Introduction

The Chemistry Teacher survey was conducted in response to member concerns about the impending VCE Chemistry Course review. It was distributed through the February issue of Contact, the newsletter of the Science Teachers’ Association of Victoria. A copy also was posted out with their registration confirmation to all participants in the 2004 VCE Chemistry conference. Preliminary results were provided at the VCE Chemistry Conference, February 2004. Since then, another 65 responses have been received. All responses are now included in the following findings. These include direct quotes from the survey responses.

The questions asked are incorporated into the findings.

Number in Sample: 126

Sources of responses

City Government Schools 21
City Independent Schools (non-Catholic) 25
City Catholic Schools 8
Rural Government Schools 33
Rural Independent Schools (non-Catholic) 2
Rural Catholic schools 4
Location and category unclear or not provided 32
Other 1

Note:
1. A small number of schools sent more than one response. One school sent a single response from two teachers.
2. Outer suburban schools were included in the category of city schools.
3. To allow teachers to express their viewpoints freely, they were not required to state their name or school. Sometimes school details were supplied but their category could not be readily determined.

Table 1

<table>
<thead>
<tr>
<th>Feature</th>
<th>Percentage requesting this feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course rationale.</td>
<td>46</td>
</tr>
<tr>
<td>Statement of how VCE Chemistry links into the other VCE Sciences and other VCE studies (such as common topics and skills).</td>
<td>56</td>
</tr>
<tr>
<td>List of the specific objectives for each level.</td>
<td>83</td>
</tr>
<tr>
<td>List of the practical skills expected at each level.</td>
<td>84</td>
</tr>
<tr>
<td>List of the mathematical skills assumed at each level.</td>
<td>63</td>
</tr>
<tr>
<td>List of the ICT skills assumed at each level.</td>
<td>45*</td>
</tr>
<tr>
<td>Tables of the specific Chemistry skills and knowledge expected at each level.</td>
<td>87</td>
</tr>
<tr>
<td>Explicit assessment advice for each level.</td>
<td>84</td>
</tr>
<tr>
<td>Explicit statements about the depth of knowledge and skills required for the external examinations.</td>
<td>83</td>
</tr>
</tbody>
</table>

Please describe any other features that would help you:

* A number of respondents stated a concern that access to technology would not be available at all schools. It is for this reason they are reluctant to have this mandated.
Sample responses to ‘other features that would help you’:

- I feel that the Year 12 Course needs to be a syllabus, so that we, as teachers, are not second guessing the extent to which the examiners test areas that can be described as at the ‘edge’ of the study design. (Several respondents made similar statements and annotated the last option about explicit statements as an absolutely essential feature.)
- Details about the standard required for internally assessed Coursework
- A study design that has clearly defined sections. The document already is formidable and difficult to wade through...
- Lists of available resources and where they can be accessed
- Suggested timeline and week-by-week basis of what material should be covered in Units 1 – 4
- Approximate proportional time allocation for each topic in each level
- Suggested time for each topic in hours
- List of suitable practical activities, including for sacs (3 respondents).
- Examples of problems and the standards expected
- Sample assessment tasks with annotated markings
- More detailed and specific assessment criteria for sacs. The present ones are far too vague.
- Ideas for different assessment tasks
- Suggested experiments for each objective
- Pre-requisite knowledge and skills for Unit 1
- If statements are too explicit it may be difficult to get a variety in exams
- Electronic version of Study Design that can be partly and fully downloaded
- Format the study design so it is interesting and exciting to students.

Conclusions: The Study Design Handbook

1. What is of prime concern to teachers is that the Study Design provides sufficient explicit information for them to prepare their students appropriately for the examinations and to conduct their internal assessment at the appropriate level.

2. Teachers are not strongly concerned about the inclusion of the rationale behind the Course or how it links to other studies. A significant proportion would find it helpful, however, to have statements of the mathematical skills needed and of recommended pre-requisite skills and knowledge provided.

3. There is fairly widespread concern about prescription of ICT skills because of access issues.

4. It would be helpful to have an electronic version of the Study Design available, which includes a list of suitable practical activities, including those that are suitable for Assessment Tasks and how they might be marked, as well as suggested timelines.

5. The Study Design needs to be in a user-friendly format.
2. Practical skills

Following is a list of practical skills stated in various study designs. Which of these do you think should be specified in the next VCE Chemistry Study Design at each level?

**Table 2**

<table>
<thead>
<tr>
<th>Practical skills</th>
<th>Units 1 &amp; 2</th>
<th>Units 3 &amp; 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Write a clear aim for the investigation.</td>
<td>83</td>
<td>79</td>
</tr>
<tr>
<td>Take accurate measurements with laboratory equipment.</td>
<td>88</td>
<td>85</td>
</tr>
<tr>
<td>Take accurate observations.</td>
<td>88</td>
<td>83</td>
</tr>
<tr>
<td>Perform the investigation in a safe and responsible manner.</td>
<td>87</td>
<td>83</td>
</tr>
<tr>
<td>Record results accurately in a table or spreadsheet that has been provided.</td>
<td>83</td>
<td>65**</td>
</tr>
<tr>
<td>Design a table in which to systematically record results.</td>
<td>69</td>
<td>81</td>
</tr>
<tr>
<td>Perform accurate calculations using experimental results to the appropriate number of significant figures.</td>
<td>72</td>
<td>89</td>
</tr>
<tr>
<td>Show all steps of calculations in logical steps and communicate reasoning clearly.</td>
<td>83</td>
<td>86</td>
</tr>
<tr>
<td>Draw graphs to display, for example, changes in concentration or mass or volume over time.</td>
<td>76</td>
<td>79</td>
</tr>
<tr>
<td>Interpret and discuss the graphs that are obtained.</td>
<td>77</td>
<td>85</td>
</tr>
<tr>
<td>Identify and discuss any trends or patterns in the results.</td>
<td>71</td>
<td>87</td>
</tr>
<tr>
<td>Draw conclusions that are related to the aim.</td>
<td>88</td>
<td>85</td>
</tr>
<tr>
<td>Identify and discuss sources of error.</td>
<td>79</td>
<td>86</td>
</tr>
<tr>
<td>Identify and describe the design of the experiment.</td>
<td>48</td>
<td>60</td>
</tr>
<tr>
<td>Critically analyse and evaluate the design of the experiment.</td>
<td>48</td>
<td>75</td>
</tr>
<tr>
<td>Design and perform an experiment.</td>
<td>56</td>
<td>60</td>
</tr>
<tr>
<td>Calculate the uncertainty and percentage error in a quantitative result.</td>
<td>20</td>
<td>37</td>
</tr>
<tr>
<td>Use chemical conventions correctly.</td>
<td>83</td>
<td>86</td>
</tr>
<tr>
<td>Other (please specify)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Several respondents left one or both columns blank. In some cases they clarified this by stating that in their belief everyone does all these things anyway and hence they should not need to be mandated. (This belief is not supported by evidence.)

