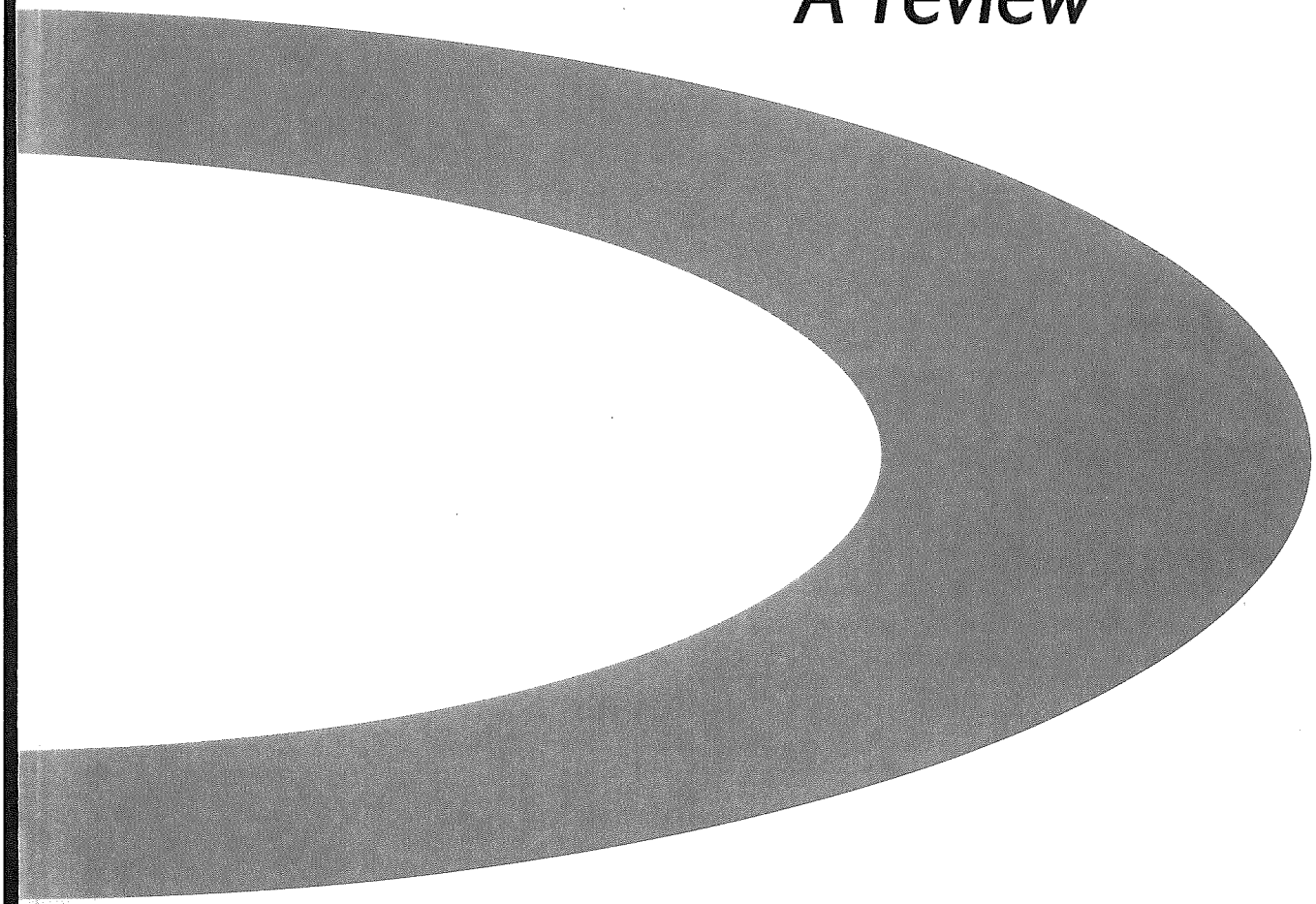
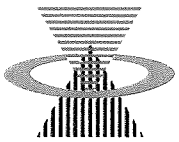
Chemistry Research at Norwegian Universities and Colleges

A review





The Research Council of Norway

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A review

Norges forskningsråd

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To the Research Council of Norway

The panel for the review of chemistry research at Norwegian universities and colleges hereby submits the following report.

The task of making a fair and adequate review of the whole field of activities has been demanding. The panel is of the opinion that the review will be a worthwhile instrument for the Research Council of Norway, as well as for the faculties, institutes, departments, sections and research groups concerned.

The panel is in agreement on the assessments, recommendations and conclusions contained in the present review.

Jens Weitkamp
Chairman

Jean-Claude G. Bünzli

Sine Larsen

Lauri Niinistö

Gerald Pattenden

Jack W. Ponton

James H.P. Utley

Preface

This is the report of an *ad hoc* international panel set up by the Research Council of Norway to assess chemistry and chemical engineering research at Norwegian universities and colleges.

The report has been prepared specifically for the Research Council of Norway, which reserves the right to use the contents as it sees fit. As the report is expected to reach a wide audience, the panel hopes its deliberations will promote a useful, constructive debate within the Norwegian chemistry community.

This is the first review of chemistry research at Norwegian universities and colleges ever to be commissioned by the Research Council of Norway. The meetings with staff at the various centres took place between February and late May 1997, although the information-gathering process began in November 1996. During the period in question, certain institutions were undergoing reorganisation and amalgamation, meaning significant changes were being implemented in certain departmental structures. These uncertainties have, to some extent, affected the preparation of uniform, consistent background data. The project has involved comprehensive assessments of the individual research efforts of about 200 professors and lecturers. The task of achieving insight into such a variety of research efforts has been extremely demanding.

Nevertheless, the panel feels it was able to discuss research-related issues with a significant number of staff and to obtain sufficient and adequate information on which to base balanced and fair assessments. Co-operation with the panel and the Research Council was exemplary in most institutions and departments. There were just a few isolated incidents of incomplete or reluctant co-operation. It is possible that, in these cases or through mistakes of its own, the panel may have reached incomplete conclusions. In general, however, the panel is confident that its analyses and recommendations are well founded. It is hoped that the report will be looked upon as a constructive basis for improvements, developments and change.

Contents

Conclusions and recommendations

The panel was asked to address, among other matters, questions concerning the balance between research fields in a national context, and the quality and relevance of national efforts in an international context. Where possible, the panel also considered the relevance of individual research fields with respect to basic research and the needs of industry. Inevitably, these objectives involved making comparisons between the different centres concerning their research activities and achievements in the major areas of chemistry.

These comparisons are presented here, together with the strategies for future development suggested by the conclusions.

The national picture

Chemistry has particular significance for Norway, not least as an essential supporting science for the metallurgical and petrochemical industries which are of such great importance to the country. This, and the fact that Norway is a large, but very sparsely populated country, explains the development of centres of academic research at four major universities, Oslo, Bergen, Trondheim, and, more recently, Tromsø. Each of these locations is required, for educational purposes, to maintain a profile which is as broad as possible. However, the panel notes that, despite this, there has been some welcome rationalisation in the focusing of research topics. For instance, Trondheim has become more oriented towards applied research.

Although the subject of chemistry is flourishing at universities in Norway, the number of groups at the cutting edge of contemporary developments is too small. Chemistry has not developed in Norway at the same pace as it has in other highly industrialised European countries. Perhaps the opportunities are poorer. There is less pride in achievement, and less urgency and/or stimulation. Perhaps Norwegian society at large is not willing to offer sufficiently strong incentives for top-quality university research so that outstanding scientists will be attracted to careers in the prospering domestic industry.

Chemistry in Norway remains, to a large extent, based on traditions. The subject and the people have not moved sufficiently with the times; what movement there has been appears to have been towards applied rather than basic research. Norwegian structures are rather rigid, leadership is often poor, and strategy is insufficiently developed. This lack of planning has resulted in missed opportunities, and has gravely undermined progress in some subject areas. There is an urgent need for the chemistry departments at all Norwegian universities, as well as the Norwegian chemistry community as a whole, to focus on and improve mid-term strategic planning.

At a higher level of detail, the panel recognised weaknesses which are common to all or most of the institutions visited. These weaknesses are described in the following paragraphs, accompanied by general observations concerning potential remedies. More specific recommendations may be found in the sections dealing with individual departments and groups.

⇒ There is little mobility of staff. It is common to find that a given department's research group is almost exclusively recruited from its own products and that they remain at the same university from doctoral graduation until retirement. This inhibits vitality and creativity. It also partly explains the persistent pursuit of lines of research which, although of crucial importance when started by the "great men" of Norwegian science, have little to offer nowadays.

⇒ The output of doctoral graduates in chemistry (8 per million population yearly) compares unfavourably with that of major European countries (Netherlands 18, UK 19, France 20, Germany 27).

⇒ With some notable exceptions, there is a reluctance to make full use of the generous sabbatical leave schemes which are available. They should be used selectively to revitalise and re-orient research programmes. It would also be good practice to expect focused plans to be submitted prior to sabbaticals and detailed reports, including publications written and grant applications made, afterwards.

⇒ A further sign of the malaise in Norwegian chemistry is that it appears to be difficult to attract good selections of high quality candidates for professorial positions. It is appreciated that part of this is due to the relatively low salaries offered and the lack of flexibility on salaries and conditions when it comes to trying to "headhunt" top people, especially from abroad.

⇒ Unlike most leading chemistry research countries, Norway does not have a system whereby research grants can be won, in peer-reviewed competitions, by research supervisors who can then hire the best post-doctoral assistants for the project. This will often facilitate the hiring of excellent foreign post-doctoral fellows. The current scheme(s), whereby post-doctoral fellows are selected by the Research Council and sent abroad or remain with their home universities, does not introduce enough much-needed new experience into the research programmes.

⇒ Research at the interface with materials science is well developed, which is consistent with the importance of this area to Norwegian industry. However, there is relatively little activity at the highly crucial chemistry/biology/medical sciences interface. It is a matter of urgency for bioinorganic, bioorganic, synthetic organic and natural products chemistry research groups to devote more attention to extending their boundaries.

⇒ Departmental structures are generally very rigid and feature many subdivisions. These can prevent effective interaction between individuals with common research interests which cut across traditional barriers. Furthermore, the efficient sharing of expensive instruments is also inhibited by these rigid structures. Such barriers to collaboration and sharing were refreshingly low at Tromsø.

⇒ Departments are often organised in a manner which takes no account of the selective distribution of resources and staff teaching loads. This practice works to the disadvantage of those who are active in research and the most prolific staff members, and requires careful attention.

⇒ Travel is expensive in Norway and the distances between research sites are vast. Nevertheless, there should be better interaction between the groups at different universities.

⇒ In general the research atmosphere was not very stimulating, and this is also evident from the relatively low number of departments which run regular research seminar programmes. In most departments elsewhere which have active research programmes, seminars are taken as a sign of research vigour, attracting speakers from other universities and industry both at home and abroad. They are usually attended by virtually all staff members and students in the department in question.

⇒ Colleges have a few staff members engaged in high quality chemistry research. It would be healthy for the Research Council to recognise and fund such productive researchers on an individual basis, even if only at a "pump-priming" level. To some extent, this point is related to those made previously regarding the mobility of research personnel, because research potential can develop at a wide range of institutions. Having some migration of successful individuals between departments would help to counteract complacency and contribute to the vitality of national research activities.

The role of the Research Council

Chemistry is the principal atomic and molecular science. It has an initiating and leading role in the fundamental development of many areas, including medicine and the bio-sciences, and in the conception, design and synthesis of special compounds and materials. World-wide, chemical-based industries comprise a leading wealth-creating sector in most advanced industrial countries. Norway is highly industrialised, and well-trained chemists are in demand. It is government's role to be the main funder of basic research in the academic world and "... to sustain ... expertise across the core disciplines of biology, chemistry, mathematics and physics and to provide the climate where centres of international excellence can develop and flourish" [UK White Paper (1993)]. The Norwegian government's agents in such affairs include, in a major role, the Research Council.

The preceding national overview, and the more detailed suggestions and recommendations given in the following sections, should help to set an agenda for the Research Council in seeking to revitalise chemistry research at Norwegian universities. In our view it will be necessary for the Research Council to become more pro-active and to have clear objectives of its own. This is the path currently being followed by research councils in other major European countries.

In particular, the Research Council should not simply respond to grant proposals (the so-called "responsive mode"), but set its own agenda and priorities, providing earmarked funding for initiatives in key areas. For instance, the panel has concluded that an initiative in organic synthesis should be set up as a matter of urgency. There may be other areas, for instance, analytical chemistry, where similar stimulation is justified. Such initiatives will require special funding and resourcing.

Other ways in which chemistry at universities may be invigorated include:

- the establishment of a vigorous programme to encourage support of targeted research areas through post-doctoral fellowships;

- encouragement, through special funding, of international collaboration and travel (including colloquia and seminars in Norway);

- the promotion of workshops and weekend "retreats" designed to involve special topics and high-level invited speakers, and intended to stimulate research and to maintain closer contacts between researchers with common interests;

- seeking ways in which doctoral students may be encouraged to move location more often and, generally, to become more ambitious and success-oriented.

The panel believes that, to a large extent, the problems that face the Norwegian university chemistry community are exacerbated by the absence, on the part of the Research Council, of a carefully thought-through strategy for the development of the subject. The Research Council is in a powerful position and can make a difference. It is common experience elsewhere that hearts and minds follow funding.

The main research areas

Organic chemistry

On a world scale, organic chemistry, including biological organic chemistry, is probably the largest and one of the most active areas of chemistry. Research in organic chemistry underpins major advances in understanding biological systems at a molecular level, medical research, the discovery and development of pharmaceuticals, agrochemicals and special materials, the fundamental understanding of reactivity, and the mechanisms of organic reactions.

Against this background, the current state of organic chemistry in Norway gives much cause for concern. Although it has previously enjoyed a strong position, little cutting edge research is being done currently, for example, at the interface with biology. The panel has examined all aspects of the programmes presented, especially physical-organic chemistry, synthesis and natural products, and related chemistry. It has been noted that several eminent Norwegian organic chemists have recently retired or are within a few years of retirement. Excluding these, there are few organic chemists (probably less than five) operating in Norway at anything approaching an internationally recognised high standard.

The group in Oslo is probably the strongest, mainly by virtue of the number of staff and research workers involved. In Bergen and Tromsø, there are energetic and ambitious efforts in train, which offer some hope for the much-needed recovery for organic chemistry in Norway. However, the numbers involved are probably sub-critical. With the retirement of Trondheim's world-class natural products chemist and, in a few years, of another very active professor, organic chemistry in Trondheim will be at a low ebb. No convincing strategy has been designed to remedy this. Organic chemistry is so essential for the balance of departments that it is unthinkable for any chemistry department to tolerate such weakness.

The panel recommends that:

- at least one centre for synthetic organic chemistry be established (probably in Oslo, but possibly in Bergen), and that the other universities in Norway be encouraged to build up the subject;

- since organic chemistry, particularly synthesis, is labour intensive, earmarked studentships, post-doctoral fellowships, and special research fellowships must be provided and accompanied by sufficient (realistic) funding to cover the costs of consumables; and

- synthetic organic chemists be encouraged, possibly by targeted programmes, to capitalise on activities and developments occurring at the chemistry/biology interface. Sharply focused programmes aimed at innovative synthesis could also be developed to include organic materials, polymers and petrochemicals.

Inorganic chemistry

Inorganic chemistry is represented as an independent discipline at three universities in Norway, namely, Oslo, Bergen and Trondheim. Each university has developed its own characteristic research profile. Traditionally, inorganic chemistry has been closely connected with structural chemistry, benefiting from the instrumentation of the latter.

The Oslo group's work is focused on solid state inorganic materials. It is characterised by high quality and productivity as well as by a high level of relevance to applications and other fields, such as catalysis. The panel feels that this type of research should continue to receive substantial support.

Another group which has an internationally recognised position in its special field is the Department of Inorganic Chemistry at NTNU in Trondheim. There, the range of topics is broader, and increased support should be given to those projects whose international and industrial impact is high, and which take an innovative approach and include a fair amount of basic research.

