3 in Chemistry Courses at Intermediate 1 to Advanced Higher. This will be achieved by requiring candidates to produce evidence once for Outcome 3 in each Course, and using it for Outcome 3 in all three Units of the Course. This will replace the existing requirement to produce three distinct pieces of evidence. This will require some minor changes to the Units, as currently the Outcomes and evidence requirements make reference to the context of the Unit.

2. Issue: Threshold scores in NABs at Advanced Higher

There has been some concern about the level of difficulty of the NABs at Advanced Higher. Candidates who go on to pass the exam easily are failing the Unit tests on the first attempt. The result is that there is a burden in terms of the amount of re-assessment required. The Chemistry Assessment Panel discussed whether it would be best to re-write the NAB tests at a more appropriate level but decided that this would take too long to make an impact on the assessment burden.

Recommendation: Threshold scores in NABs at Advanced Higher

The threshold score for the NAB tests should be reduced from 18/30 to 15/30 at Advanced Higher (and 10/20 for the 20-hour Unit tests). This change is being made because of clear evidence from 2001 that candidates who narrowly failed NABs at their first attempt went on to pass the examination.

2.4 External assessment of the Courses

Description of the overall approach to external assessment

Each Chemistry Course is assessed by a single question paper with the following duration:

Intermediate 1	1 ½ hr paper worth	60 marks
Intermediate 2	2 hr paper worth	80 marks
Higher	2 ½ hr paper worth	100 marks
Advanced Higher	2 ½ hr paper worth	100 marks

Each Question Paper has two parts:

- Part A has multiple choice questions and grid questions.
- Part B has structured questions

The Question Papers sample across all component Units of the Course, and are designed to generate evidence against the Course Grade Descriptions. All three Outcomes are assessed, and the nine prescribed practical activities (PPAs) are sampled.

Advanced Higher external assessment

In addition to the Question Paper at Advanced Higher, candidates are required to do a 20-hour Unit *Chemical Investigation*. For internal/Unit assessment, candidates are required to keep a record of the Investigation (in a lab notebook or daybook) with respect to the planning and collection of experimental data. For external assessment, candidates are required to write up a formal report (of about 2000 words) which is sent to a Visiting Examiner, who marks it and carries out an interview at the candidate's centre. 25 marks are available for the external assessment of the Investigation Report: three marks are awarded by the centre for the candidate's ability to manage resources; four marks are awarded for the candidate's performance in the interview; but up to another four marks can be awarded on the basis of the candidate providing, during the interview, additional evidence which is not present in the report, against the other

assessment categories. In total, then, the Visiting Examiner can award up to eight marks not able to be assessed by alternative means.

The mark for the Investigation is added to the mark achieved in the Course exam (out of 100) to arrive at the total mark for Course assessment.

Note on comparability with other Courses in the same broad subject area

The sciences have adopted a similar approach, in that the exam at each level is the same length. The structure of the papers varies across the sciences. Chemistry is the only subject which has a section of grid questions.

Does the external assessment of the Courses meet the assessment criterion (10)?

Yes, at Int 1–H
No, at AH the external assessment load is:

Examination — 2 hours 30 minutes
Investigation report — 2000 words
Interview with Visiting Examiner — 20 minutes

Issues and recommendations

1. Issue: use of grid questions in Higher and Advanced Higher examinations

Grid questions are made up a number of terms on which a series of questions is asked. Setters find these questions very difficult to set and, given that the terms need to be related, this can restrict the degree of sampling which takes place. The questions are also inherently difficult since some of them are 'open' questions — candidates do not know if there is more than one answer. It is probable that removing the grid questions and increasing the number of multiple choice questions in the paper would mean that greater sampling would be possible, and that the increasingly negative National Rating of Chemistry might be improved slightly.

Recommendation: use of grid questions in Higher and Advanced Higher examinations

Grid questions should be removed from Higher and Advanced Higher examinations and replaced by additional multiple choice questions. This could be done for session 2002-2003.

2. Issue: assessment load in Advanced Higher — 2·5 hour Examination, Investigation Report of up to 2000 words, and 20 minute Visiting Examiner Interview

The examination samples the content of all of the component Units, except the *Investigation* Unit. The investigation allows candidates to carry out an open-ended piece of practical work for which they have sole responsibility — a reflection of the way in which real scientists work.