** A number of these respondents preferred that at this level students design their own results tables rather than use provided tables.

Sample responses to ‘other’:
- Data collecting and processing
- Accurate use of SI units
- Equation-writing skills
- Verbally reporting findings clearly
- Explain the links between the accepted theory and the findings of the task.
- Most experimental design processes should be covered in Year 11 with more application of this in Year 12 in detailed studies.
- It is really important for students to design their own tables for Years 11 and 12
- A write-up does not necessarily demonstrate any practical skills. There should be a practical test for at least Year 12.
- There is never enough time in Year 12 to design and perform an experiment.
- I don’t feel that it is necessary to specify. Surely it is being done already.

- Provide an opportunity to perform multi-stage experiments extended over a period of time, such as those that were part of the HSC Options
- We need ideas for student-designed experiments
- What does it mean to critically analyse and evaluate the design of an experiment and to design and perform an experiment?
- Designing experiments and evaluating experimental designs are excellent goals for able students but frustrating for average secondary students
- All the skills are important. The real question is which are more important and which can be successfully dealt with in the time available?
- This looks like VCE Physics. Experimental tasks should not be a major assessment task for Chemistry. (However, the same respondent strongly agreed that practical investigations should be amongst the prescribed Assessment tasks for Units 3 & 4 in the next table.)
Please give your opinion on these matters in relation to practical work.

Key: SA – strongly agree, A – agree, D – disagree, SD – strongly disagree, U – uncertain

Table 3

<table>
<thead>
<tr>
<th>The new Study Design should:</th>
<th>Percentage giving this response*</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Recommend the maximum number of students in a practical group.</td>
<td>SA 28  A 39  D 15  SD 5  U 8</td>
</tr>
<tr>
<td>• Specify the minimum number of hours to be spent on practical work in each Unit.</td>
<td>SA 39  A 52  D 3  SD 1  U 2</td>
</tr>
<tr>
<td>• Specify the specialised laboratory equipment that students should be able to competently use.</td>
<td>SA 38  A 50  D 5  SD 2  U 3</td>
</tr>
<tr>
<td>• Include the use of data-logging equipment (such as pH probes for titrations) amongst the required practical skills.**</td>
<td>SA 8   A 36  D 24  SD 14  U 14</td>
</tr>
<tr>
<td>• Include practical investigations amongst the prescribed Assessment Tasks for Units 3 &amp; 4.</td>
<td>SA 42  A 42  D 4  SD 2  U 6</td>
</tr>
</tbody>
</table>

Other comments:

* Some respondents did not provide a response to all statements; for this reason the percentages in each row do not add up to 100%.
** Most of the respondents who disagreed or who were uncertain on this point stated this was because of the issue of access to data-logging equipment.

Responses to ‘other comments’:

• If you want practical skills to have real relevance, allow students to design and test their own experiments, but these cannot be part of the SACs – too much pressure for students to reflect upon and enjoy their successes/failures.
• Practical work must be central to this Course.
• Specify an extended research task involving gathering primary data and report writing.
• The Study Design must have scope for investigative practical learning. Too many pracs are ‘menu-driven’. Safety is a major concern, so this would limit topics available (eg corrosion)
• Concern that some schools will only complete the minimum of this is specified. The maximum should be specified instead.
• Some practical work needs to be seriously approached and thoroughly reported, but some should be for fun and illustrative purposes only.
• The Course content needs to be cut to provide more time for practical SACs (4 respondents)

Conclusions: Practical Skills

1. Teachers overwhelmingly support the specification of a range of practical and report-writing skills.

2. However, teachers are more divided on the issue of prescribing that students design their own experiments or identify, analyse and evaluate the design of a provided experiment. As more than half nevertheless recognise that these are important skills (some believing they are even more important than the normal ‘recipe-driven’ experiment), especially for Year 12, inclusion of these skills may need extra support, advice and teacher training. This also points to a need to examine how teachers might be encouraged and shown how to teach these skills through simple investigations in earlier years. (Student-designed investigations are recommended in the current CSFII documents but teacher responses suggest that even if their students did perform them, the skills may need reinforcement.)

3. Practical work is viewed as an important aspect of a Chemistry course. A significant majority of teachers wish to continue the practice of including practical tasks amongst the Assessment Tasks for School-Assessed Coursework and would also like to see the Study Design specify the minimum number of hours to be spent on practical work in each Unit as well as the laboratory equipment the students should be able to use with competence.

4. There is recognition amongst teachers that students also need to perform experiments as part of their learning experiences, to help them understand concepts and enjoy Chemistry, not only to gain practical skills.

(continued overleaf)
Conclusions: Practical Skills (continued)

5. It would be helpful to teachers to recommend or mandate the maximum number of students in a practical group in the Study Design. (This could help address the problem of students entering University with insufficient hands-on practical experience.)

6. There is again concern about prescription of ICT skills because of access issues.

7. Prescribing that students calculate uncertainty and percentage error was not supported, especially for Year 11. (However, this was a requirement of the Year 11 and 12 Chemistry Courses in the 1980s in Victoria and is required in other chemistry courses, for example in England and in some other states.)

3. Approach to learning

The current approach used is thematic learning, based on broad chemical themes such as energy. An alternative approach that is being increasingly adopted across the world is a contextual approach. Chemical concepts and skills are taught through a series of topics such as artworks, shipwrecks, water, building and the human body. They are then reinforced and extended in subsequent topics. These Courses, such as the Salter Course, are attracting increasing numbers of students.