Bioinorganic chemistry is a rapidly developing field at the interface of inorganic chemistry and biology. A good example of bioinorganic research which is worthy of support is the biophysical/bioinorganic chemistry group in Bergen, which is well-equipped and studies the metal ion binding of oligonucleotides. Bioinorganic chemistry could also be given more focus in Tromsø, in preference to classical inorganic chemistry.

Analytical chemistry

There are currently only two chairs in analytical chemistry in Norway, both in the Oslo area (Oslo and Ås). Analytical chemistry is clearly underdeveloped at the other universities, although there is some analytical activity connected with environmental or organic chemistry. The new chair at the Division of Inorganic Chemistry in Bergen will focus on environmental analysis.

Given the importance of analytical chemistry to modern materials science, for instance, the panel feels that serious consideration should be given to strengthening the position of the subject at the universities outside Oslo. This is especially important for NTNU, where there is an obvious need for materials and surface analysis. However, the expansion of analytical research and education should not be made at the expense of the groups in Oslo and Ås, which both have strong, internationally recognised research records. The dynamic chemometrics group in Bergen also deserves continued support.

Physical chemistry

This field is difficult to define. It is widely diversified in Norway, which is one reason why it is discussed under separate sub-fields. It is the opinion of the panel that some sub-fields are more than adequately staffed in Norway, and that the general level in physical chemistry is good.

Theoretical chemistry

Theoretical chemistry is a traditional field of chemistry in Scandinavia, not least in Norway. All the various chemistry departments host a group in theoretical chemistry, but the staffs are out of balance compared with other European countries. Faculty members are particularly active and the level of publication maintains a high international standard. The panel is of the opinion that the strength of this field should be maintained, although perhaps not at all the universities, and that there should be a shift, possibly through targeted research programmes, towards the key issues of contemporary chemistry.

Experimental physical chemistry

Strong points were identified in surface and colloid chemistry (Bergen, high international level), thermodynamics (Trondheim) and spectroscopy (Oslo), with very active faculty members. Vibrational spectroscopy is particularly well represented, as well as NMR (usually outside physical chemistry departments). With the exception of Oslo, mass spectrometry appears to be less well developed. Basic polymer sciences might be expected to hold a stronger position, given the importance of the field and its continuing relevance for the Norwegian petrochemical industry. The Trondheim group focuses mainly on applied chemistry. There appears to be a strong need for revitalisation of the group in Oslo.

Structural chemistry

Nobel Prize winner Odd Hassel initiated structural chemistry in Norway, and it is therefore well represented in this country, where efforts are more than adequate. Whilst the groups in Oslo, Trondheim and Bergen tend to follow the traditions set in both gas phase electron diffraction and X-ray single crystal diffraction, the group in Tromsø has specialised in protein crystallography. Another important initiative is the establishment of the Swiss-Norwegian beam line at ESRF (Grenoble). The panel recommends that the latter activities be maintained at least at their present level, that new instrumentation for gas phase electron diffraction be concentrated at one university and that adequate equipment and staffing be maintained for X-ray single crystal diffraction at each university. Another justification for maintaining this level of activity is to support the hoped-for expansion in synthetic chemistry.

Environmental chemistry

With the exception of Tromsø, environmental chemistry is represented in one form or another at all universities. The strongest groups are in Ås and Oslo, both of which are analytically oriented and have long experience in environmental monitoring and problem-solving. The former group, at the Laboratory for Analytical Chemistry, has the advantage of being able to integrate a full range of analytical techniques (including radioanalytical ones) into its research. Both groups work on the basis of extensive international collaboration, and their programmes

aim at offering a complete chain from sampling to modelling. This type of comprehensive approach should be encouraged.

Nuclear chemistry

The only sizeable Norwegian group is located at the University of Oslo. This group is adequately staffed and is involved both in basic and applied research: cancer therapy and radio-analytical chemistry. Radio-analytical methods are also used by a group in Ås. The general level of the research meets good international standards, and the group has access to major European and American facilities in the field. It is essential that activity in this field be maintained, since the group is the only centre which educates students in radiochemistry. The development of clinical and environmental applications will strengthen the position of the group within Norwegian science.

Applied chemistry/chemical engineering

Research in applied chemistry and chemical engineering appears to be concentrated in Trondheim. Notable work in applied chemistry is, however, being pursued in other places as well, especially at the University of Oslo and certain colleges. The following major areas of activity can be identified: (i) heterogeneous catalysis, (ii) process systems engineering, (iii) separation processes and applied thermodynamics and (iv) polymer science. High quality research is being carried out in the first two areas, which should be supported or even expanded. Some useful research is performed in area (iii), while that of area (iv) tends to be somewhat old-fashioned. In view the overwhelming importance of petroleum and gas processing for the Norwegian economy, an additional group working in an innovative field of heterogeneous catalysis would seem to be desirable and should be installed in Bergen, where it could best be associated with the Surface and Colloid Chemistry group. Support must be maintained for chemical engineering at NTNU, which is the only chemical engineering department in Norway, and contains a lively process systems group of international stature. While valuable research in applied thermodynamics and the field of gas hydrates is being pursued at colleges, in view of the limited size and equipment of these groups, closer co-operation with the established universities is recommended. Current work in polymer science in many cases centres around topics defined decades ago by Professor Ugelstad. A re-orientation towards important, modern research goals within polymer chemistry in Norway is recommended.

1. Introduction

1.1 Mandate

The Research Council of Norway has organised a review of chemistry research at Norwegian universities and colleges. An ad hoc international panel was established and charged with the mandate given in the Appendix. According to the mandate, the review should assess the institutions according to:

⇒ The quality and relevance of their research on the research group level;

⇒ The role of the institutions within the national research framework; and

⇒ How each institution performs professionally in a national context and with respect to international collaboration.

1.2 Panel members

The evaluation panel consisted of the following experts:

Professor Jens Weitkamp Chairman Institute of Chemical Technology I Department of Chemistry University of Stuttgart D-70550 STUTTGART	Professor Jean-Claude G. Bünzli Institute of Inorganic and Analytical Chemistry University of Lausanne BCH 1402 CH-1015 LAUSANNE
Professor Sine Larsen Centre for Crystallographic Studies Department of Chemistry University of Copenhagen University Park 5 DK-2100 COPENHAGEN	Professor Lauri Niinistö Laboratory of Inorganic and Analytical Chemistry Department of Chemical Technology Helsinki University of Technology FIN-02015 ESPOO
Professor Gerald Pattenden Department of Chemistry University of Nottingham University Park GB-NOTTINGHAM NG7 2RD	Professor Jack W. Ponton Chemical Engineering Department University of Edinburgh King's Buildings, Mayfield Rd. GB-EDINBURGH EH9 3JL
Professor James H.P. Utley Department of Chemistry Queen Mary and Westfield College University of London, Mile End Road GB-LONDON E1 4NS	

Executive Secretary Signe Dahle Urbye, the Research Council of Norway, played a key role in compiling all the input from the panel members and in the processing of the report.

1.3 Key information and major issues

In spring 1996, the Research Council of Norway informed the relevant institutions about their initiative to carry out a review on a group and institutional level of chemistry research at Norwegian colleges and universities. The review panel was established in November 1996.

Based upon the scheme outlined below, written information was prepared by the institutions and distributed to the panel members. The panel had the opportunity to study the written material before visiting the institutions.

In terms of formal meetings, the panel had: a one day planning meeting; two days at the Norwegian University of Science and Technology (NTNU); two days at the University of Oslo; one day at the University of Tromsø; one day at the University of Bergen; and half days at Telemark College, Stavanger College, the Agricultural University at Ås and Agder College, respectively.

During the panel's visits to the various institutions, the heads of faculties/departments/ institutes presented brief outlines (1 to 1.5 hours) of their programmes. Then the research groups/sections/departments presented and discussed their work, providing further information in subgroups which included two panel members. Short visits to the laboratory facilities were usually included. This gave the panel further insight into the main goals, activities and work of each research group. Based on all the information received, two panel members have written a general evaluation, a SWOT Analysis (Strengths, Weaknesses, Opportunities, and Threats), assessment and recommendations which have been extended to aggregated levels. Endeavours were made to ensure uniform treatment through plenary discussions.

The purpose of the review and its probable structure were determined in advance and, to some extent, discussed with representatives of the institutions. The following list covers the main items of information required and the main issues to be addressed.

Information collected

* Size and organisation of the groups; higher organisational level
* Research topics for the groups (key words and descriptions)
* List of employees
* Ages of employees
* Turnover of employees
* CVs of employees
* List of publications, conferences, books etc. 1992 to 1997, identifying the five most important achievements
* List of citations for the past five years (from NIFU)
* Expenditures annually, and for the past five years
* Annum annually and for the past five years
* List of main pieces of equipment
* Number of degrees granted in the past five years:
  - undergraduate, graduate, post-graduate
  - (doctorates)
* Current number of students within the same categories

* Number of graduate placements
* Contribution to international science
* Participation in:
  - National scientific collaboration (publications)
  - International " " "
  - Research programmes
* Collaboration with:
  - Research institutes
  - Industry

Major issues (to be addressed in an international context):

- The quality of the group's scientific activity:
  - at the national level
  - at the international level
- The balance between experimental and theoretical activities in the field
- The relevance and adequacy of the group's equipment and annual allocations
- National collaboration related to expensive equipment
- Strategies/future plans for research
  - research objectives
  - short/long term
- The relevance of research for:
  - National strategies
  - National advantages (resources, activities etc.)
  - Industry
  - Authorities

- The relevance of the research to the educational profile
- The impact on the groups' research activities of national funding from the Research Council of Norway (basic funding/strategic university programme, programmes, free projects and equipment)
- SWOT Analysis

Aggregated level

◊ The balance of the groups' scientific activities in and among the various institutions;
◊ The balance of the various research fields/institutions in a national context;
◊ Consideration of the major issues listed above in a national/international context.

1.4 Outline of the review report

Initially, the report presents general information relating to the panel and the procedure adopted for the review. The selected institutions are described, and standard figures are given based on data provided by the Norwegian Institute for Studies in Research and Higher Education (NIFU).

The review gives a brief description of the institutions and the various organisational levels down to the research groups, including SWOT analyses, assessments and recommendations. Consolidated recommendations are presented based on the evaluations undertaken at the lower levels. The various institutions are also assessed in a national context.

The appendix contains details of the organisations, programmes for the various site visits and other relevant background information.

2. A presentation of the institutions

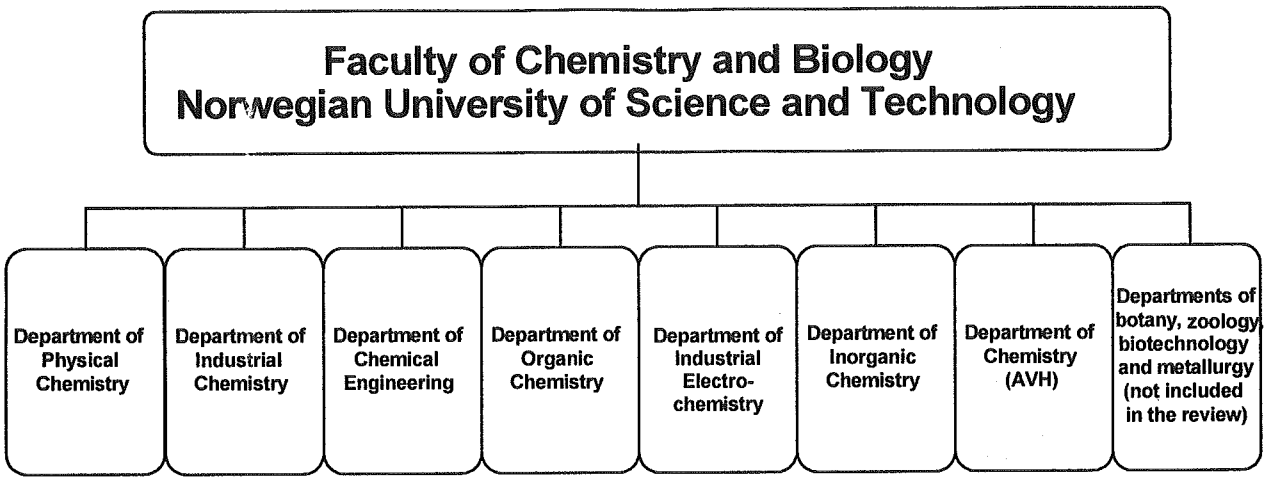
2.1 Selected institutions and their organisation

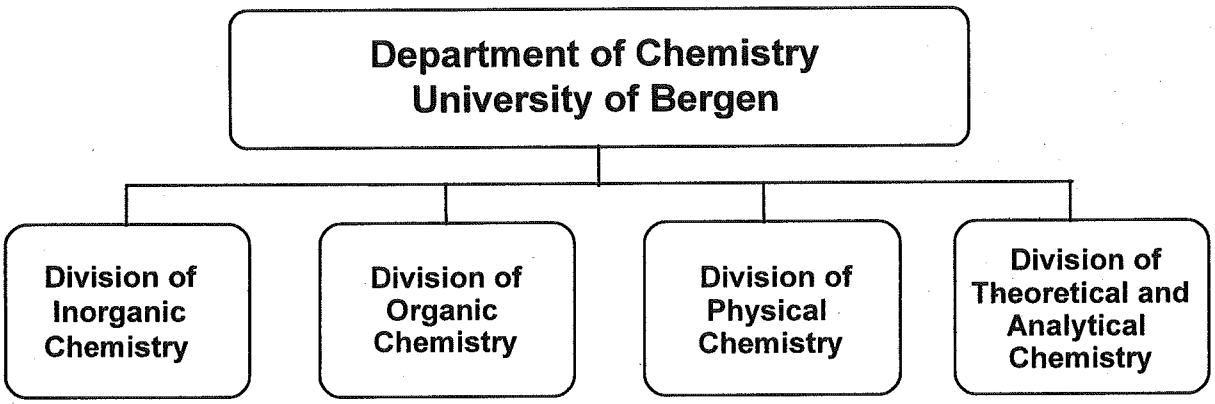
The following institutions were selected for the review:

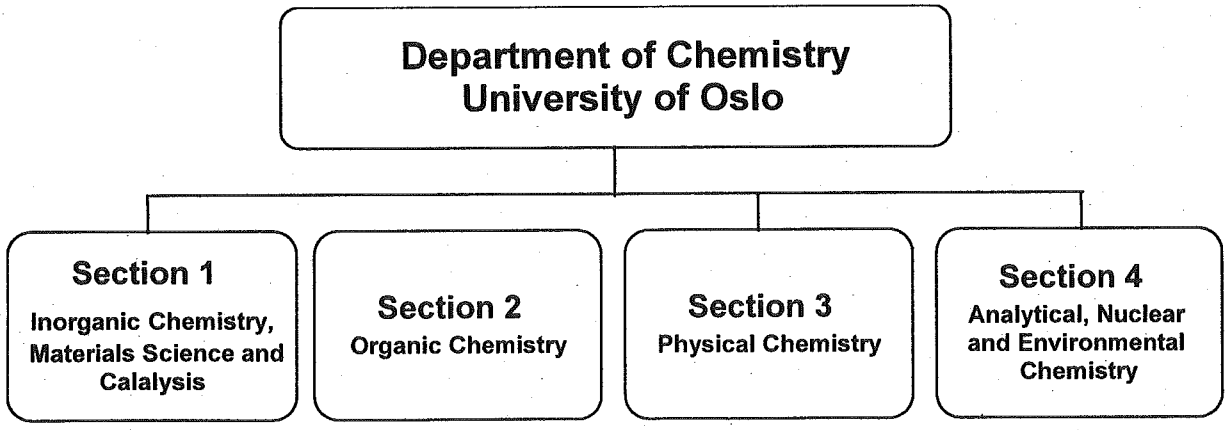
- Norwegian University of Science and Technology
  ⇒ Faculty of Chemistry and Biology (biology and biochemistry excluded)
- University of Bergen
  ⇒ Department of Chemistry
- University of Oslo
  ⇒ Department of Chemistry
  ⇒ Institute of Pharmacy (selected groups within chemistry)
- University of Tromsø
  ⇒ Department of Chemistry
- Agricultural University of Norway
  ⇒ Laboratory for Analytical Chemistry
- Agder College
  ⇒ Department of Sciences, Chemistry group
- Stavanger College
  ⇒ Institue of Mathematics and Natural Sciences, Chemical Engineering group
- Telemark College
  ⇒ Department of Technology

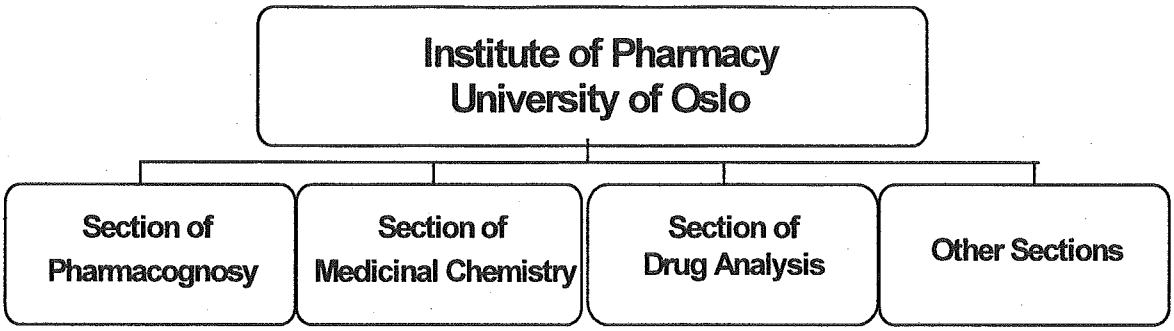
Different names are used for the same organisational level at the various institutions. For example, faculty level at the NTNU corresponds to departmental level at the University of Oslo, department level at the NTNU to division level at the University of Bergen and section level at the University of Oslo and the University of Tromsø.