This investigation draws on all previously acquired practical skills, knowledge and understanding of the subject — in a sense, it is a culmination of all of the scientific education that has gone before. The report can be used to discriminate between candidates in relation not only to their production of an extended piece of scientific writing, but also to their understanding of the underlying science, and their application of theory and principles. A Visiting Examiner assesses the report, and carries out a 20-minute interview with each candidate.

While there are strong arguments for retaining both an examination and an investigation, and this would be in line with other Advanced Higher Courses, the use of visiting examining can be questioned in terms of:

- possible candidate stress, and additional workload
- additional workload for the teacher/lecturer in preparing the candidate and helping to organise the Visiting Examination
- additional workload for the SQA co-ordinator

- administrative burden for SQA
- potential for errors in data (see section 2.6, below)

It is important to note the marks allocation for this component:

- Total marks for the investigation — 25 (total for Course 125)
- Centre awards — up to 3 marks
- Interview — up to 4 marks, with an additional 4 marks available to supplement marks for report
- Report — 18 marks

In summer 2001, SQA commissioned a consultant to produce a report based on a quantitative and qualitative analysis of the effect of the interview on the marks given for the Investigation Report in Advanced Higher Biology, Chemistry and Physics in diet 2001. This report suggests that removing the interview from the assessment procedure would improve validity, reliability and cost-effectiveness in the assessment of the Investigation Report.

The report recommended that the interview be removed and the marks be allocated elsewhere in the report — one option would be to allocate marks for the quality of the context of the subject of the investigation.

Recommendation: assessment load in Advanced Higher - 2·5 hour Examination, Investigation Report of up to 2000 words and 20-minute Visiting Examiner Interview

The Examination and Investigation Report should be retained, but the 20-minute interview with a Visiting Examiner should be dropped. Assessment guidelines for the Investigation Report should be revised to reflect this.

3. Issue: review of Chemistry

There are two areas of concern that has been causing the Chemistry Assessment Panel (and its predecessor, the Chemistry Subject Panel) concern for a number of years. These are the decline in numbers of candidates studying Chemistry at Higher, and the relative difficulty of Chemistry Higher as evidenced by the very negative National Rating of the subject.

In session 2000–01, SQA commissioned a study into Chemistry to explore these issues and:

- to determine whether Chemistry suffers from a negative image (and if so, what action should be taken)
- to consider whether SQA Chemistry Courses were sufficiently interesting, and if not, what changes could be made to existing Courses

The report suggests that greater relevance in Chemistry Courses would help, and applications-led Courses might be the answer, with the technology of chemistry providing some of the needed relevance. One possible factor behind falling numbers is the experience candidates have of Chemistry at Standard Grade, and the report proposes that action should be taken to review Standard Grade Chemistry — an applications-type Course might again be more appropriate.

The report was welcomed by the Assessment Panel and its finding that it was time to consider a new approach to Chemistry was agreed. It was, however, acknowledged that the Chemistry teaching profession was not ready for any major changes and a period of consolidation of the curriculum was required. It was also noted that curriculum change of the type proposed required a great deal of research and time to develop, but that SQA should begin what would be a long-term project to revise Chemistry Courses.

Recommendation: review of Chemistry

SQA should begin a long-term project to update and revise Chemistry Courses to address the relative difficulty and decline in popularity of the subject.

2.5 Quality Assurance

Description of the overall approach to quality assurance

Quality Assurance of Chemistry Examinations

SQA's standard setting, vetting and marking procedures apply. Attendance at markers meetings is mandatory.

Quality Assurance of Investigation Report at Advanced Higher

The allocation of Visiting Examiners (VEs) to centres cannot be done within SQA's Awards Processing System, and is carried out manually. Centres send reports direct to their named VE who contacts the centre to arrange an appropriate time for carrying out the interviews.

Does the quality assurance of the Courses meet the assessment criterion (11)?

Yes, at Int 1–H
No, at AH — the use Visiting Examining for the AH Investigation is neither effective nor efficient, since it requires a huge amount of manual administration by SQA and centre staff.

Issues

AH Investigation – visiting examining

In terms of its effectiveness and efficiency as a quality assurance mechanism, the independent report on Visiting Examining has found that is it no more effective than standard marking and marker check procedures.