Table 4

<table>
<thead>
<tr>
<th>Which one of these is your preferred approach?</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Current thematic approach</td>
<td>36 %</td>
</tr>
<tr>
<td>Contextual approach</td>
<td>8 %</td>
</tr>
<tr>
<td>Mixture of the two approaches</td>
<td>58 %</td>
</tr>
</tbody>
</table>

Please state any comments or suggestions you would like to make:

NB For the purposes of this survey, a ‘thematic approach’ means broad chemical themes eg. energy, structure and bonding, equilibrium. A ‘contextual approach’ means specific areas in which chemistry is applied, eg. shipwrecks, artworks, the human body

Responses to ‘other comments’

- A contextual approach allows for the relevance of Chemistry in the real world to be explored.
- I believe anecdotes and experiences (from both teachers and students) can be of enormous benefit in a contextual approach. It is a more mature approach and helps to engage learners really well.
- A mixture of the two approaches would be no problem, provided links, materials, etc. are provided to the teacher.
- I prefer thematic but we should move slowly across if it is attracting numbers.
- Contextual approaches can work if structured to allow for good solid chemistry within the context.
- Students seem to need a solid framework to learn in.
- I don’t see the current approach as all bad and would be cautious about a complete change.
- To a large extent this should be up to the individual teachers to decide.
- One of the most successful and popular parts of the current course is the analytical chemistry because it is linked to a context. Food chemistry, however, students find simply boring.
- I think the present course is on the right track, but too much time is spent on structures in Unit 1. This kills many students’ interest. There is not enough time to explore interesting topics.
- Needs a large variety of contexts to accommodate all schools /students /teachers.
- The current approach is close to the background of my overseas students.
- Many concepts and skills are needed to appreciate the thematic approach.
- I can introduce my own contexts as I find it suits me and my current students.
- I am relatively comfortable with a mixture of the two approaches if that is the most popular criterion. Not very happy to move over to a totally contextual approach.
- There needs to be some change.
- Thematic gives students security and yet it links into society very well. It is culturally reasonably neutral whereas some contexts discriminate against students with limited experiences.
- With contextual approaches the support would need to be broad and more detailed to cater for the differences in the students’ environments/backgrounds.
- I prefer a well-structured development of key concepts.
- A contextual approach may make the subject more appealing to students and fits in with our approach to Junior Science (2 respondents)
- A mixture is probably a good compromise.
- The contextual approach may limit the concepts taught.
- A good teacher always puts the various themes into context.
• A contextual approach has failed in VCE Physics and limited the exam (one respondent). A contextual approach has been used before with limited success (One respondent.). (No further detail was supplied to elaborate on or support either claim.)

• I have found the thematic approach to allow students to understand the relevance of the topics. They now never ask: “Where do you apply this?”

• A contextual approach needs to be locally relevant eg. swimming pool chemistry as an illustration of pH, redox, equilibrium and acid-base theory

• The link to tertiary courses should be clearly established from the outset, unlike the present VCE format.

• One option per unit that is contextual; rest thematic.

• Most students studying Units 3 & 4 Chemistry intend to study a science-related course at University. Context provides relevance but we need to ensure that the relevant underlying chemical theory (core theory required for tertiary study) is being taught.

• I need more information on a contextual approach.

• A contextual approach may help with understanding and is also interesting for teaching staff (2 respondents)

• I am very interested in finding out more about contextual approaches.

• Contextual means watering down.

• I have never seen or heard of a contextual approach.

Conclusions: Approach to Learning:

More than half the respondents would be pleased to see or at least feel comfortable about the introduction of at least some contextual areas of study within the Study Design. This may help engage the students more and help increase the retention rate. However, these areas of study will need a clear structure and the teachers will need to be supported. Any contexts selected will need to take into account the diversity in the backgrounds and interests of students and teachers.

4. Applied chemistry

Some of the following new areas of applied chemistry are now the major focus of research conducted by scientific organisations. If sufficient support is provided to teachers for any areas of applied chemistry that are not in the current Course, which of the following areas would you like to see in the new Study Design and at what level?

Table 5

<table>
<thead>
<tr>
<th>Area of applied science</th>
<th>Percentage ticking this area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysis of consumer products*</td>
<td>35  69</td>
</tr>
<tr>
<td>Commercial galvanic and fuel cells*</td>
<td>21  68</td>
</tr>
<tr>
<td>Electrolytic production of Al, Na and NaOH*</td>
<td>10  52</td>
</tr>
<tr>
<td>Environmental analysis and monitoring</td>
<td>54  25</td>
</tr>
<tr>
<td>Food chemistry*</td>
<td>25  57</td>
</tr>
<tr>
<td>Forensic chemistry</td>
<td>48  25</td>
</tr>
<tr>
<td>Manufacture of sulfuric acid*</td>
<td>8   48</td>
</tr>
<tr>
<td>Materials science</td>
<td>51  6</td>
</tr>
<tr>
<td>Molecular biology</td>
<td>11  33</td>
</tr>
<tr>
<td>Nanotechnology</td>
<td>20  23</td>
</tr>
<tr>
<td>Neuroscience</td>
<td>4   20</td>
</tr>
<tr>
<td>New generation fuel cells</td>
<td>7   59</td>
</tr>
<tr>
<td>Petrochemicals*</td>
<td>49  44</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>17  42</td>
</tr>
<tr>
<td>Polymers*</td>
<td>67  31</td>
</tr>
<tr>
<td>Power production*</td>
<td>17  28</td>
</tr>
<tr>
<td>Proteomics</td>
<td>3   6</td>
</tr>
<tr>
<td>Using the synchrotron for chemical analysis</td>
<td>6   20</td>
</tr>
<tr>
<td>Wine-making</td>
<td>37  23</td>
</tr>
</tbody>
</table>

Other suggestions or comments

Key: * in the current Course.
Responses to ‘other suggestions or comments’:

• Four respondents left this table blank. Of these, one stated that the cost is prohibitive to smaller schools and one stated “Areas in the current course already add relevance. Any others would be a definite bonus. I really have no preference.”
• Six respondents only listed topics for Year 12 and two only listed topics for Year 11.
• Respondents sometimes indicated that they thought a topic should be taught at both levels.