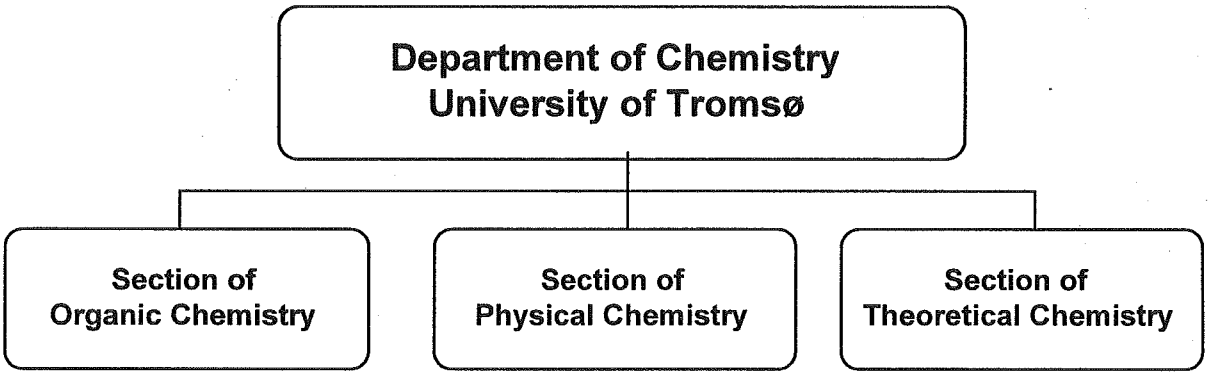
The various institutions are organised as follows:

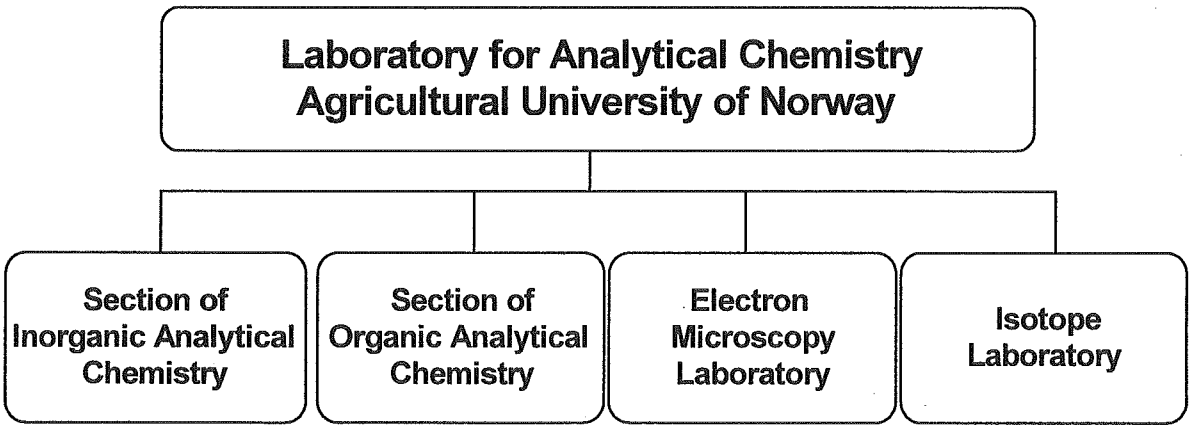


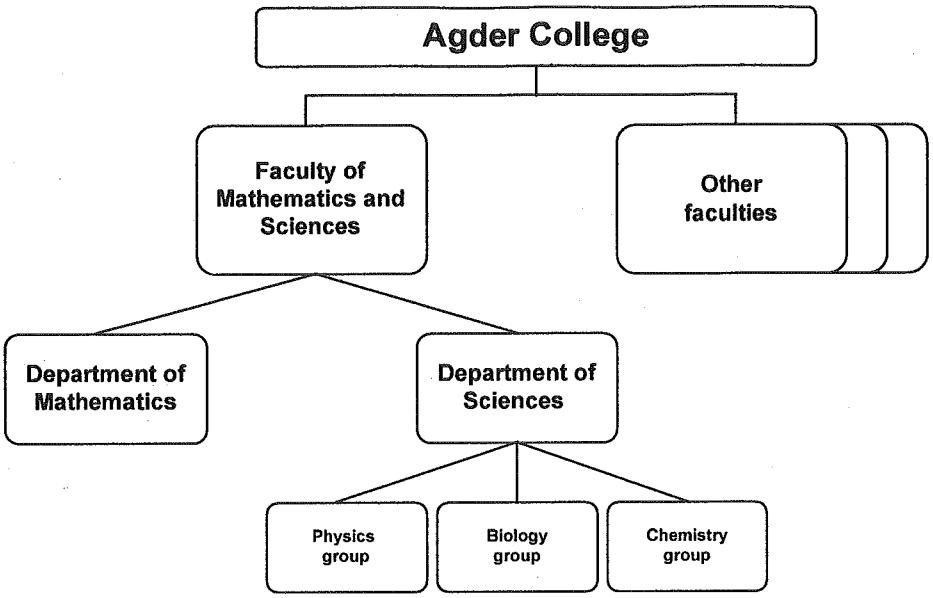


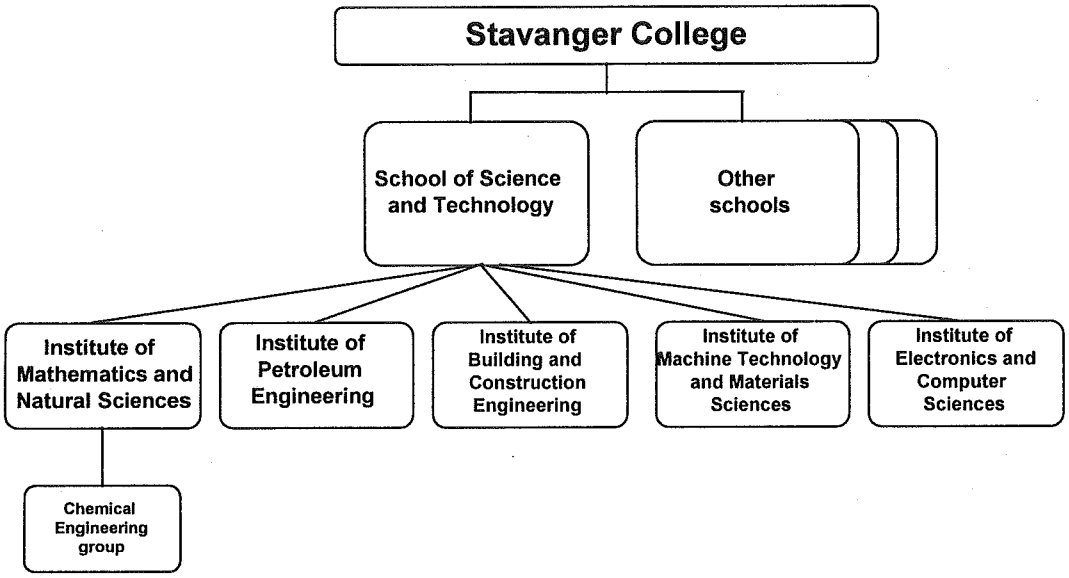


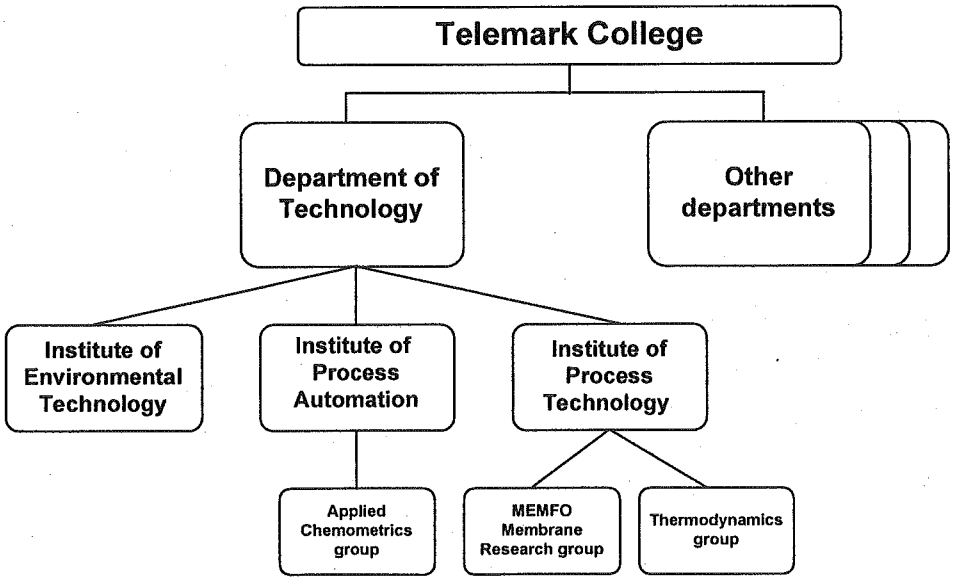

Institute of Pharmacy
University of Oslo
Section of Pharmacognosy
Section of Medicinal Chemistry
Section of Drug Analysis
Other Sections


Department of Chemistry
University of Tromsø
Section of Organic Chemistry
Section of Physical Chemistry
Section of Theoretical Chemistry


Laboratory for Analytical Chemistry
Agricultural University of Norway
Section of Inorganic Analytical Chemistry
Section of Organic Analytical Chemistry
Electron Microscopy Laboratory
Isotope Laboratory


Agder College
Faculty of Mathematics and Sciences
Other faculties
Department of Mathematics
Department of Sciences
Physics group
Biology group
Chemistry group


Stavanger College
School of Science and Technology
Other schools
Institute of Mathematics and Natural Sciences
Institute of Petroleum Engineering
Institute of Building and Construction Engineering
Institute of Machine Technology and Materials Sciences
Institute of Electronics and Computer Sciences
Chemical Engineering group


Telemark College
Department of Technology
Other departments
Institute of Environmental Technology
Institute of Process Automation
Institute of Process Technology
Applied Chemometrics group
MEMFO Membrane Research group
Thermodynamics group

2.2 Key figures

2.2.1 Doctoral degrees

Main figures

The following figures are based on statistics from the Doctoral Degree Register. The Doctoral Degree Register is maintained pursuant to regulations laid down by the Data Inspectorate of Norway.

From 1991 until the spring of 1996, 2800 doctoral degrees were conferred by institutions of higher education in Norway. Of that number, 765 or slightly more than one fourth were awarded in science and technology. Of these, 108 were classified as being in chemistry and earned from the faculties of mathematics and natural sciences at Norwegian universities. In addition, 98 doctoral degrees in chemistry were taken at the Faculty of Chemistry and Chemical Technology at the former Norwegian Institute of Technology, NTH (from 1 January 1996, incorporated in the Norwegian University of Science and Technology, NTNU[1]). This adds up to a total of 206 doctoral degrees in chemistry and chemical engineering taken at Norwegian universities.

The 206 doctoral degrees are distributed as follows:

Dr. scient.	96
Dr. philos.	12
Dr. ing.	98

Institutional distribution

Figure 2.1 shows the distribution of the doctoral degrees in chemistry by institution 1991-1996.

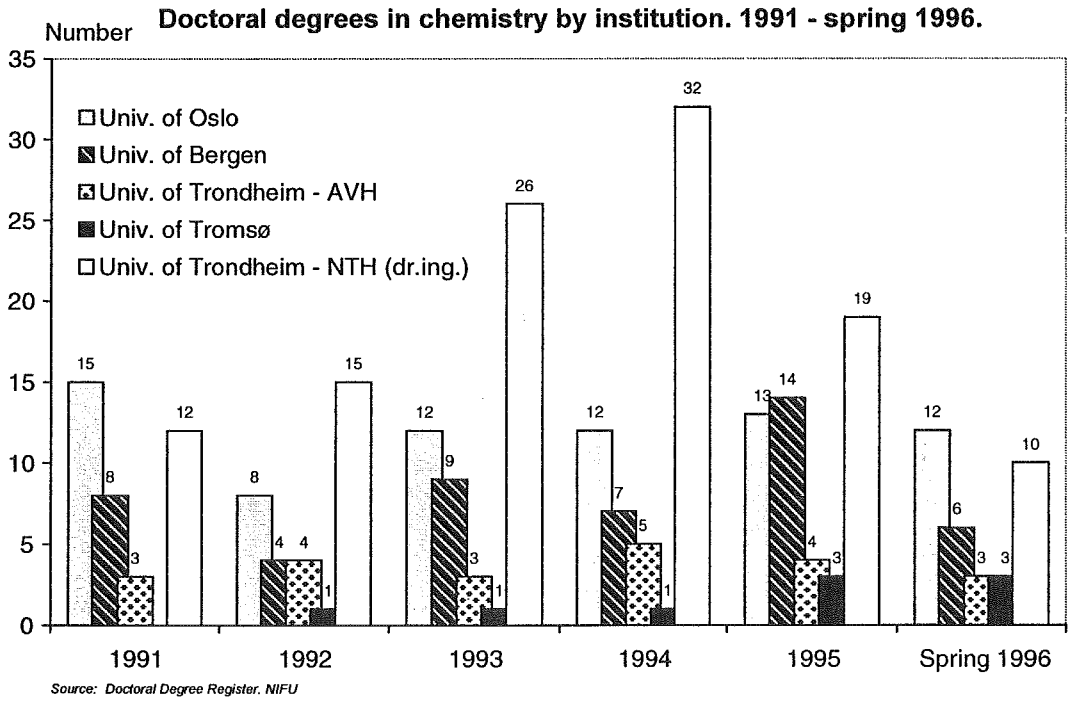


Figure 2.1. Doctoral degrees in chemistry, by institution, from 1991 to spring 1996. In addition to the 206 degrees in chemistry and chemical engineering the figure includes 43 doctoral degrees in biochemistry at the universities and 16 in biotechnology/biochemistry at the former NTH.

1 Also incorporated in NTNU is the former College of Arts and Science (AVH).

Gender distribution
The percentage of women among doctoral degree candidates was higher in chemistry than in mathematics/natural sciences in general, 38% compared with 27% during the period under review. The overall percentage of women awarded doctoral degrees in Norway was 27%.

Distribution by subfields
Based on the titles they confer, doctoral degrees are classified by disciplines and subfields. Within the natural sciences, departmental association or field of study will usually be decisive for the disciplinary or subfield classification. Table 2.1 shows the distribution by subfields of doctoral degrees in chemistry awarded by Norwegian faculties of mathematics and natural sciences.