2.6 Administration

Issues

Advanced Higher *Investigation* — administration of Visiting Examining

The organisation of Visiting Examining for Advanced Higher is complex and labour intensive as the procedure is not standard and cannot be processed on SQA's computerised Awards Processing System. As a result, it is difficult to track data, and this increases the risk of data errors and/or loss.

Staff in centres have to fill in a special 'AH 5 supplement' form on which they enter centre details, Visiting Examiner numbers, candidate names in alphabetical order of surnames, (dates of birth if required to distinguish between two or more candidates with the same name), the titles of the candidates' Investigation Reports, and marks out of 3 for assessment category (g) 'Management of resources'. Centre staff send the completed top copies together with the Investigation Reports directly to the Visiting Examiner(s). A third copy is sent to SQA.

Visiting Examiners have to complete the forms 'AH 5 Supplement' when they have completed the visiting examining process, by entering marks for assessment categories (a) to (f), adding the centre marks for assessment category (g), and noting the total mark out of 25 for each candidate. The Visiting Examiners are then required to return the Investigation Reports, together with the top copy of the AH 5 Supplement form to SQA. The VEs retain one copy until the end of July as a contingency against the loss of the reports and/or other copies of the form.

SQA staff have to manually transfer marks to a form which can be used by data processing bureaux — this has the potential for introducing data errors. As there are no links between APS and allocations of centres and candidates to Visiting Examiners, normal procedures cannot apply to Marker Check and Finalisation. These procedures are only possible as the result of massive manual intervention of SQA staff and examiners.

SQA will take steps to reduce the administration associated with Visiting Examining in session 2001-2002.

3 Summary of review process and issues raised

Who	Mechanism	Issues
Subject specialists	Comments received by post and e-mail. Implementation evidence - research report on Visiting Examination for AH Investigation	55 responses by 25 October 2001 - these are referred to in the report. A full summary and collation of comments will be made available separately Main recommendations are outlined in the report.
SQA Co-ordinators	SQA SAMs and CRMs	No issues raised
Principal Assessors and Senior Moderators	All Chemistry Examining Team members (16) as well as Chemistry Assessment Panel members (12) invited by letter to comment on specific Chemistry issues. These issues were also discussed with Moderation team members during central moderation events. The Science Advisory Group also discussed these issues at the meeting on 27 September 2001.	22 responses received were received and discussed at the Chemistry Panel meeting of 25 September. This feedback has been incorporated into the report.
Units within SQA	Internal views sought - especially Assessment Moderation Unit	Issues raised about manageability of the Visiting Examining at AH in terms of cost effectiveness and added value
Candidates and parents	SPTC survey	No issues raised
Other surveys and reports	HMIE August 2001	High proportion of Chemistry PTs commented on difficulties caused for students by the volume of assessment Some depts teaching more than one level of Course in a single class were identified as having problems. These were most apparent in History, Chemistry and Geography, where poor overlap between Int 2 and H was identified as an issue.

	MORI January 2001	Teachers of Sciences (80%) are more inclined to maintain that students are not prepared for the external exam Science teachers (72%) more inclined to feel that implementation of internal assessment had not worked.
	SFEU/Higher Still May 2001	One college commented that science Courses have additional demands in practical assessments and the need for 3 assessments in this area. Makes evening class provision more time-consuming. Many students in this market are unwilling to devote more than one day a week to class-based study.

Appendix 1 – facts and figures

Approximate total assessment loads

Chemistry, Int 1

1 hours 45 minutes per Unit x 3 = 5 hours 15 minutes
1 hours 30 minutes exam
Total = 6 hours 45 minutes

Chemistry, Int 2

1 hours 45 minutes per Unit x 3 = 5 hours 15 minutes
2 hours exam
Total: = 7 hours 15 minutes

Chemistry, H

1 hours 45 minutes per Unit x 3 = 5 hours 15 minutes
2 hours 30 minutes exam
Total: = 7 hours 45 minutes + prelim (2 hours 30 minutes) + time to produce evidence for Appeals in Unit 3

Chemistry, AH

1 hours 45 minutes per 40-hour Unit x 2 = 3 hours 30 minutes
2 hours 30 minutes for 20-hr Unit
lab daybook for Investigation Unit - ongoing
2000 word report
20 minute interview
2 hours 30 minute exam
Total: 8 hours 50 minutes + investigative work + 2000 word report