Additional suggested areas:
• Surface chemistry
• Organic syntheses
• Cosmetics
• Sunscreens and skin chemistry
• Chemicals in agriculture
• Swimming pool chemistry

Comments:
• These should be covered in a more contextual meaningful way.
• Shifting Surface Chemistry from Unit 3 to unit 1 allows teachers to avoid teaching it. If they cannot understand or teach surface chemistry, what hope for nanotechnology or the synchrotron?
• Areas that form part of the Course must have adequate resources – that is, there must be many practical activities that can be conducted and there must be theoretical support material for the teachers. (2 respondents)
• Year 11 Chemistry needs more focus on applications of Chemistry.
• Forensic and environmental analysis and wine-making can be part of the analysis of consumer products. (3 respondents)
• Wine-making fits in well with the analysis of consumer products, molecular biology and materials.
• Wine-making is a great topic but how can students be engaged if we can’t encourage or condone drinking?
• Some of these should be optional topics for individual student work, such as an Independent Research Project. (2 respondents)
• Support would certainly be required to implement units on nanotechnology or neuroscience. High tech units are best treated as options. (2 respondents)
• Wine-making should be a student project.
• Forensic science and biomed are attracting more students. It would make sense to link them with Units 1 to 4.

• In developing curriculum for new areas, we need to make sure the experiments and exercises can be done/completed in a typical school lab and within a 90 minute teaching session
• Something goes in – something must come out.
• We need less topics, not more.
• Polymers should be an option.
• Forensic science should be an option.
• Nanotechnology should be an option.
• There is insufficient time to include too much applied chemistry. (2 respondents)
• Imagine the booking queue for the synchrotron – if it were compulsory!
• Analysis of consumer products should include mass spectrometry and NMR spectroscopy.
• Nanotechnology and materials science should just be introduced.
• Environmental monitoring should include atmospheric chemistry.
• The introduction of focus items is pointless unless students have sufficient background to understand the concepts involved. Trendy or busy activities do not in themselves lead to increased understanding or to improved student outcomes.
• Applied Science topics are appropriate if they fit in with key concepts being taught but they should not dominate to the extent that the Course is made to fit around them. Some of the topics (eg, proteomics) are probably too difficult to cover meaningfully in a Year 12 Course.
• Applied Chemistry allows students to see the relevance of the theory to the real world, but again, where do we find the time to include more examples of applied chemistry than already exist?
• Replace old fuel cells with the new.
• Sulfuric acid is OK but perhaps a choice with ammonia etc.
• Sulfuric acid and electrolytic production should be removed entirely.
• Food Chemistry should be moved to Year 11 unless it is more ‘gutsy’. (2 respondents)
• It would be hard to squeeze it all in but it would be fun! Unit 2 is very boring for kids – lots of arithmetic and not much application. Would like to see forensic and environmental applications in Year 11.
• The Chemistry involved in some of these topics is too complex for the average Year 12 student. Do not make the subject inaccessible to average C-type students.
• New generation fuel cells could be part of what we do on commercial galvanic and fuel cells.
• No doubt some of the fields listed above are areas of current research. However we must adjudge the level of chemical principles they involve to justify including them in a Chemistry Course.
• We should try to retain the current sense of applicability of the concepts taught.
• ‘Trendy’ new areas should always be incorporated, if relevant, but not if the coverage is merely superficial. If reasonable full explanations are too complicated for secondary students the topic should be ignored.

Conclusions: Applied Chemistry

1. Whilst current applications such as polymers, analysis of consumer products and commercial galvanic and fuel cells continue to be strongly supported, there was a significant interest in the introduction of environmental analysis and monitoring and in forensic chemistry, and quite a strong interest in the introduction of the study of pharmaceuticals, into both Year levels. Materials science also attracted a lot of interest for Year 11. This could be linked with the study of polymers.
2. It was clear that teachers thought that new generation fuel cells should be included in the study of commercial galvanic and fuel cells.
3. The continued study of power production is not strongly supported, and of those that do support it, many felt it would be better in Units 1 and 2.
4. There was qualified support for some new areas of Science, such as nanotechnology. It was felt that such an introduction must be very carefully thought out so that its chemistry is of suitable standard for the age group. It must be well resourced and supported with a range of possible practical activities and information for the teacher.
5. It may be worth considering extending the scope of analysis of consumer products beyond those currently considered to include wines, as well as environmental and forensic analysis, with some of this analysis introduced in Year 11 to make Unit 2 more relevant.

5. Quantitative chemistry

What specific changes, if any, would you like to see in the timing of the introduction of particular quantitative skills?

Responses

• Introduce more quantitative Chemistry into Unit 1, including mole theory (almost half of the respondents stated this!)
• More time needs to be available for analysis of consumer products (2 respondents)
• Titrations and gravimetric analysis are really Year 11 skills and should be emphasized more in Year 11 when doing stoichiometry, which otherwise is very dry (8 respondents)
• Shift analysis of consumer products to the end of Unit 4 (1 respondent)
• A couple of my ex-students went to perform a titration prac at Melbourne University and they were the only two in the class who knew how to! (1 respondent)
• Students should perform at least two titrations by the end of Year 11 (2 respondents)
• Introduce mass spectrometry earlier, to tie in with earlier introduction of mole theory. (1 respondent)
• The timing of the skills will need to depend on whether we have a contextual or a thematic approach.
• Put some of the rates and equilibrium work into Year 11 eg acid-base equilibria
• Instrumental analysis is fine when it is because it fits into the University timetable for instrumental analysis workshops.
• Could do with some preliminary work in Year 10.
• It is good that calculations are held off until Unit 2.
• Unit 1 is too easy at present.
• We need flexibility in when we introduce things in Year 11.
Are there any quantitative skills not on the current Study Design that you think should be introduced?

Responses
- Data-logging
- Should we find a way to use a graphics calculator?
- IR, NMR, mass spectrometry in chemical analysis
- Error analysis in practical work (2 respondents)
- $pK_a$ and $pK_b$
- Further calculations with $K$ eg. $K_b$ in Unit 3 Chemistry
- $\Delta G$ and $\Delta S$, $K_p$ and $K_c$
- Conductivity-concentration graphs
- Standard electrode potentials (not actually specified in current Study Design)
- A gravimetric analysis should be prescribed.

Are there any quantitative skills that you think should be omitted?

Responses
- Back titrations (3 respondents)
- Calculations in equilibria
- Less instrumental methods
- Quantitative experiment on Food in Unit 4
- Colorimetric analysis
- Limit the number of concentration units needed (2 respondents)
- Obsolete methods
- Surface chemistry in its current form (move to Year 10) (5 respondents)
- Mathematical manipulation of equilibrium constants eg. $K_1 = 1/\sqrt{K_2}$

6. Organic chemistry

What specific changes, if any, would you like to see in the timing of teaching organic chemistry in the current Study Design?