Table 2.1. Distribution of doctoral degrees in chemistry/biotechnology and biochemistry by subfields and disciplines (1991 – spring 1996)

Subfield	Number	Average age
Mathematics/Natural Sciences faculties [1)]		
Analytical chemistry	3	32.7
Biochemistry	43	35.6
Physical/theoretical chemistry	20	31.4
Organic chemistry	26	33.9
Inorganic chemistry	8	35.4
Chemistry - unspecified	51	33.6
Sum MN-faculties	151	34.0
Faculty of Chemistry and Chemical Technology, NTH [2)]	114	30.6
Total	265	32.7

Source: Doctoral Degree Register, NIFU

1) Incl. natural science departments at the University of Tromsø
2) Figures from 1992, incl. one degree without association (siv. ing. in Porsgrunn)

Age distribution
As indicated in Table 2.1, the average age of candidates at thesis defence was 33. There were no significant differences between the genders in this respect. Those taking dr. ing. degrees were, on average, somewhat younger (31), while those who took dr. scient. or dr. philos. degrees were slightly older (34). At the faculties of mathematics and natural science, the average age was 35, while the average age for all doctors, regardless of discipline, was 37. Table 2.1 lists the average ages for all subfields within mathematics and the natural sciences.

Trends

Figure 2.2 shows the development in the number of doctorates in chemistry in mathematics/natural sciences since 1980.

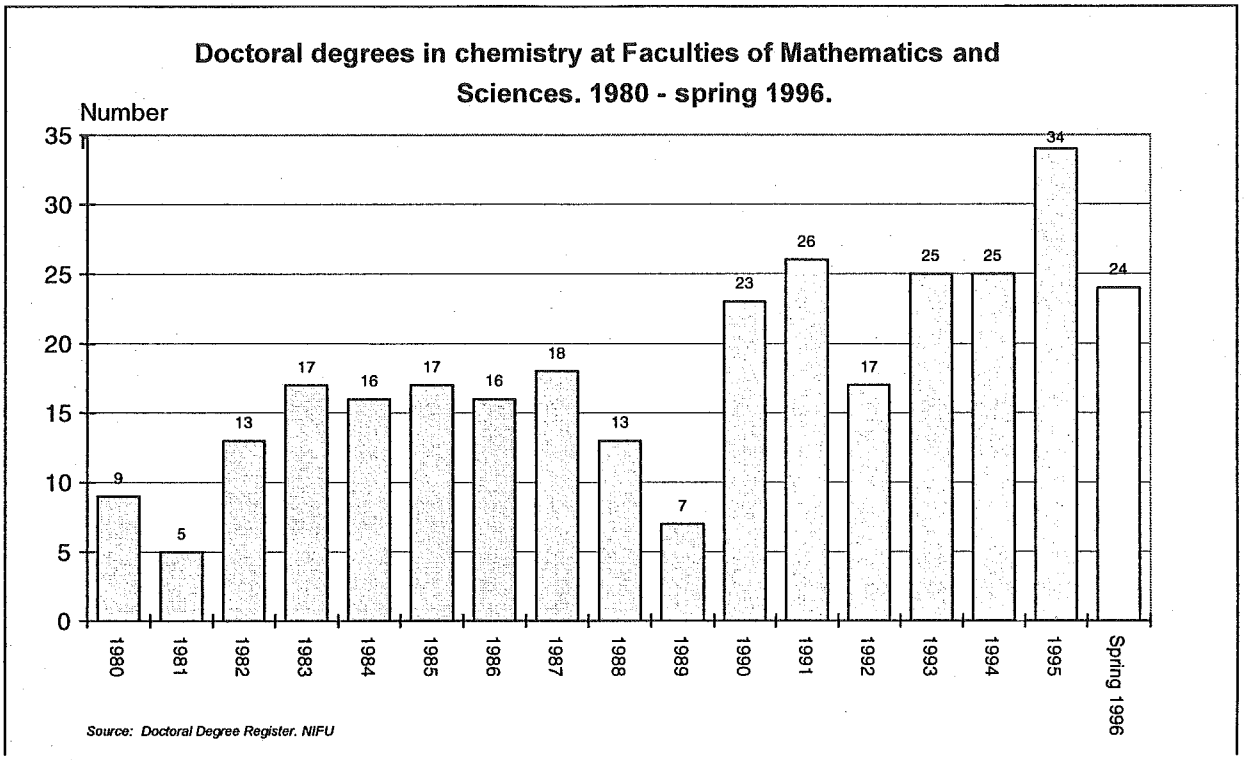


Figure 2.2. Doctoral degrees in chemistry at the faculties of mathematics and natural sciences from 1980 until spring 1996. 20% to 25% of the candidates were in biochemistry.

2.2.2 Expenditures for R&D

The figures and data in this chapter have been collected and compiled for the Research Council of Norway by the Norwegian Institute for Studies in Research and Higher Education (NIFU). Most of the figures are from Norwegian R&D Statistics 1995.

Tables on R&D expenditure and scientific personnel at units of Norway's four universities and the Agricultural University of Norway are presented in the following. These units may be called university departments of *chemistry* in the sense that most of their R&D activities are related to chemistry. The included units are[2]:

2 The selection of the units was undertaken in collaboration with the Division of Science and Technology at the Research Council of Norway. Departments at the Norwegian University of Science and Technology tend to classify a large part of their work under technology. However, borders between chemistry and other related fields, above all the bio-sciences and technology, are not always clear-cut. The classification of activities must, therefore, be based on discretion. In *this* context we will, nevertheless, regard all 14 units as university departments of chemistry. The statistics cover 1995.

University of Oslo	
	Institute of Pharmacy - Section of Pharmacognosy
	Institute of Pharmacy - Section of Medicinal Chemistry
	Department of Chemistry
University of Bergen	
	Department of Chemistry
University of Trondheim (NTNU from 1 January 1996)	
	Department of Organic Chemistry/NTH
	Department of Inorganic Chemistry/NTH
	Department of Physical Chemistry/NTH
	Department of Chemical Engineering/NTH
	Department of Industrial Chemistry/NTH
	Department of Electrochemistry/NTH
	Department of Chemistry/AVH
University of Tromsø	
	Department of Chemistry
Agricultural University of Norway	
	Laboratory for Analytical Chemistry

Abbreviations:

NTNU	Norwegian University of Science and Technology (from 1 January 1996)
NTH	Norwegian Institute of Technology at the University of Trondheim (before 1 January 1996)
AVH	College of Arts and Science at the University of Trondheim (before 1 January 1996)

Table 2.2 includes preliminary figures[3] based on estimates for total R&D expenditure in the higher education sector (HES).

Table 2.2. R&D expenditure at selected university departments compared with total R&D expenditure in 1993 and 1995 (MNOK)

Category	1993	1995	Change in %
Total R&D expenditure in Norway	14 336	14 933	4.2
Hereof, higher education sector	3 894	4 139	6.3
Hereof, natural science[1)] and technology [1)]	1 134	1 070	-5.6
	355	422	18.9
Selected departments	181	160	-11.9

1) Field codes revised in 1995

However, survey data are available for externally funded R&D activities as well as for that part of the basic allocations, which is used to cover current costs and expenditure on scientific

3 See "Weekly Statistics" no. 44/96 from Statistics Norway.

equipment. Figures are not available for payroll costs. Tables 2.3 to 2.6 are based on available, but preliminary, figures on R&D expenditure at university departments of chemistry. The Institute of Pharmacy, Section of Medicinal Chemistry, at the University of Oslo did not respond to the queries, so expenditure figures for this department are not included in the tables[4].

Table 2.3. R&D current expenditure and R&D capital expenditure by main source of funding at selected university departments in 1995 (MNOK)

Main source of funding	R&D current expenditure	R&D capital expenditure	Total
Basic appropriation	88 072	6 470	94 542
External funds	62 101	3 158	65 259
Total	150 173	9 628	159 801

Table 2.4. R&D expenditure at selected university departments by main source of funding in 1995 (MNOK)

Institution	Basic allocation	External funding[5]	Total
University of Oslo	*33 669*	*11 847*	*45 517*
Institute of Pharmacy - Section of Pharmacognosy	2 034	915	2 949
Institute of Pharmacy - Section of Medicinal Chemistry			
Department of Chemistry	31 635	10 932	42 568
University of Bergen	*12 832*	*2 680*	*15 512*
Department of Chemistry	12 832	2 680	15 512
University of Trondheim (NTNU from 1.1.1996)	*42 253*	*47 960*	*90 213*
Department of Organic Chemistry/NTH	3 567	2 504	6 072
Department of Inorganic Chemistry/NTH	9 847	14 701	24 548
Department of Physical Chemistry/NTH	3 154	2 493	5 647
Department of Chemical Engineering/NTH	7 148	13 860	21 007
Department of Industrial Chemistry/NTH	4 529	6 154	10 684
Department of Industrial Electrochemistry/NTH	4 318	6 881	11 199
Department of Chemistry/AVH	9 689	1 367	11 056
University of Tromsø	*5 787*	*2 772*	*8 559*
Department of Chemistry	5 787	2 772	8 559
Agricultural University of Norway			
Laboratory for Analytical Chemistry			
Total	94 542	65 259	159 801

4 This also applies to the Laboratory for Analytical Chemistry at the Agricultural University of Norway. As Tables 2.3 to 2.6 do not include these two units, total real sums will actually be somewhat higher than they appear.

5 The external funds in the table are based on the information given by the institutions to NIFU. The evaluation panel has found discrepancies between the external funds given in the table and the corresponding numbers given to the panel during the site visits. In the case of the Department of Chemistry at the University of Bergen the external funds should for example be increased by about MNOK 10 in 1995.

Table 2.5. Basic appropriation for R&D current expenditure and R&D capital expenditure at selected university departments 1995 (MNOK)

Institution	R&D current expenditure	R&D capital expenditure
University of Oslo	*31 834*	*1 836*
Institute of Pharmacy - Section of Pharmacognosy	1 894	140
Institute of Pharmacy - Section of Medicinal Chemistry	..	..
Department of Chemistry	29 940	1 695
University of Bergen	*11 198*	*1 634*
Department of Chemistry	11 198	1 634
University of Trondheim (NTNU from 1.1.1996)	*39 951*	*2 302*
Department of Organic Chemistry/NTH	3 435	132
Department of Inorganic Chemistry/NTH	9 382	465
Department of Physical Chemistry/NTH	2 971	183
Department of Chemical Engineering/NTH	6 844	304
Department of Industrial Chemistry/NTH	4 364	166
Department of Industrial Electrochemistry/NTH	4 038	280
Department of Chemistry/AVH	8 917	772
University of Tromsø	*5 089*	*698*
Department of Chemistry	5 089	698
Agricultural University of Norway	..	..
Laboratory for Analytical Chemistry	..	..
Total	88 072	6 470

Table 2.6. Externally funded R&D at selected university departments by source of funding in 1995 (NOK 1000)

Institution	Source of funding				
	Business/ industry	Research Council of Norway	Other public funding	Other sources/ foreign	Total
University of Oslo	*2 585*	*8 427*	*351*	*485*	*11 847*
Institute of Pharmacy - Section of Medicinal Pharmacy	..	..	..	..	..
Institute of Pharmacy - Section of Pharmacognosy	0	716	73	126	915
Department of Chemistry	2 585	7 710	278	359	10 932
University of Bergen	*310*	*2 159*	*0*	*211*	*2 680*
Department of Chemistry	310	2 159	0	211	2 680
University of Trondheim (NTNU from 1.1.1996)	*23 225*	*19 661*	*682*	*4 393*	*47 960*
Department of Organic Chemistry/NTH	1 159	879	0	466	2 504
Department of Inorganic Chemistry/NTH	10 518	2 250	0	1 933	14 701
Department of Physical Chemistry/NTH	1 142	1 044	0	308	2 493
Department of Chemical Engineering/NTH	4 595	8 624	443	198	13 860
Department of Industrial Chemistry/NTH	1 360	3 561	175	1 058	6 154
Department of Industrial Electrochemistry/NTH	4 451	2 101	0	329	6 881
Department of Chemistry/AVH	0	1 202	64	102	1 367
University of Tromsø	*40*	*2 522*	*0*	*210*	*2 772*
Department of Chemistry	40	2 522	0	210	2 772
Agricultural University of Norway	..	..	..	..	..
Laboratory for Analytical Chemistry	..	..	..	..	..
Total	26 160	32 768	1 033	5 299	65 259

Table 2.7 indicates how departments distribute R&D current costs by discipline and type of activity. Only half of the departments identify chemistry as the main focal point of their R&D activities. All departments, with the exception of those at the Norwegian Institute of Technology, say that their R&D activities mainly involve basic research. At the Norwegian Institute of Technology, the departments classify about half of their R&D activity as basic research.

Table 2.7. Estimated distribution of R&D current expenditure by type of activity at selected university departments in 1995 (percentage)

Institution	Type of activity			
	Basic research	Applied research	Develop-ment	Total
University of Oslo				
Institute of Pharmacy - Section of Pharmacognosy	90	10	0	100
Institute of Pharmacy - Section of Medicinal Chemistry	..	..	..	..
Department of Chemistry	82	17	1	100
University of Bergen				
Department of Chemistry	80	20	0	100
University of Trondheim (NTNU from 1.1.1996)				
Department of Organic Chemistry/NTH	50	50	0	100
Department of Inorganic Chemistry/NTH	50	50	0	100
Department of Physical Chemistry/NTH	20	25	55	100
Department of Chemical Engineering/NTH	30	60	10	100
Department of Industrial Chemistry/NTH	10	70	20	100
Department of Industrial Electrochemistry/NTH	10	80	10	100
Department of Chemistry/AVH	90	0	10	100
University of Tromsø				
Department of Chemistry	100	0	0	100
Agricultural University of Norway				
Laboratory for Analytical Chemistry	80	10	10	100

2.2.3 R&D personnel

Tables 2.8 to 2.10 present figures on scientific personnel at departments of chemistry.

Table 2.8 shows that about 400 people held scientific positions in chemistry departments, accounting for 18% of the 2,200 scientific positions in the natural sciences in 1995. The total number of scientific personnel at universities and university-level colleges was almost 8,800 people in all fields of science.

Table 2.8. Scientific personnel at selected university departments, compared with total scientific personnel in 1993 and 1995

Category	1993	1995	Change in %
Total scientific personnel	8 567	8 755	2.2
Hereof natural sciences[1)] and	2 109	1 962	-7.0
technology [1)]	751	777	3.5
Selected departments (chemistry)	416	386	-7.2

[1)] Field codes revised in 1995

Table 2.9 shows the distribution of personnel by professional rank and between the institutions. In 1995, tenured personnel constituted 41% of the positions, recruitment personnel 45%, and externally funded personnel (excluding recruits) 13%.