Responses
- Put into Unit 2 to accommodate increasing the amount of quantitative chemistry in Unit 1 (3 respondents)
- Move all organic chemistry to Units 1 and 2 and just retain any applications (such as food chemistry) in Year 12 (6 respondents)
- Break up the organic chemistry. Study alkanes and alkenes at one point and functional groups later. (1 respondent)
- Start it sooner (2 respondents)
- It must follow bonding.
- It is good to have students drawing structures and modelling at an early stage.
- The introduction to organic chemistry fits well with Unit 1 and then is reinforced in Units 2, 3 and 4.
- More time dedicated to it – perhaps in Unit 2.
- Develop it progressively over the four units.
- I do find it a rush to get through the ethene as it takes a bit for the students to commit those equations to memory.
- Alcohols and fatty acids could be introduced in Unit 3 with instrumental analysis and then reinforced in food chemistry in Unit 4.
- Nomenclature should be introduced in Unit 1.

Is there any organic chemistry not on the current Study Design that you think should be introduced?

Responses
- Nucleic acids (3 respondents)
- Cyclic and aromatic compounds, especially if pharmaceuticals are introduced. (6 respondents)
- Ethers (2 respondents)
- Silicones
- Initiation into reaction mechanisms; it is important to prevent organic chemistry being just memory work (3 respondents)
- Primary, secondary and tertiary alcohols
- Stereochemistry
- Organochlorines and links to CFCs, refrigerant and atmospheric chemistry (1 respondent)
- Alkynes
- Aldehydes and ketones (2 respondents)
- Organic syntheses, such as how aspirin is produced (2 respondents)
- Amino functional group
- Amino acids
- DNA structure
- Condensation polymerisation (2 respondents)
- SI and IUPAC conventions
- Look at proteins in more detail
- Biochemistry
- Change the focus from petrochemicals to biochemistry
- Needs to be more organic chemistry in the Course (2 respondents)
Is there any organic chemistry in the current Study Design that you think should be omitted?

Responses
- Is our current petrochemical theory up-to-date?
- Food additives (1 respondent)
- We must reduce the amount of rote learning (1 respondent)
- Some bits of food. (3 respondents)
- Making esters (1 respondent)
- Food Chemistry (2 respondents)
- I am not sure that giving it (organic chemistry) 2 slots in the study design is warranted. It might be an area where the content of Units 3 & 4 might be reduced.

Is there any inorganic chemistry not on the current Study Design that you think should be introduced?

Responses
- Have more preparative experiments
- Study the Haber process instead of the Contact process – a more elegant illustration of equilibrium principles.
- Perhaps a brief section on rocks and ceramics so a greater variety of materials is covered.
- More on crystal structures and lattices.
- Precipitation skills and knowledge.
- I would like to see iron or copper production reintroduced (preferably iron)
- Radioactive elements
- Return of solubility curves to complement water analysis and precipitation reactions in Units 1 & 2.

Is there any inorganic chemistry in the current Study Design that you think should be omitted?

Responses
- Rote learning of C cycle, N cycle, specific gases, environmental aspects of water treatment
- Rote learning of petrochemicals
- Duplication of N and C cycles
- Less atmospheric chemistry
- Sulfuric acid – it is boring (2 respondents)
- History of the Periodic Table (2 respondents)
- Development of atomic theory and nuclear genesis theory
- Overemphasis on commercial batteries, fuel cells and electrolytic productions
- The strengths, structure and bonding of complex materials eg. fibres, composites, is too technical. Not suitable for Unit 1, maybe even for a Chemistry Course.
- The properties of materials should only go as far as can be explained by metallic, ionic and covalent bonding
- Some material in Unit 1 should be assumed knowledge from Year 10 CSFs eg. particle theory, atoms, elements.
- Get rid of out-of-date applications like the mercury cell.

1. Most respondents commented very little on the sequencing and content of the current Course, instead making their views on these matters known in later sections of the survey. (See later conclusions for further discussion.) The most notable exception was that quite a significant number of respondents recommended that the mole theory be introduced in Unit 1, some of these suggesting that organic chemistry be transferred to Unit 2 to fit it in.

2. A number of respondents recommended that at least two titrations and a gravimetric analysis should be performed in Year 11 to break up stoichiometry and make it more interesting.

3. Several respondents pointed out the need to include the chemistry of cyclic organic compounds if pharmaceuticals are introduced.

4. There was some expression of interest in reducing the emphasis on petrochemicals to allow for the introduction of more biochemistry.

5. A few respondents suggested that organic chemistry should be mostly taught in the Year 11 Course. Others felt that all these areas of chemistry should be woven through all units, so they could be reinforced.

6. There was some concern that course content be updated to suit current practice. Some analytical methods and the treatment of petrochemicals were two areas especially mentioned.

7. There was concern expressed by a number of respondents about the amount of rote learning required in the Course and over-emphasis of some areas at the expense of others. It was felt by some that reductions could be made in the number of commercial cells, electrolytic processes, instrumental analyses and gases of the atmosphere that are prescribed.

8. Food chemistry and surface chemistry were raised by a small number of respondents as needing review. It was felt by these respondents that in their current form they are not challenging enough for the year level. The issue of insufficient time for surface chemistry was also raised. It was suggested that surface chemistry be relegated to Year 10.

9. Some respondents felt that that Course pre-requisites could be set to include particle theory and basic atomic theory, which are listed in the CSFII documents, rather than taking up time on these again in Unit 1.

8. Overall Course content

A number of STAV members who are practising Chemistry teachers have expressed the following opinions. Please give your response to their statements.

Table 6

<table>
<thead>
<tr>
<th>Issue</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly disagree</th>
<th>Uncertain</th>
</tr>
</thead>
<tbody>
<tr>
<td>The new Study Design should have less total content, to allow time to cover the content more thoroughly in the real time available in our school.</td>
<td>43</td>
<td>29</td>
<td>13</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>The new Study Design should give students the opportunity to study at least one area of study in greater depth.</td>
<td>13</td>
<td>33</td>
<td>26</td>
<td>8</td>
<td>21</td>
</tr>
<tr>
<td>Structure and bonding should be woven throughout the two year Course and not concentrated in Unit 1.</td>
<td>30</td>
<td>24</td>
<td>29</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>There is too much of this topic in Unit 1.</td>
<td>25</td>
<td>37</td>
<td>17</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>The Periodic Table and its trends should be studied at the start of Year 12, so that everything else can be linked to it.</td>
<td>28</td>
<td>40</td>
<td>15</td>
<td>9</td>
<td>9</td>
</tr>
</tbody>
</table>

NB Some respondents did not provide a response to all statements; one respondent did not include this sheet in the questionnaire. For this reason the percentages in each row do not add up to 100%.
8. **Overall Course content**

Would you like to explain or qualify the opinions you stated above?