Table 2.9. Scientific personnel at selected university departments by institution and professional rank in 1995

Institution	Professors	Senior lecturers	Lecturers	Total tenured personnel	Recruits	External	Total
University of Oslo	*36*	*17*	*2*	*55*	*59*	*18*	*132*
Institute of Pharmacy - Section of Pharmacognosy	3	1	0	4	4	1	9
Institute of Pharmacy - Section of Medicinal Chemistry	2	1	0	3	3	0	6
Department of Chemistry	31	15	2	48	52	17	117
University of Bergen	*14*	*7*	*1*	*22*	*18*	*4*	*44*
Department of Chemistry	14	7	1	22	18	4	44
University of Trondheim (NTNU from 1.1.1996)	*36*	*21*	*3*	*60*	*105*	*19*	*184*
Department of Organic Chemistry/NTH	3	3	0	6	8	0	14
Department of Inorganic Chemistry/NTH	4	5	0	9	19	9	37
Department of Physical Chemistry/NTH	4	1	1	6	8	1	15
Department of Chemical Engineering/NTH	8	2	0	10	34	1	45
Department of Industrial Chemistry/NTH	4	2	2	8	15	3	26
Department of Industrial Electrochemistry/NTH	4	1	0	5	13	3	21
Department of Chemistry/AVH	9	7	0	16	8	2	26
University of Tromsø	*7*	*2*	*0*	*9*	*7*	*4*	*20*
Department of Chemistry	7	2	0	9	7	4	20
Agricultural University of Norway	*1*	*2*	*0*	*3*	*2*	*1*	*6*
Laboratory for Analytical Chemistry	1	2	0	3	2	1	6
Total 1995	94	49	6	149	191	46	386
Total 1993	92	66	8	166	206	44	416

Personnel are distributed by subdisciplines in Table 2.10. The review committee would like to point out some difficulties with this method of distribution. The Research Personnel Register at NIFU categorises people under the discipline which is "most characteristic" for the R&D activities at the unit in which they work, i.e. *en bloc* according to this criterion. Within chemistry, however, individual departments were asked to classify each individual under the discipline in which they conduct the most R&D activities. Only a few of the departments undertook such a classification. It is also important to remember that some departments do less than half of their R&D work in chemistry. Three departments did not mention chemistry at all in discussing the type of R&D work they perform. Thus, there is no consistent connection in the data between the percentage distribution of R&D activities that the institutes were asked to undertake, on the one hand, and the categorisation of scientific personnel by scientific fields, on the other. Comparing the distribution of subdisciplines in 1989 and 1995, one additional factor is that personnel were classified by the Council Secretariat of the former Norwegian Research Council for Science and the Humanities in 1989, while the departments' own coding system was used in 1995. This means that discretion should be used when comparing distributions by subdisciplines.

Twenty-eight women were in scientific positions at departments of chemistry in 1995. Seventeen per cent of them were in tenured positions. The corresponding figure for 1989 was 13%. The percentage of women is thus higher in chemistry than in the natural sciences as a whole (11% in 1995), but somewhat lower than for all tenured positions, regardless of field of learning (20%).

A total of 165 people or 41% of all scientific personnel in chemistry had taken doctoral degrees. Of these, 27% took their degrees abroad. Of the 135 Norwegian doctoral degrees, only 14% were taken at an institution other than the one where the person took undergraduate degrees.

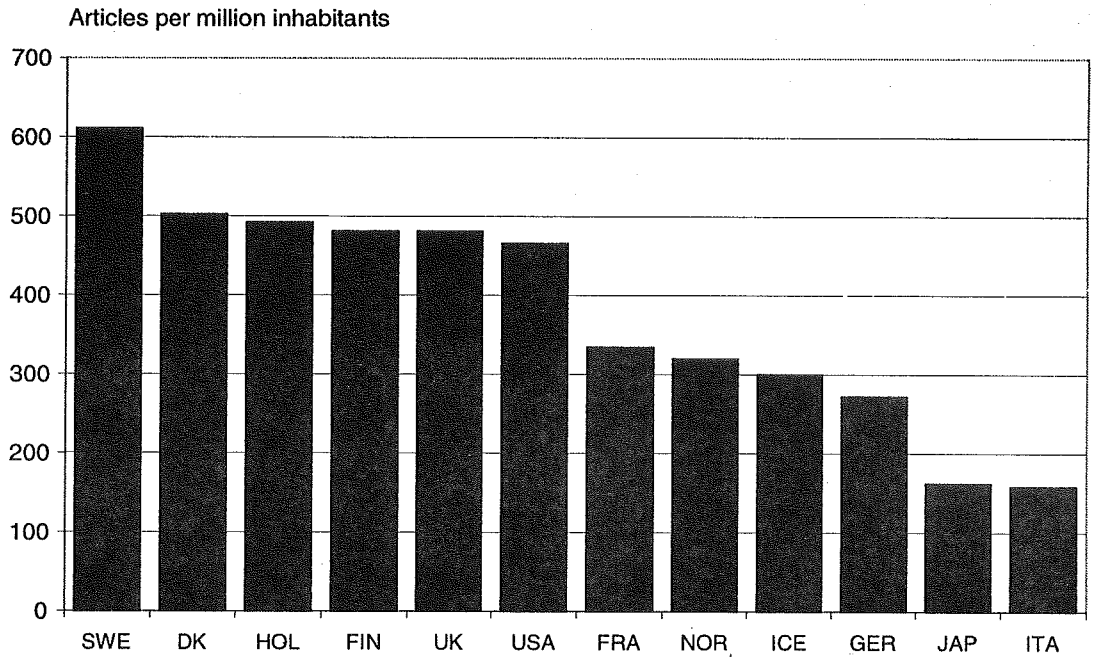
Table 2.10. Scientific personnel at selected university departments by institution and subdiscipline in 1995

Institution	Analytical chemistry	Bio-chemistry	Physical/ Theoretical chemistry	Nuclear chemistry	Organic chemistry	Inorganic chemistry	Chemistry unspecified	Chemical technology	Technology unspecified	Total
University of Oslo	*9*	*0*	*0*	*6*	*42*	*15*	*60*	*0*	*0*	*132*
Institute of Pharmacy - Section of Pharmacognosy					9					9
Institute of Pharmacy - Section of Medicinal Chemistry					6					6
Department of Chemistry	9			6	27	15	60			117
University of Bergen	*2*	*0*	*0*	*0*	*14*	*10*	*18*	*0*	*0*	*44*
Department of Chemistry	2				14	10	18			44
University of Trondheim (NTNU from 1.1.1996)	*4*	*4*	*15*	*0*	*19*	*40*	*10*	*71*	*21*	*184*
Department of Organic Chemistry/NTH					14					14
Department of Inorganic Chemistry/NTH						37				37
Department of Physical Chemistry/NTH			15							15
Department of Chemical Engineering/NTH								45		45
Department of Industrial Chemistry/NTH								26		26
Department of Industrial Electrochemistry/NTH									21	21
Department of Chemistry/AVH	4	4			5	3	10			26
University of Tromsø	*0*	*1*	*0*	*0*	*4*	*0*	*15*	*0*	*0*	*20*
Department of Chemistry		1			4		15			20
Agricultural University of Norway	*2*	*1*	*0*	*2*	*0*	*1*	*0*	*0*	*0*	*6*
Laboratory for Analytical Chemistry	2	1		2		1				6
Total	17	6	15	8	79	66	103	71	21	386

2.2.4 Publications and citations

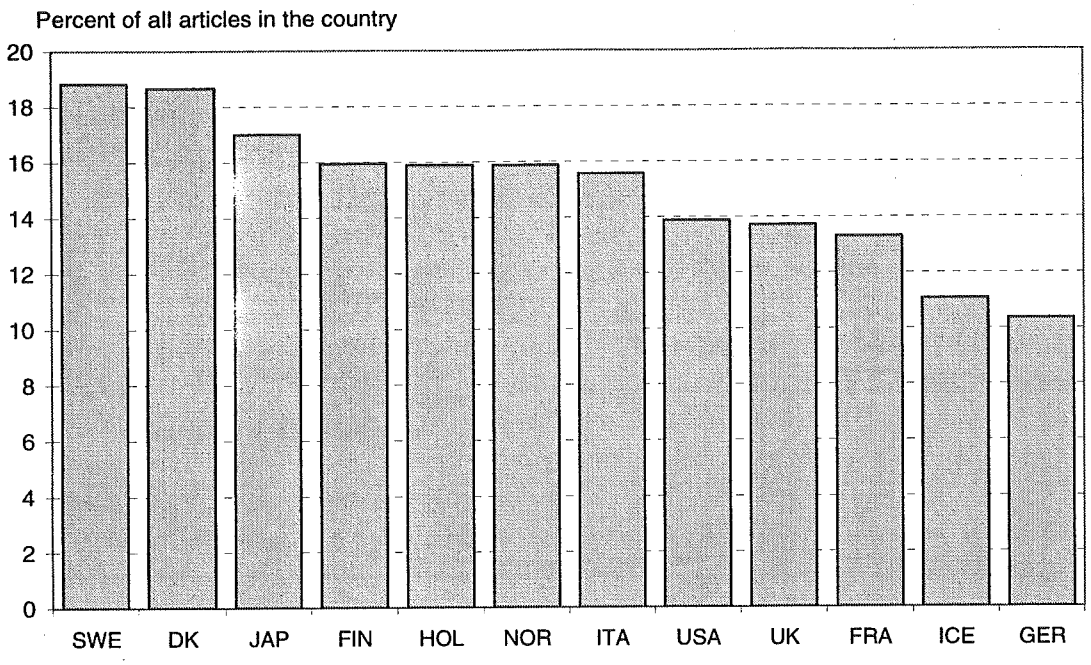
Within the field of chemistry, 3,566 Norwegian articles (where Norway was stated as the address of the author) were published from 1981 to 1995. This accounts for 0.36% of the world's articles in the field and 7.9% of all Norwegian articles (chemistry accounts for a world-wide share of 12.3%). The universe of the database is, according to NIFU's definition, all international scientific journals. Eighty per cent of the articles were cited in subsequent articles. Sweden publishes three times as many articles and Denmark 50% more.

Figure 2.3 shows the number of articles per million inhabitants for selected countries, while Figure 2.4 presents the articles in chemistry as a percentage of the country's total number of scientific articles from 1981 to 1995. For Norway, the 8% corresponds to the other Nordic countries and USA. The relative citation impact of 0.91 for Norwegian articles is lower than for other countries, with the exception of Finland and Iceland (Figure 2.5), and below the average number for the world. By comparison, Swedish and Danish articles are cited more frequently with a relative citation impact of 1.29 and 1.22, respectively.



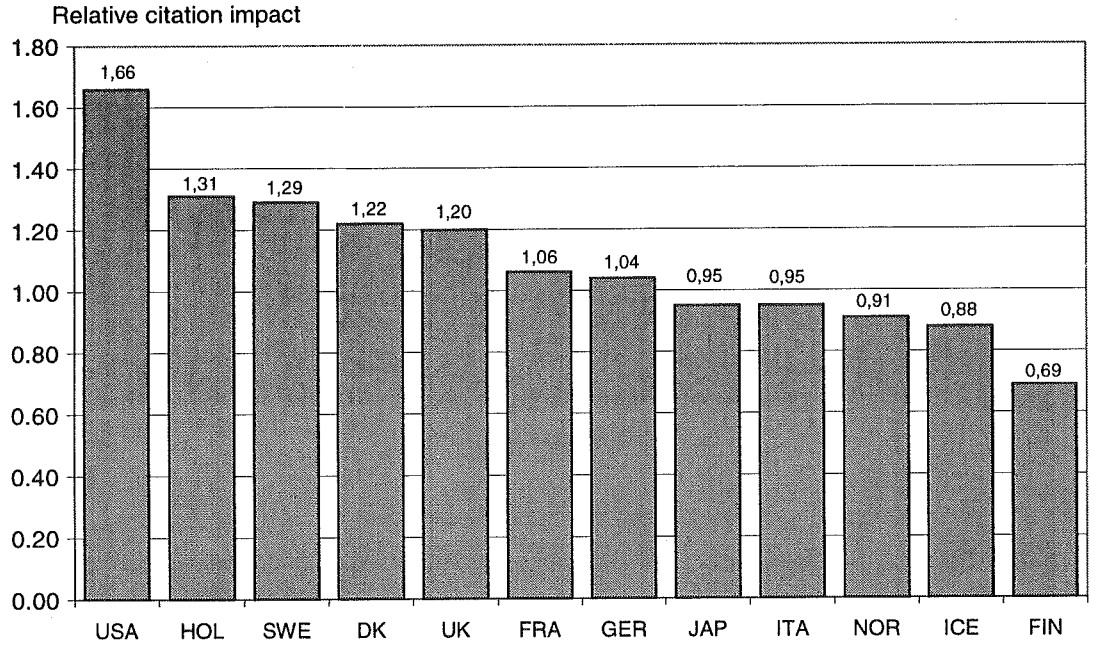
Source: National Science Indicators On Diskette/Institute for Scientific Information

Figure 2.3. Articles per million inhabitants in the field of chemistry in selected countries from 1981 to 1995.



Source: National Science Indicators On Diskette/Institute for Scientific Information

Figure 2.4. Articles in the field of chemistry as a percentage of each country's total articles from 1981 to 1995.

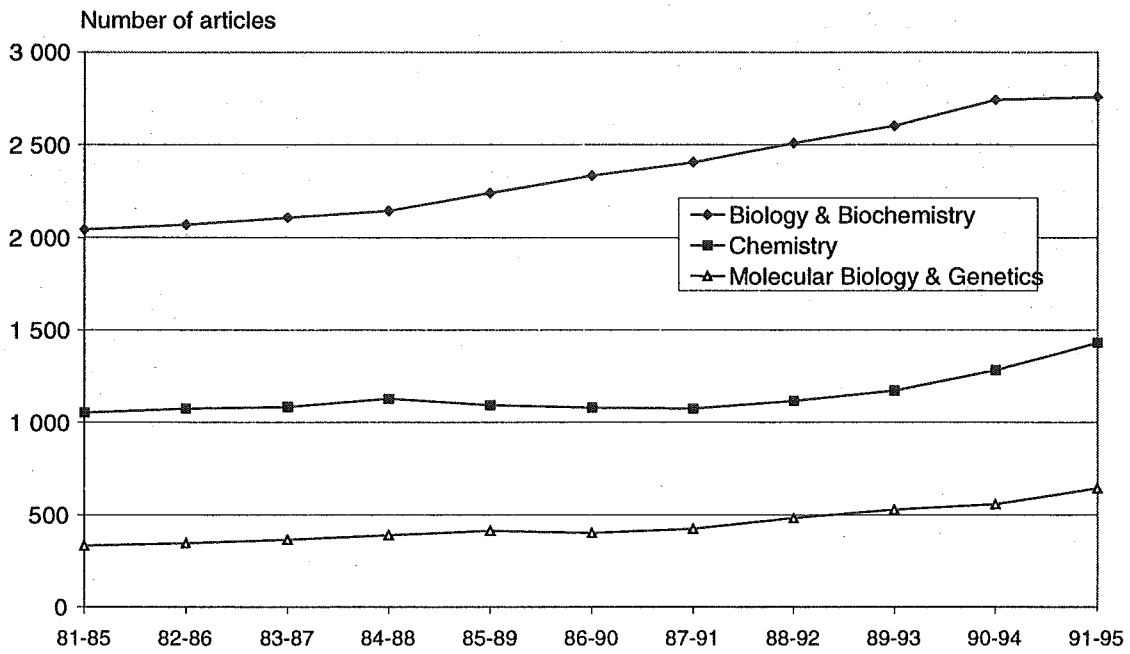


Source: National Science Indicators On Diskette/Institute for Scientific Information

Figure 2.5. Relative citation impact in the field of chemistry in selected countries[6].

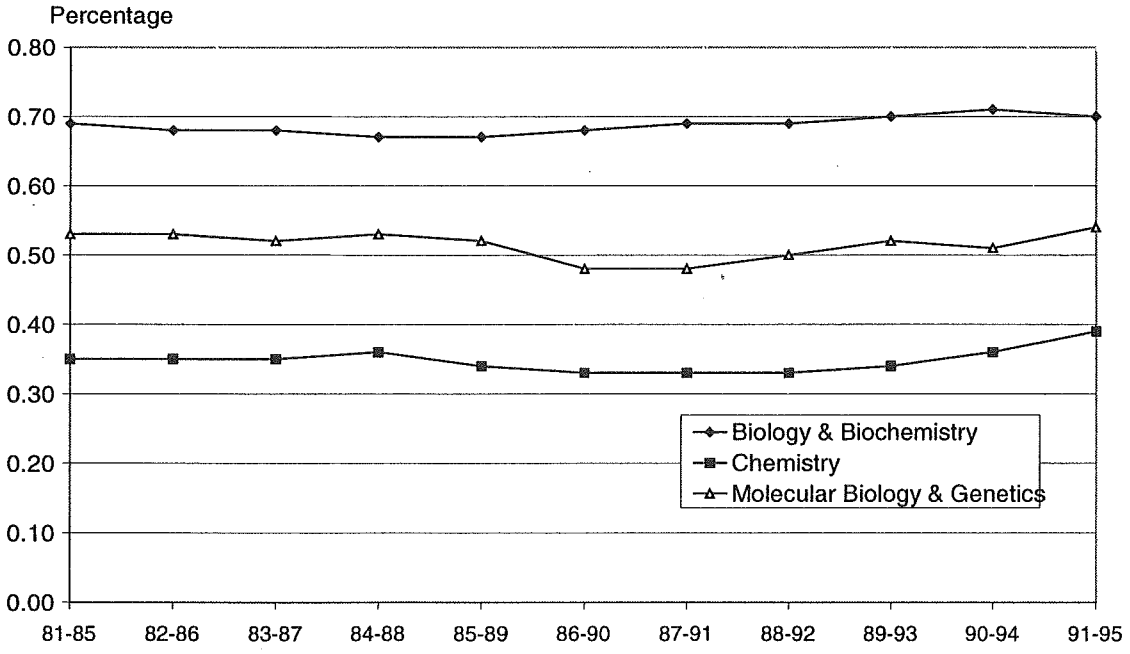
6 The panel means there is an inconsistency between some of the data (Iceland and Finland) in Figures 2.5 and 2.12 which cannot be explained by the periodisation and the fact that publications in the earlier 5-year periods have a higher probability of citation impact over the years than the more recent ones.