What other concerns or suggestions would you like to discuss?

Responses:

**Quantity of content**
- There is too much content in the current Course, so aspects cannot be studied at any great depth. This leads to only superficial understanding by students. *(3 respondents)*
- There is too much in Unit 1. I rarely get surface chemistry done.
- Unit 3 is fine but finishing Unit 4 is tight. *(2 respondents)*
- There is not enough time. I have had to teach the Course after school and even in a student’s home.
- There is not enough time. I have to hold extra classes, even in the holidays *(2 respondents)*
- There is less time in Unit 4, so we should have about one third as many SACs and less content. Too much time is spent on assessment – detrimental to student learning and understanding.
- The Course has served us well since 1979. But students only do two thirds of what they did then. How can you water down the Course any more without trivialising it? They teach much more in Canada, England and Japan.
- The major concern is the amount of content combined with the amount of SAC tasks. Too much is trying to be squeezed into too tight a time frame. The assumption appears to be that there are 18 weeks available to teach each of Units 3 and 4. No account is taken of public holidays, school events, excursions and other studies.
- The time factor is a genuine concern at Year 12. I think the difficulty of the content is about right but it is turned into something more difficult than it should be by the limited time factor (and lengthy SACs in other studies).
- Unit 1 is just too jam-packed. No time for effective revision.
- Less content at Year 12 is a must if there are to be changes. Too cramped with too much emphasis on learning ‘old things’.

**Studying an area in greater depth**
- The amount of content is right at present – don’t change it. Any less content would trivialise the subject. Most Chem students study tertiary chemistry so must have as broad a base as possible.
- There is often not much time to discuss practical work in class.
- The general student perception is that Chemistry is hard. It needs to be less content driven and reduce the number of SACs.
- I agree in principle with issue 1 but the content has been cut fairly drastically over the past few years. I cannot see too much work that could be left out.
- Just because there is a review, changes are not mandatory. It is perfectly acceptable the way it is.
- The content of Chemistry takes longer to teach than the other subjects.
- The content in all units needs to be reduced *(2 respondents)*.
- Have less content in Unit 3 but not Unit 4.
- I lose 4 weeks per year. I currently missed my class for 9 days straight!
- Mandate the total time in the study design.

- The removal of CATS now allows time for detailed study.
- Do not reintroduce Options (Cheating and so on) *(4 respondents)*
- Less content done in depth is more valuable to students in the long term.
- Topics such as bonding and stoichiometry need to be treated in detail if real understanding is to occur.
- I feel that it is better to get a taste of a bigger range than to spend too much time on one area. In this way it gives them an inkling of the opportunities that can open up to them from the study of chemistry.
- Students at some schools will be disadvantaged if they have to go out and get resources.
- I have a concern about the time needed for conferencing with students – demands on the teacher.
- I agree for Year 11 but not Year 12.
- Delete surface chemistry and replace it with an optional study of iron, nitric acid, sodium chloride or electrolysis.
- We can teach more and in more depth if the ‘feel good’ bits are omitted.
Structure and bonding

- Structure and bonding is too boring/dry in one go. It should be spread over Units 1 and 2. (3 respondents)
- Unit 1 Chemistry is too abstract and alienating for many students. The structure and bonding puts them off – lots drop out. Feel really strongly that Unit 1 is too academic – very little contextual relevance. We lose them here and it is hard to get them back. Unit 2 emphasis on heaps of stoichiometry has a similar effect. It should be a gradual build-up – not a case of sink or swim.
- Spreading structure and bonding out would mean you could have better coverage with more mature Year 12 students.
- Leave hydrogen bonding until it comes up in Year 12.
- If there was less on structure and bonding in Unit 1 perhaps more time could be spent looking at trends in the Periodic Table. This would allow linkages to be made earlier on.
- It is possible to make bonding interesting and an overview of the major bonding types is pretty fundamental to chemistry and needs to be covered fairly early in a course, but unless a teacher is committed to it I could envisage serious drudgery for students.
- The bonding unit, while important, is boring to teach.
- A lot of bonding is now taught in Year 9 and 10 texts so much of the bonding in Unit 1 should be quick revision.
- You need all the bonding in Unit 1 so you can build on it in Units 2 – 4 (2 respondents)
- Spread the types of bonding over Units 1 and 2 (2 respondents)
- Bonding and the Periodic Table should be covered briefly at the start of Unit 1 and done again at the end of Unit 4. Of all the topics, bonding is probably the most difficult for students.

History and philosophy of science

- There is not enough time to study any history and philosophy.
- History is particularly appropriate when studying the Periodic Table.
- The history of Science should be introduced from Year 11 and the journey of discovery highlighted.
- Students find history rather irrelevant.
- Students can still understand the principles of designing and evaluating an experiment without the history and philosophy of science.
- The history and philosophy of science is fundamental for students to gain a grasp of how these theories have developed over time.

Other

- There is too much memory work. It is better that the students understand the Course and solve chemical problems rather than memorise slabs of information.
- Introduce basic Chemistry skills at a lower level (ie. Years 9 and 10) as in Europe and England. When students already have the basic Chemistry, we can concentrate on other chemical concepts or technologies in greater depth at VCE levels. We spend too much time on basic Chemistry at Years 11 and 12, hence insufficient time.
- Should be more pure chemistry and less applied chemistry. Basic principles need to be understood before application. The Year 11 and 12 syllabuses from WA is a well-designed syllabus and well integrated.
- The VCE should be an integrated two-year program.
- As a teacher who is teaching IB Chemistry, I appreciate being able to structure the order of presenting concepts in IB as best seems to suit the students. The divisions into Units 1, 2, 3 and 4 now seems artificial and constricting.
- It would be nice to see some new practical exercises that are content based and not so follow the recipe.
- Too many students choose Chemistry for the wrong reasons and struggle through abstract topics like mole concept and stoichiometry for no good reason. If we can’t attract able students for the ‘right’ reasons, I would be reluctant to ‘dumb down’ the course so it is a viable option for students with little scientific ability or interest.
How many weeks are really available to teach your VCE classes each year?

Responses (not every one responded):

| Year 11: | Range: 26 – 38 |
| Year 12: | Range: 20 – 36, with many teachers stating they have less in Unit 4 than Unit 3 (for example, 15 in Unit 3 and 11 in Unit 4) |

Conclusions: Overall course content

1. A very high proportion of teachers believe that new Study Design should have less total content, to allow time to cover the content more thoroughly in the real time available in their school. The time they have available varies significantly from school to school. The VCAA should consider mandating the minimum number of contact hours, to reduce the disadvantage experienced by many students.

2. Teachers were fairly divided over the issue of studying any topic at greater depth. Resourcing new areas, cheating, the time required for conferencing with students if they undertake individual projects and the impact this would have on the breadth of the course were all areas of concern. On the other hand, in other parts of the survey teachers had suggested that new emerging areas of Chemistry or some other topics might best be approached as optional for an in-depth study.

3. More than half the teachers felt that structure and bonding should be woven throughout the two year Course and not concentrated in Unit 1. Reasons included the need for continual reinforcement, the advantage of a more mature experienced approach if some is introduced at Year 12 and the current Course overwhelming or boring many students, many of whom drop out at the end of Unit 1 as a result of the long time spent on a very abstract topic with a limited range of relevant practical work.

4. More than half the teachers felt that the major work on the Periodic Table should not be compacted into a rushed time at the end of Unit 4, when it becomes something to simply memorise rather than the providing the links between and underlying reasons for so many things they have learned. In fact, many of those who disagreed with the statement only disagreed with the suggestion that it be moved to Unit 3. Many of these teachers recommended that a major part of this work be completed at the start of Unit 1, building on any Periodic Table work in earlier years. Some teachers already introduce sub-shells at this point and state the students have no difficulty managing this. They felt that this can then be built on and reinforced over the four years units.

5. Almost three quarters of the teachers surveyed felt that teaching the history and philosophy of science is an integral part of teaching Chemistry. However, it should be spread throughout the two years and not compacted at the end of Unit 4.

6. There is concern stated here and elsewhere in the survey about the amount of rote memory work in the course. It is recommended that this be reduced so that students’ understanding of the principles and ability to apply their knowledge are encouraged and assessed rather than just their ability to memorise.

7. The lack of flexibility of the teaching programme through the Unit system is another issue of concern, especially at Year 11.

8. The issue of work that is completed prior to VCE and any consequent pre-requisites needs careful examination. This may help avoid loss of time revising very fundamental concepts covered in Year 10.
9. Assessment model

A number of STAV members who are practising Chemistry teachers have expressed the following opinions. Please give your response to their statements.

Table 7

<table>
<thead>
<tr>
<th>Issue</th>
<th>Percentage of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Strongly Agree</td>
</tr>
<tr>
<td>In line with other states and with other VCE Sciences, there should be fewer school assessment tasks.</td>
<td>37</td>
</tr>
<tr>
<td>The Study Design should specify what level of knowledge and skills is examinable. All exam questions must be checked to ensure that they fall within these specifications.</td>
<td>57</td>
</tr>
<tr>
<td>The external exams should rely less on rote learning of material and more on application of knowledge.</td>
<td>24</td>
</tr>
<tr>
<td>Students should be able to bring one page of notes into the examination.</td>
<td>17</td>
</tr>
<tr>
<td>The exam papers should be balanced so that the weighting of questions reflects the time spent on each aspect of the Course.</td>
<td>58</td>
</tr>
<tr>
<td>The data sheet provided with the examinations should include table of the formulae of common compounds, and data such as their MP and BP, density, colour, pK&lt;sub&gt;a&lt;/sub&gt; and solubility in water.</td>
<td>21</td>
</tr>
</tbody>
</table>

Other comments or suggestions:

NB Some respondents did not provide a response to all statements; one respondent did not include this sheet in the questionnaire. For this reason the percentages in each row do not add up to 100%.

Comments and suggestions:

School Assessment Tasks (SACs)

- In Chemistry, the fact that pracs are part of the assessment task is good. I try to do a prac each week, and if every second or third is accompanied by a short test and becomes an assessment task, then good. Because I know schools where they deal differently and the only experiments they allow their students to perform are those of the assessment tasks. I cannot conceive of teaching chemistry without hands-on, so I would hate to see some have an excuse for reducing the practical component even further!
- Reduce the number of SACs and make one a more detailed experiment and report.
- I think there should be no more than 4 SACs per unit. This would allow smaller pracs/demonstrations to be done to show a point and allow full discussion of what’s happening rather than say “I can’t discuss it. It’s a SAC.”.
- I think there should be no more than 4 SACs per unit. A folio of prac reports could be one of the four.
- The number of tasks requires students to continually learn work as you go along, rather than at a burst for a test/exam.
- The variety of tasks takes the pressure off one task and makes assessment more valid with a broader range of skills assessed.
- Too many SACs = added stress to students and staff fitting in assessment rather than building interest, love of learning, etc.
- SACs work really well to get students to make prac work relevant and all students are engaged in the prac as all are assessed.
- The reports with an open book component are a waste of time and could be replaced by a test. Exams should cater for all learning styles.
STAV VCE Chemistry Teacher Survey (continued)

- The 12 SACs are good. They keep the kids studying and involve practical skills, analysis and interpretation. They make a good focus for teaching and content.
- Encourage student creativity and practise of the concepts by encouraging more self-designed practical work – with clearly stated goals. The ‘worth’ of this could be reduced to 10% to avoid current stress students feel with SACs.
- I believe that 2 of the 6 SACs should be tests, 3 of the 6 experiments and the last one an investigative report on a new area of chemical research. This would give a more balanced format for school-assessed coursework.
- The assessment criteria should be mandated by the VCAA. The weightings could vary from current ratings.

Examinable knowledge and skills

- We need greater examination of all the Course content, not just a repetition of past questions on a very narrow section of the Course.
- I think the exams should be a lot longer so that all the major outcomes can be assessed thoroughly. It really upsets me when important sections that had considerable time and effort applied to them do not even get examined as a short answer question. It turns the exam into a bit of a lottery for some students and makes the process rather unfair.
- The exam should explore some unknown territory to discriminate thinkers from rote learners.
- This could become a legal minefield.
- The 2003 Midyear exam required knowledge of nonane, which is not part of the Course. If a student has language difficulties this is not testing their knowledge.