Figures 2.6 to 2.11 show trends in Norway from 1981 to 1995. In order to avoid focusing on random outcomes, it was decided to present accumulated figures for five-year periods. The data for biology/biochemistry and molecular biology and genetics are shown only because they appeared simultaneously on the database.



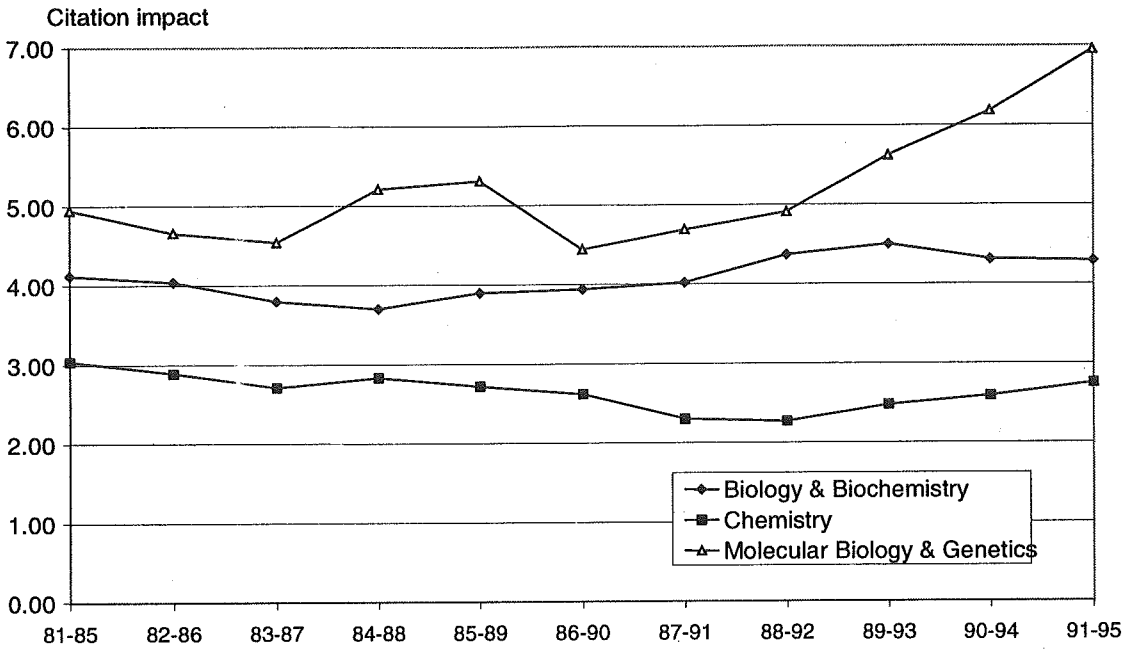
Source: National Science Indicators On Diskette/Institute for Scientific Information

Figure 2.6. Norwegian articles in the field of chemistry from 1981 to 1995. Cumulative figures for five-year periods.



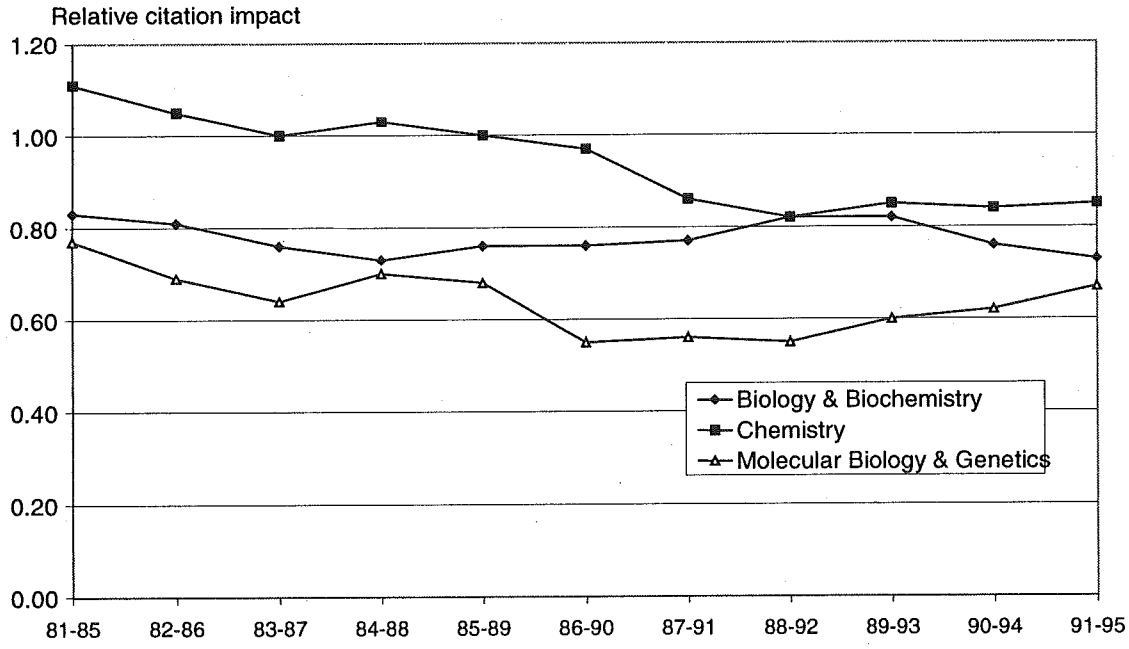
Source: National Science Indicators On Diskette/Institute for Scientific Information

Figure 2.7. Percentage of Norwegian articles in the world-wide production of articles on chemistry.



Source National Science Indicators On Diskette/Institute for Scientific Information

Figure 2.8. Citation impact for Norwegian articles in the field of chemistry.



Source: National Science Indicators On Diskette/Institute for Scientific Information

Figure 2.9. Relative citation impact for Norwegian articles in the field of chemistry.

As shown in Figure 2.6, the number of articles increased by about one third during the period in question, particularly over the past six years. Chemistry's percentage of total production

also increased (Figure 2.7). The citation frequency in chemistry showed a decreasing tendency until the middle of the period. The increased publication frequency seemed to have reversed this trend, leading to a rise in citation impact as well as in the relative citation impact towards the end of the period (Figures 2.8 and 2.9). (Compared with other research areas, articles on molecular biology & genetics and biology & biochemistry are generally cited three times and twice as often, respectively, as articles on chemistry.)

Figure 2.10 offers a comparison between chemistry and the other natural sciences. In the early part of the period, there were fewer Norwegian articles in journals classified under geoscience and physics, but the gap had almost closed by the end of the period. The figures for mathematics remained almost constant.

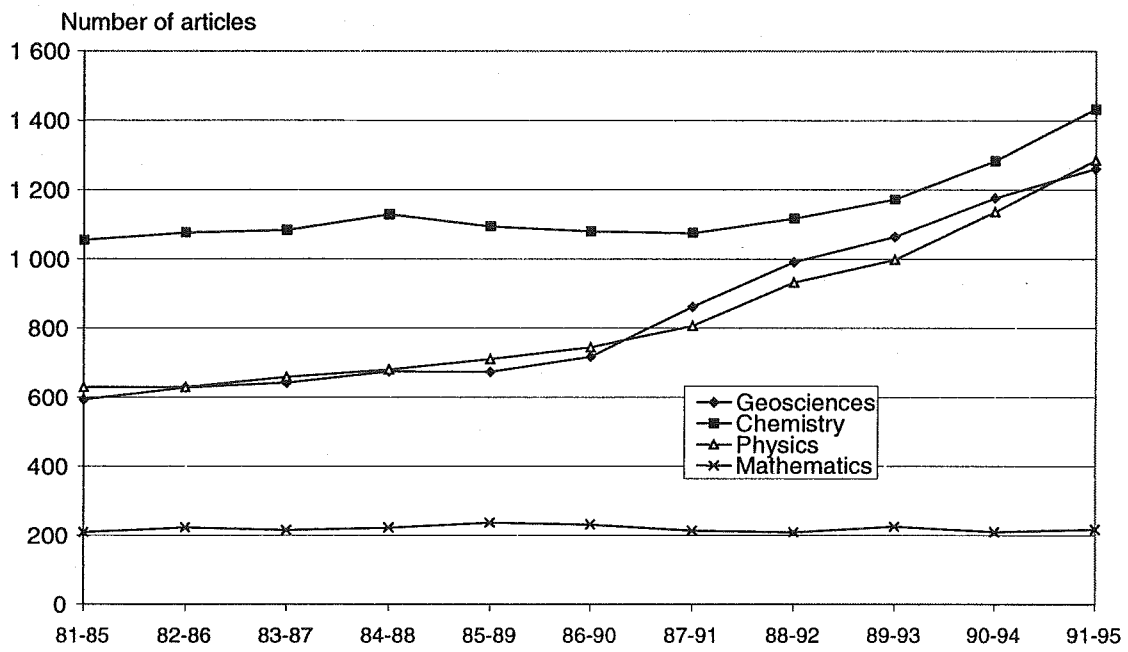
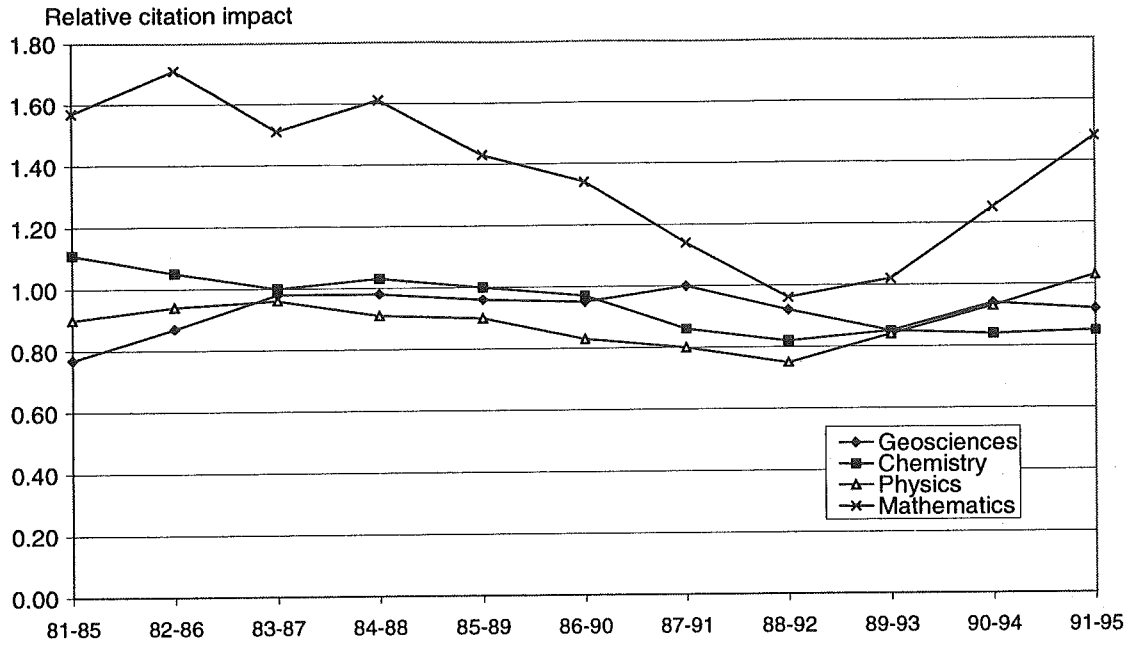


Figure 2.10. Norwegian articles on chemistry, geosciences, physics and mathematics from 1981 to 1995.

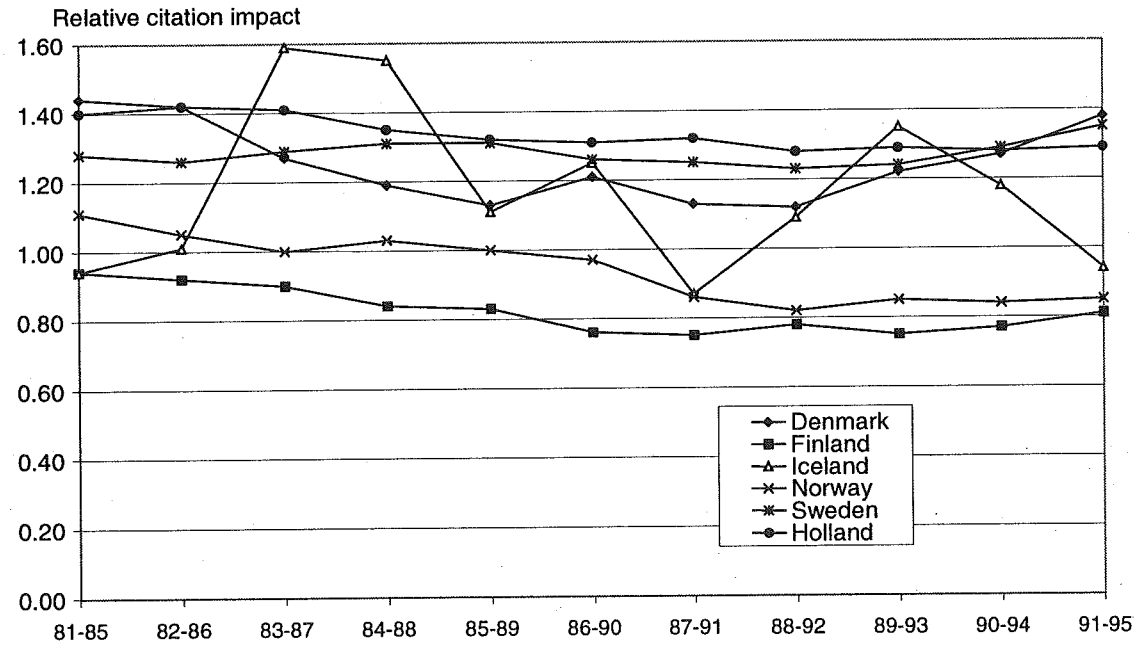
The relative citation impact for the same research areas is presented in Figure 2.11.



Source : National Science Indicators On Diskette/Institute for Scientific Information

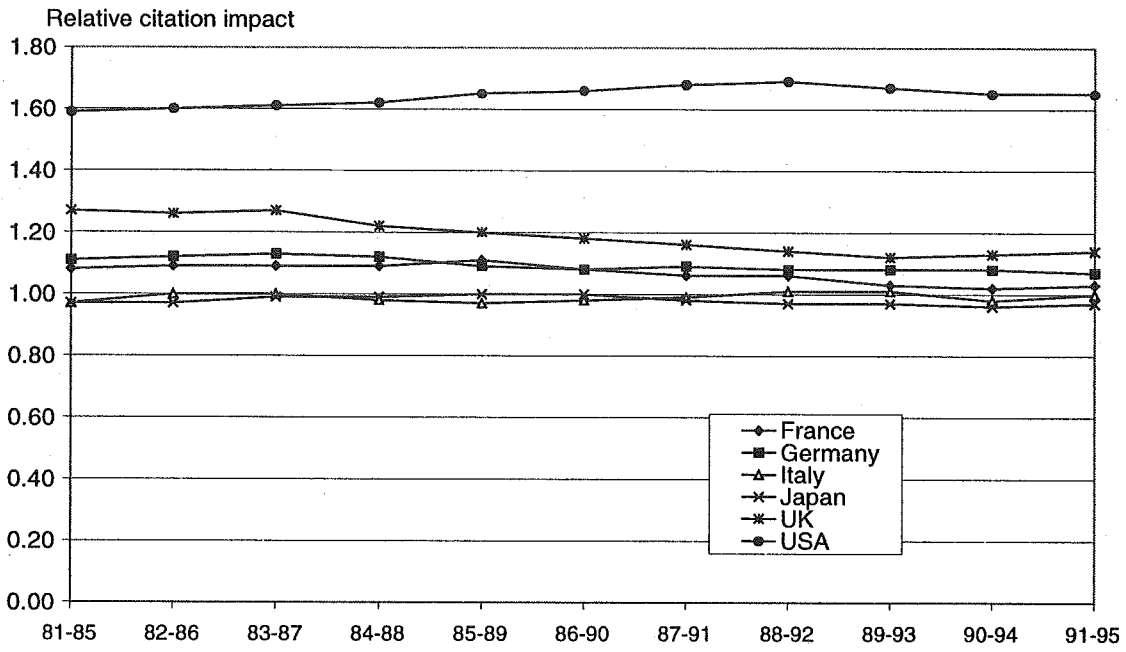
Figure 2.11. Relative citation impact for Norwegian articles on chemistry, geosciences, physics and mathematics from 1981 to 1995.

Figures 2.12 and 2.13 show the relative citation impacts for the countries used for comparison.



Source: National Science Indicators On Diskette/Institute for Scientific Information

Figure 2.12. Relative citation impact in the field of chemistry in selected countries from 1981 to 1995. Cumulative figures for 5-year periods.



Source: National Science Indicators On Diskette/Institute for Scientific Information

Figure 2.13. Relative citation impact in the field of chemistry in selected countries from 1981 to 1995. Cumulative figures for 5-year periods.

3. Review of the individual research groups

3.1 Norwegian University of Science and Technology

3.1.1 Faculty of Chemistry and Biology

The faculty was recently established through a merger of chemistry and biology activities at the former traditional university AVH (three departments) and the technical university NTH (eight departments). The chemistry-related departments are listed below, while biology-related activities and metallurgy are outside the scope of the present review. Each department has an elected head. The faculty is led by an elected board, including the dean and vice-dean. The Department of Chemistry is presently located on a campus some distance away from the other six chemistry-related departments. However, this will change in about three years when a new science building is completed on the Gløshaugen campus.

The faculty is responsible for the subject of chemistry, biology and metallurgy at the Norwegian University of Science and Technology (NTNU). In chemistry it offers 80 undergraduate and 39 graduate courses and has 621 undergraduate and 81 graduate students. Key statistics for the faculty are listed in Table 3.1 below. The various activities will be described in more detail in the following chapters.

Table 3.1. Key faculty figures for the individual departments

Parameters	Chemistry	Inorganic Chemistry	Organic Chemistry	Chemical Engineering	Physical Chemistry	Industrial Electro-chemistry	Industrial Chemistry	Total (*)
Professors**)	11	8	3	10	6	6	8	52
Associate professors	6	5	3	1	2		4	21
Other scientific positions	1		3		1	2-3	1	8-9
Research assistants	6	5	5	3	4	1	3	27
Non-scientific positions	12	9	4	4	3	2	4	38
1)Dr. ing./ Dr. scient.	10	19	13	39	9	16	15	121
2)Diploma/Cand. Scient.	23	14	12	40-50	10	8	25-30	ca. 150
3)Total University budget Running expenditures Univ.	5.1 1.3	7.2	3.1	5.8	3.0 0.6	2.9	5.2 1.4	32.3 6.5***)
4)External funding		17.6	1.2	12.6	2.9	11.7	5.5	51.5

Other scientific positions: other fixed positions, post-doctoral fellows, etc.
1) Number of registered students per year
2) Number of candidates per year
3) In MNOK (salaries included)
4) In MNOK
*Department of Botany, Zoology, Biotechnology and Metallurgy are not included here
**Including adjunct professors
*** Includes total investment by NTNU, divided among the chemistry departments

Overall assessment and recommendations

General description

The faculty comprises seven departments ranging from pure chemistry to chemical engineering. This broad range of technical and fundamental disciplines is unique in Norway. Most of the departments are characterised by close co-operation with industry and SINTEF.

Evaluation

Strengths

- Generally well-equipped laboratories, especially for those groups associated with SINTEF and industry;
- Traditionally good links with industry;
- Good employment prospects for graduates.

Weaknesses

- Some departments are too weak (e.g. organic chemistry), especially in view of NTNU's role and integrated structure as Norway's national technical university;
- Considering their importance in modern science and technology, some groups are below the critical size or do not exist (e.g. analytical chemistry);
- Unfavourable age distribution in some departments;
- Insufficient international contact (both ways).

Recommendations

As the sole technical university in Norway, NTNU should aim at maintaining and even improving its leading position. To achieve this, a medium-term strategy should be established for the entire faculty. Among other factors, it should include the following objectives:

To:

- achieve maximum benefits for research and education from the merger and the new building;
- enhance active interaction with industry to also include innovative high-tech projects;
- counteract the imminent danger of deterioration of maintenance and workshop facilities;
- improve international interaction at virtually all levels by encouraging exchange visits to and from Trondheim; and
- consider the possibility of merging the Departments of Chemical Engineering and Industrial Chemistry if this should turn out to be of mutual interest and bring about synergistic effects.

The beneficial effects of interaction with SINTEF are appreciated by the panel. They should not, however, result in excessive dependence on SINTEF.
The absence of analytical chemistry as an independent discipline to support NTNU's materials research and other fields of research should be remedied. This could best be achieved by establishing, under firm leadership, a department to embrace the existing small groups.

3.1.1.1 Department of Chemistry (Rosenborg Campus)

The department's research activities are organised as subgroups in the following areas:

a) *Analytical Chemistry:* electroanalytical methods, ultrasound, diffusion in layers, pheromones;
b) *Environmental Chemistry*: determination of metals and persistent organic contaminants, radionuclides. The aim is to understand the natural processes and how anthropogenic activities influence natural processes;
c) *Structural Chemistry:* investigation of (i) inorganic compounds (e.g. zeolites) and various other samples (solutions, metalloenzymes, environmental and geology-related samples) by synchrotron (EXAFS) and X-ray powder diffraction methods and (ii) organic molecules by gas phase electron diffraction. Quantum mechanics and molecular mechanics calculations are also performed;
d) *Organic Chemistry:* bio-organic, enantiomerically pure compounds, benzyl glycidyl ethers;
e) *Bioinorganic and Biophysical Chemistry:* metalloproteins, metalloenzymes, protein purification, enzyme kinetics, EPR, NMR;
f) *Didactics in Chemistry Education.*

The department was visited by the entire review panel. Presentations were made by a representative from each research group in the presence of most of their colleagues.

Analytical Chemistry

Research and its evaluation

The activities of three staff members who specialise in this area were presented. The majority of their research involves the application of electroanalytical methods. The HPLC method is employed in one minor project. The rate of publication is generally rather low.

Environmental Chemistry

Research and its evaluation

The staff comprises two permanent members (one professor, one assistant professor), one post-doctoral fellow, four doctoral students and eight to ten graduate students. In addition, the group benefits from collaboration with an assistant professor who is retired from the Geological Survey of Norway.

The research activities aim at understanding natural processes and the influence of human activities on these processes. The group participates in a strategic university programme funded by the Research Council of Norway and entitled "Basic research on pollutants and their effects". Research topics include the effects of metal contamination on terrestrial and aquatic systems, the influence of acid precipitation on vegetation, and radioecology.

The research team is active in several environmental fields of importance to the country and its industrial enterprises. It has won recognition at the national level, and maintains a high level of activity thanks to an extensive network of national and international collaboration. The group has produced about 100 publications over the past five years.

Structural Chemistry

Research and its evaluation

The permanent staff of the group comprises four professors and one assistant professor, two post-doctoral fellows, two doctoral and two graduate students who are working on two major projects.

The synchrotron group
The group consists of one professor, one assistant professor and one post-doctoral fellow. This group's research is focused on the structures of inorganic materials (including catalysts), solutions and metalloenzymes. A new activity started in environmental and earth sciences in 1997. The group has developed special expertise in EXAFS and X-ray powder diffraction methods. Molecular modelling, solid-state NMR and FTIR are among the other methods employed occasionally.

The use of synchrotron radiation requires that measurements be done abroad. The group has developed good research co-operation with colleagues at synchrotron facilities in France (e.g. the SNBL line in Grenoble), England (Daresbury) and USA (Brookhaven).

Although the research problems investigated are relevant, especially to catalysis, the group attracts few graduate students and is exclusively funded by the Research Council of Norway. While the publications are of high scientific international quality, their number is still limited, probably due to the small size of the group (and the geographical distance to synchrotron facilities).

The electron diffraction group
This is a relatively small unit (three professors, one post-doctoral fellow) which, together with a group in Oslo, forms an informal research organisation called "The Norwegian Electron Diffraction Group". In its special field, electron diffraction, it is one of the world's leading groups. While the experimental facilities are in Oslo (section 3.3), calculations are also carried out in Trondheim. The Trondheim group engages in extensive international collaboration and plans to construct its own ED instrument.

Electron diffraction is used to identify the structures of small organic and inorganic molecules in the vapour phase. The group also carries out and publishes quantum mechanics and molecular mechanics calculations. For calculations which call for more CPU power, the

group's equipment is linked to Norway's national resources on a CRAY computer. Apart from the calculations mentioned above, there is little synergy with the synchrotron group. The group has published 64 publications over the past five years.

The group studies a wide selection of organic molecules, ranging from halogen-substituted alkanes to aromatic systems. *Ab initio* quantum chemical calculations play an essential role in the study of these systems. The inorganic compounds investigated range from simple covalent compounds to organometallics. Although the requirements for vapour pressure and stability restrict the choice of samples, several new compounds have been measured each year. In some cases, theoretical calculations have also been applied. The electron diffraction measurements generally represent state-of-the art studies.

Organic Chemistry

Research and its evaluation

This group consists of two permanent staff members, one professor and one associate professor, in addition to a doctoral student and four to six graduate students. The group is working on projects involving the reactivity of antioxidants, but focuses mainly on investigations of different aspects of enzyme-catalysed reactions that lead to enantiomerically pure compounds, principally by systematic studies of the factors that influence the catalytic function of lipase. The group combines results from different experimental techniques in their investigations and has many international contacts, including TU Delft, KTH Stockholm, TU Graz, BASF and Novo-Nordisk (DK), which supplies enzymes. The group has a good publication rate despite its limited size.

Bioinorganic and Biophysical Chemistry

Research and its evaluation

The staff comprises one professor, two doctoral students and seven graduate students. Research activities centre on the study of metalloproteins and metalloenzymes, especially those containing Fe, Mo, Cu, and V. The role of iron-sulphur clusters in nitrogen fixation is also being studied, as are mono-oxygenation reactions (e.g. dopamine, B-monooxygenase).

The research team possesses expertise in the main experimental techniques used in bio-inorganic chemistry, such as protein purification, enzyme kinetics, EPR and NMR. Although it works on attractive subjects, the staff appears to be somewhat undersized to compete effectively with international groups working in similar fields. No publications have been produced over the past five years, but several manuscripts will soon be ready for submission.

Didactics in Chemistry Education

Research and its evaluation

The panel is aware that a political decision has been taken to implement didactics in chemistry education at NTNU at the professorial level. The topic has a significant European and international dimension. Staff members initiated research only 1.5 years ago, so it is still too early to make an evaluation. However, interaction should be encouraged with high schools and with other professors involved in the field (for instance, at the Department of Chemistry in Oslo).

SWOT Analysis of the department as a whole

Strengths

- Analytical chemistry is important for industry and government, particularly in terms of the emphasis placed on the rigorous training of scientists capable of dealing with environmental issues professionally;
- The graduate programme in analytical chemistry should, in principle, provide a small but steady stream of recruits to assist in carefully planned experimental research programmes;
- High productivity in terms of publications on organic, structural and environmental chemistry;
- The wide range of basic research projects in organic chemistry appears well connected and has strong industrial relevance;
- The Organic Chemistry group has good access to modern spectroscopic equipment;
- The Organic, Structural and Environmental Chemistry groups have good international contacts.

Weaknesses

- Low publication rate in Analytical and Bioinorganic/Biophysical Chemistry;
- Low external funding for Analytical Chemistry;
- Too few doctoral students;
- Unfavourable age distribution in some of the groups (Analytical, Organic, Electron diffraction);
- The small size of some of the groups (Organic, Analytical, Bioinorganic/Biophysical);
- The maintenance costs for major equipment are difficult to cover;
- Heavy, unevenly distributed teaching load;
- Teaching is funded at subsistence level, and the teaching laboratories have to use items of equipment borrowed from the research laboratories;
- The experimental facilities for electron diffraction are in Oslo;
- The Analytical Chemistry group does not appear to be strong enough on the research side to survive the merger intact.

Opportunities

- Clearly, the Analytical Chemistry group hopes the merger with the former NTH will allow the establishment of an Analytical section;
- The merger with the former NTH could have a synergistic effect on the two small research groups in organic chemistry and bioinorganic and biophysical chemistry, which might lead to an increase in the staff;

- Possible synergies in structural/physical/biochemistry with the former NTH.

Threats
- That the reorganisation will not allow for a section dedicated to analytical chemistry; and
- Without renewal of staff, several groups may fall below the critical size for an experimental labour-intensive research group.

Recommendations

- A reasonably high level of activity in environmental chemistry should be maintained within the NTNU structure. The group at the Department of Chemistry is of medium size and may have difficulties in further developing its activities. Closer collaboration between Analytical Chemistry (Department of Chemistry, Rosenborg Campus) and Chemometrics (Department of Physical Chemistry) would certainly be beneficial;

- The synchrotron studies should be continued with priority over the recent powder X-ray diffraction and molecular modelling studies;

- Research co-operation with other Norwegian groups should be developed further to make full use of the potential the powerful synchrotron methods offer to solve problems where other methods fail;

- Collaboration should be encouraged between the Organic Chemistry groups on both campuses through common grants for doctoral students. A joint educational programme should be established for graduate students (doctoral and graduate) in organic chemistry and biocatalysis;

- A strategy should be developed for strengthening research in bioinorganic and biophysical chemistry, eventually in collaboration with biotechnology resources at the faculty;

- The faculty should assign sufficient resources to support the chair in didactics in chemistry education in an effort to facilitate beneficial interaction with related groups in Oslo and other European countries;

- The electron diffraction group is encouraged to collaborate more closely with other relevant NTNU research groups upon moving into the new building; and

- Bioinorganic chemistry and biophysical chemistry are research fields which will sustain rapid development in the 21st century. Thought should therefore be given to integrating this small group into a larger unit (biochemistry or biotechnology).

3.1.1.2 Department of Inorganic Chemistry

Basic description

The main areas of activities are the *production of light metals* (electrolysis of aluminium, magnesium and refractory metals, silicon, carbon electrode technology), *ceramics* (fluoride

glasses, perovskites, silica, silicon and aluminium nitrides, silicon carbide) and some general aspects of inorganic chemistry such as *molten salts*, *glasses*, *sol-gel* (carbon technology, phase transitions, thermodynamics) and *Ziegler-Natta catalysis* (including quantum chemical calculations). The department is adequately equipped for synthesis, scanning electron microscopy, spectroscopy, structural analysis, and various materials testing methods, all of which include high temperature techniques.

As reflected in the funding, the department has extensive contacts with national and international industry. This influences the choice of research topics to a significant extent. Departmental staff participate in the national R&D programme for development of the Norwegian processing industry (PROSMAT 2000), in the strategic university programme on polyolefins and on a project with the University of Oslo on the physical chemistry of glasses and perovskites.