Level of exam questions

- Try to avoid ‘smart-arsed’ questions designed to catch kids out. (2 respondents)
- Why not make MC items 3 marks for best answer, 2 marks for next best answer and so on?
- Assessment should not be too difficult to deter students from taking up the study. Many students perceive the subject as too demanding, particularly in the first units. Academic rigour can be retained but include some exercises to enable the ‘practical’ students to get involved and see that science can be for them too!
- Units 3 & 4 exams need a rethink. Too much on the higher level thinking skills. Papers are not liked by the students – too many old-fashioned exam questions.
- I would suggest a change to the assessment papers to include questions requiring more than just 1 or 2 sentences. I don’t think we pay enough attention to the ability of our students to justify a position.
- I think the current exams have enough application work already. The analytical work seems to be increasing in difficulty. Would like questions reverting back to listing stages for longer calculations.
- I still feel there is a role for rote learning. For many students application of knowledge may only occur well after exposure to the material taught. Chemistry seems to be one of the core subjects required for many tertiary institutions so that far more ‘less able’ students keep up with chemistry more so than in past years.

Page of notes

- Never allow cheat sheets. They marginalise learning and knowledge. Instead put additional data on the data sheets (removing any unnecessary data from these).
- I would rather see the information on the data sheet, with students having to learn how to use them. I disagree with the Physics and Maths summary sheets for the same reasons.
- Students who understand formulae will remember them.
- Don’t make students memorise any information or data they can look up in a book.
- Lots of Chemistry is rote learning. The potential to cheat is much higher with a page of notes.
• Don’t compare Chemistry with Physics. That is all about applying formulae. In chemistry there are not many formulae to learn and you can’t do them without knowing them by heart.
• Physics and maths allow a page of notes. We’re decreasing student numbers by not.
• Students are not required to rote learn information for other maths and science subjects.
• If one page of notes were brought in there would be no need to memorise simple formulae but we can then see their extended applications.
• If a page of notes would mean no other support is given (such as a chemical formula in a question), then no!
• If it means making the exam harder, then no!
• To supply this would represent a further ‘dumbing down’ and decline in academic requirements.

Data sheet
• Giving formulas in exams will not help weaker students – they still will take forever to manipulate them because they have not practised enough.
• Would it really hurt to have the names of elements and simple formulae on the data sheets to avoid student panic and mind blanks?
• The current data sheet is appropriate. Basic chemical knowledge should be assessed.
• Formulae that are not currently used should be removed in case they confuse students, but even some common formulae such as n = cv could be included (3 respondents)
• Put the formulae of complex ions and uncommon ions on the data sheet.
• Put the formulae and electrovalencies of common ions on the data sheet.
• For IB students it is a constructive part of the IB Course to teach students how to access the extensive IB data book as required. It is a real science skill to know how and where to look up data correctly.

Other
• The VCAA needs to get its act together and publish all exam dates before the beginning of the school year!
• The current system is better than the old CAT system.
• Move all the external assessment to the end of Unit 4.
• It would be easier if exams were only at the end of the year for all subjects.
• More official questions should be provided so that students do not do commercial revision work that is off target.
• Chem SACs are the right length because they do not impinge on other subjects. Pity that other subjects such as English don’t work the same way. No subject should have compulsory assessment excursions in class time as this penalises all other subjects through absent students.
• The examiner’s report should be given soon after the exam while it is fresh in our minds.
• The examiner’s report should include details about the way all the marks are allocated.
• Exams are an appalling method of assessing an individual’s understanding of any subject, but I have yet to be convinced there is a fairer method. School-based assessment is fine until students from different schools need to be compared.
• I like having a mid-year exam but the results need to be held over until the end of the year.
Conclusions: Assessment

1. Teachers are generally happy that the current SACs include practical work. They see that it helps students take the practical work seriously and keep working at a steady pace. Schools that avoid practical work are forced to provide their students with at least some practical experience. However, because of the pressure of time, a majority would like to see the total number of tasks reduced to perhaps 4 per semester. This will allow teachers to provide other practical experiences that are part of the learning programme and allow students to enjoy their practical work rather than seeing it as just a test.

2. Almost all the teachers surveyed were concerned that the exams keep within the course specifications and fairly represent the time that might have been spent on each topic. A number felt that this has not always been achieved and cited cases to support their concerns.

3. The exams should also be well balanced in terms of the range of thinking skills required, so that different student learning styles and abilities are catered for. Whilst it was felt they have a reasonable amount of application work, one criticism was the use of multiple choice questions that requires several steps of calculations and therefore should really be short answer questions.

4. Teachers were very divided on the issue of a student summary sheet and expressed quite strong viewpoints for and against this practice.

5. It was felt that a student summary sheet would not be necessary if a more detailed data sheet was provided. It was argued that using a data sheet is an essential science skill. Extra features might include the formulae of some ions. These teachers also recommended that extraneous data should be removed.

The chemistry review

Two respondents expressed concerns stated below.

The first has been stated by a large number of STAV members.

“Changes in Courses need to be carefully introduced with lots of opportunity for feedback. The 2004 VCE Chemistry conference provided an excellent forum. I would like to see more of this opportunity for response as the Review Panel begins to formulate changes. Change should be stepped in Units 1-2 one year then Units 3-4 the following year.”

The views expressed in the second is also shared by a number of members:

“Will a draft of the new study design be available for review before it is accredited?

I am concerned that the content will one again ‘balloon out’! There are phrases of content in the present design that need substantial time to teach but this seemed to be ignored by the creators of the original design. It is crucial that practising (experienced) teachers get a chance to adjudge the time a new course will take.

There have been a lot of topics suggested for the applied science/chemistry course. If some of these are introduced and others retained, it is unclear what areas of chemistry will be omitted to compensate. There must be a sufficiency of chemical principles covered (not Biology or Physics) for this new course to be of the same standard as the best chemistry courses in the world.

Each year the examiner’s report expresses some level of dismay at the ability of students to explain the answers, particularly in areas like the AAS etc. Sadly, some of the blame must be levelled at poor teaching. As a result, I question the skills of a teacher that cannot explain the principles of spectroscopy etc. to be able to explain probably less familiar specialised fields like nanotechnology (more Physics than Chemistry), synchrotron operation, neuroscience and so on!”