Research and its evaluation

The standard of self-designed and -built equipment is adequate, facilitating the performance of high-quality experimental work when combined with a sound theoretical approach.

In general, the department engages in extensive national and international co-operation, particularly in connection with electrolysis and carbon technology for light metals production, a field in which the department also offers international courses.

Although the list of research topics appears quite long and heterogeneous, it is a dynamic one with new topics being added and certain older ones being deleted. For instance, research on ceramic superconductors had to be discontinued in 1995 due to a lack of funding and co-operative partners.

The following offers a brief description of the research projects, accompanied by comments provided by senior researchers.

The electrolysis of light metals
This is clearly the primary and most successful research area in the department. It covers fundamental thermodynamic and spectroscopic studies on metal-containing systems as well as more applied research on carbon cathodes and refractory materials. Its industrial and international impact is high, and each year the group produces a good number of high-quality publications, as well as diploma and doctoral theses.

Fluoride glasses and perovskites
These projects focus on the development of new materials with a strong application potential. The projects involve synthesis and comprehensive characterisation, as well as research collaboration in Norway and abroad.

Sol-gel technology
The sol-gel technique is becoming increasingly popular as a "soft-chemistry" method for the synthesis of high-tech ceramics. This relatively new project entails synergies with other ceramics projects.

Ziegler-Natta catalysis
This project appears to be rather separate from other activities of the department, but has achieved some interesting results, including the design of an innovative *in situ* FTIR cell. One project in quantum chemistry, which appears to have a limited scope, is the only study which can be strictly classified as basic research.

Other projects
The nitrophosphate fertiliser studies are worthwhile, considering the volume of fertiliser production by Norwegian industry. Otherwise, this project is, as a topic, quite separate from the other activities.

In addition, a project on aqueous chemistry has a high level of relevance for Norwegian industry. It has led to the development of the SCALE computer programme.

The remaining three projects: silicon for the chemical industry, non-oxide ceramics and micro-silica projects, are all related to other major projects and promise to have considerable industrial impact.

Overall assessment

As a whole, the research performed at the Department of Inorganic Chemistry features high-quality studies of industrial importance. The research has produced significant results in the form of scientific publications in international journals, a relatively high number of Dr. ing. theses, and some novel instrumentation designs. The current research projects may be criticised for being scattered over too wide a range of topics and also for a lack of balance between basic and applied research.

SWOT Analysis

Strengths
- Excellent experimental work;
- Practical knowledge of thermodynamics and high-temperature chemistry;
- Know-how in instrumentation design and construction, especially in terms of high-temperature and precision measurements;
- Broad contacts with industry;
- Fairly well-developed collaboration with Norwegian and foreign institutions.

Weaknesses
- Unfavourable age structure of staff (several professors will be retiring within five years);
- Difficulty in competing with industry for the recruitment of new staff members;
- Outdated equipment and little money for investment;
- Too few undergraduate students;
- Staff members are overloaded with teaching duties;
- Insufficient funding from the university, preventing development of basic research;
- The merger with AVH has led to an administrative overload.

Opportunities

- Develop more industrial contacts;
- The merger with AVH will bring research groups close to the location of the department (new building) and strengthen basic research;
- Several positions will soon be available as current staff members retire.

Threats

- Competition in world-wide industry may lead to reduced industrial activity in research and have adverse implications for the funding of research;
- Deterioration of workshop capacity and expertise;
- Expensive maintenance of instrumentation.

Recommendations

The main challenges facing the department are the uncertainty involved in sustaining funding for applied research projects through industrial contracts, and the replacement of several senior staff members who will be retiring in the next five years. Strategic plans should concentrate on:

- narrowing the range of the research topics and strengthening of the successful ones; and
- more basic research.

To achieve these goals, the department should endeavour to:

- reduce the average teaching load of its staff members;
- procure more funding to maintain equipment and expertise in the engineering shop;
- set up a fund to help younger staff members start good research programmes and to increase their mobility.

Some of these concerns could be addressed by examining the opportunities inherent in the situation at hand, mainly the merger and the future provision of a new research and teaching building in the close vicinity.

3.1.1.3 Department of Organic Chemistry

Basic description

The department is engaged in *synthetic organic chemistry* (natural substances and pharmaceutical products/intermediates, chiral synthesis, organic semiconductors and studies of reaction mechanisms and catalysis), *bio-organic chemistry* (carotenoid chemistry, including the isolation, identification and determination of structures based on chemical and spectroscopic methods and syntheses), *physical organic chemistry* (measurements based on

spectroscopic and theoretical methods, kinetics and reaction mechanisms), *computer-assisted organic chemistry* (synthesis planning, structure/activity relations and flexible organic molecules), and *analytical organic chemistry* (interaction between oil, surface reactive substances and water).

Research and its evaluation

The Department of Organic Chemistry is too small (six staff members) for a faculty that aspires to cover modern chemistry in a balanced way.

Perhaps the strongest area is synthetic chemistry. The group includes one of the world's leading experts in carotenoid chemistry, but this professor is close to retirement, meaning the activity will cease. Both synthetic and carotenoid chemistry have previously attracted external funding, although it is now at a low level.

From 1992 to 1996, 23 doctoral students were attracted to the group, seven of whom worked on organic synthesis with the head of the department. Although this indicates an active research programme, efforts have not been uniformly distributed throughout the group. The staff members who do not contribute to the research effort do not appear to compensate by undertaking more teaching.

The department faces several problems which call for urgent attention. Of the six staff members, three are over the age of 60, and they are by no means the least active researchers. One staff member is not considered an active researcher, and the panel was informed that only two staff members apply for research funding.

Furthermore, because the group engages in basic rather than applied research, it has been relatively unsuccessful in attracting external funding. The operating costs of organic synthesis are considerable, and the cost of spectroscopic and analytical services was identified to the panel as posing a serious constraint on the department's activities. The annual allowance for direct costs from the university has fallen to the point where it barely covers the cost of running the most essential practical classes in organic chemistry.

The merger between NTH and AVH was welcomed as an opportunity to strengthen organic research. The imminent appointment of a new professor (a replacement) is also a good opportunity to improve the situation with respect to activity and age distribution.

SWOT Analysis

Strengths

- A reasonable level of activity in synthesis and synthetic methodology with a good publication rate. World-class reputation in carotenoid chemistry;
- Space does not appear to be a constraint to enhanced activity;
- Doctoral graduates are highly employable.

Weaknesses

- No possibility for continuing the most successful research area after the imminent retirement of the professor who is a renowned specialist in this field;
- Two other staff members are within a few years of retirement;

- One staff member who does no research whatsoever and one who is only partially active;
- Little external funding to cope with the unavoidably high costs of modern organic synthetic chemistry (consumables and instrumental services);
- At current budget levels, modern information search and retrieval facilities (e.g. CAS on-line) are severely rationed. For example, there is no access to "Beilstein Crossfire". Such facilities are essential in order to compete in the field of synthesis;
- Staff members feel that the teaching load is heavy and poorly distributed;
- Staff members feel that teaching is funded at subsistence level. The teaching laboratories have to borrow even minor equipment from the research laboratories;
- Little involvement of staff in the Research Council of Norway or committees;
- No regular research seminars featuring outside speakers.

Opportunities
- Appoint new staff members;
- The merger with the AVH is seen by the head of the Department of Organic Chemistry as a chance to strengthen collaboration with other groups, to attract AVH students to specialist courses, and to provide opportunities for the two-year graduate students to participate in a wider range of research projects.

Threats
- That the perceived lack of pressure to perform will prevent necessary change;
- The industrial scene will change to the point where doctoral students and other students will not readily find employment and the supply of research workers will dry up;
- Funding cuts will hit libraries drastically, and there is poor provision for alternative access to the modern scientific literature.

Recommendations

- It will be important to enhance organic synthesis by making at least two appointments as vacancies arise. Within the confines of the Norwegian appointment procedures, candidates who have a proven track record of research achievement, good international contacts, and who show evidence of being able to attract external funding should be sought and given preference.

3.1.1.4 Department of Chemical Engineering

Basic description

The main research areas are: *General process engineering (*chemical absorption, liquid-liquid extraction, drying, crystallisation, reactor technology, selective methods of precipitation, extrusion and membrane separation), *process calculations* (numerical methods, modelling, simulation, statistical data processing, project planning), *process control* (dynamics and control of integrated processes), *process design* (combinatorial optimisation, basic methods for systematic process design), *thermodynamics* (phase equilibria, formation of hydrates, methods for estimating physical data and calculating equilibria, educational programmes) and *pulp and paper technology (*production processes, raw materials, fibre properties, process techniques, bleaching, pollution control, conversion and further refining).

Research and its evaluation

General process engineering
This is an important area of chemical engineering, and it used to be one of the department's strongest areas. However, it is now suffering from a shortage of younger staff members and appears to be at risk of marginalisation by international standards. Nonetheless, the group is doing good work and there is potential for growth if the group is supported by suitable new faculty appointments.

Process systems engineering
This is a particularly strong group. It enjoys international standing and has many international links. Although some areas of research within the group are rather idiosyncratic, reflecting personal interests rather than the importance of the topic, overall, the group is strong and shows good internal coherence. Generally, the research maintains an excellent standard.

Thermodynamics
Despite its importance to industry, this is not generally viewed as an exciting area of research by international standards. However, the group takes advantage of the extensive laboratory facilities available to it and is performing useful work.

Pulp and paper technology
Given that this is the only group of its kind in Norway and that it supports an industry of national importance, this group occupies a very special position. Its role is perhaps more educational than strictly research. Consequently, this is not an area with which international comparison is meaningful.

SWOT Analysis

Strengths
- Strategic position as main chemical engineering activity in Norway;
- Good links with industry;
- Extensive laboratory space;
- Possibilities for collaboration with SINTEF Applied Chemistry;
- Active young staff at full professor level (however, 60% are 60 or more);
- Generous programmes (by international standards) for sabbatical leaves;
- English speaking faculty and student community;
- Process systems engineering group of international standing;
- Modelling expertise in reactor technology.

Weaknesses
- Reliance on student researchers; lack of full-time research staff;
- Difficulty in recruiting research staff outside Norway;
- Shortage of staff below professor level;
- Formal separation from the Department of Industrial Chemistry;
- Shortage of some types of technical support staff;
- Lack of competitive 'marketplace' for research proposals;
- Dependence on SINTEF;
- Shortage of programming support staff in Process systems engineering group;

- Need for new staff positions in the field of separations;
- Further rationalisation of the relationship between the reactors group and the Department of Industrial Chemistry.

Opportunities
- Take advantage of position in Norway;
- Take advantage of links with industry;
- Take advantage of links with other Nordic countries;
- Take advantage of the international links of the Process systems engineering group;
- Take advantage of laboratory space and SINTEF equipment;
- Encourage overseas visitors to stimulate research and teach in English;
- Seek industrial funding in areas of national importance, e.g. oil and gas, H_2S removal, agrochemicals, metals;
- Exploit reactor modelling expertise within the Department of Industrial Chemistry and industry;
- Develop expertise in crystallisation;
- Identify new key technologies in pulp and paper, e.g. advanced coatings and high value added products.

Threats
- The risk of complacency as the main Norwegian centre. No national competition;
- Insularity. The lack of input from outside Norway in some areas;
- Risk of isolation from international community in rapidly developing areas.

Recommendations

Staffing balance
- The existing nine full professors represent a more than adequate number of senior staff;
- Replacements should be made at the assistant professor level;
- Fewer senior staff members should be used more extensively for teaching;
- More technical support staff are required;
- New appointments should be used to strengthen important but under-resourced areas.

Research directions
Efforts should be made to concentrate on existing strong points. There is no obvious need to expand into new areas unless, exceptionally, the opportunity arises to recruit an outstanding faculty member in a new area.

Less strong areas, e.g. separations, should be assessed critically. If new appointments are made to this area, it should be in order to strengthen the work in crystallisation.

Pulp and paper research is recognised as being strategic to the Norwegian economy. However, in re-staffing this area, account should be taken of likely world-wide trends and high technology activities, e.g. coatings research should be encouraged.

Internal co-operation
Existing co-operation with Physical Chemistry and, in particular, Industrial Chemistry, should be enhanced. Serious consideration should be given to the possibility of merging the departments of Chemical Engineering and Industrial Chemistry. Their activities are highly complementary and a joint department should be stronger than the sum of its parts.

The panel appreciates the value of interaction with SINTEF and the equipment which this provides. However, this interaction should not be allowed to result in excessive dependence on SINTEF. The development and use of a project funding mechanism directly between faculty members and the Research Council, as is common in most other countries, would provide a significant counter-balance to such dependence.

International co-operation
More extensive interchanges with the international academic community are required. This would be facilitated if faculty members were able to fund and appoint research workers at the post-doctoral level. In general, an increase in international collaboration would be desirable, even though the department's record is already good in this area.

Consideration should be given to teaching some advanced courses in English. This would provide an opportunity to extend the department's international ties by inviting academics from outside Norway to teach courses.

General
A "market oriented" approach to the recruitment of post-graduate students would be advantageous. It is much easier to recruit post-graduates in biology, for example, than in chemical engineering. Student grants could be adjusted accordingly.

The department is exceptionally well provided with laboratory space. Careful consideration should be given as to the best future use of the facilities. It should not be taken for granted, for example, that extensive pilot scale equipment represents the most prudent use.

3.1.1.5 Department of Physical Chemistry

Basic description

The department works within the fields of *quantum chemistry* (molecular vibrations, molecular topology and group theory), *thermodynamics* (energy conversion, electrochemistry, computer simulations and transport processes in porous media) and *computer-assisted instrumental analysis and chemometry* (automatic analytical laboratory systems, chemical process plants and multi-detector systems, chemometry).

The department staff is composed of eight permanent staff members, including four professors and one associate professor. In addition, there are one other associate professor and nine post-graduate doctoral students.

The department is responsible for teaching thermodynamics, quantum chemistry and chemometrics to about 150 students. Its research activities are split among three research groups.

Research and its evaluation

Quantum chemistry
The small research group (2.5 permanent positions, 0-1 doctoral student) is quite prolific (publishing 20 to 30 papers a year) and internationally recognised. It has been a leader in the analysis of molecular vibrations of polyatomic molecules. Now the group focuses more on molecular topology. One of the group's successes was its prediction of the existence of C_{60} before its experimental discovery. The group relies exclusively on in-house small and medium-sized computers. It experiences difficulty in attracting graduate and post-graduate students because of the basic character of its research.

Thermodynamics
The group has two professors, one (temporary) senior researcher, five to six doctoral students, four to five graduate students and some short-term visitors.

The group is a member of the European Thermodynamics Network and engages in extensive international collaboration. Its objective is to contribute to new concepts and design criteria for process equipment and sensors. The group is internationally recognised for its work on irreversible thermodynamics. The main fields of research are analysis of the transport processes occurring in energy conversion and determination of the basic mechanisms for coupled transport of heat, mass, and charge taking place in batteries, fuel cells, electrolysis, sensors, natural electrochemical processes and separation processes. These activities involve both theoretical and experimental investigations. In particular, the expertise in high-temperature and high-pressure instrumentation was found worthy of note.

In recent years, the group has shifted its activities more towards applied research, which has brought more external funding and attracted several students.

Computer-assisted instrumental analysis and chemometry
The group is composed of two associate professors, one adjunct professor, and one doctoral student.

The aim of the group is to develop analytical procedures to monitor the content of heavy metals and carcinogens in road dust. Activities in chemometrics are presently maintained by one adjunct professor and the doctoral student. In their approach to determining the principle properties of carcinogens, they use different statistical analyses and error estimations. Several collaborative projects are being initiated.

SWOT Analysis

Strengths
- Internationally recognised group in thermodynamics with good interaction between theory and practice;
- Good technical assistance available (also from other departments), allowing the development of advanced instrumentation;
- High scientific productivity, especially in quantum chemistry;
- Broad scope of activity supported by international collaboration.

Weaknesses
- Lack of interaction between the three research groups;
- Several activities traditionally included in a physical chemistry unit have been developed within the framework of other departments;
- The resources of the department do not allow efficient support of the diversity of research projects;
- Unfavourable age distribution;
- Lack of funding for doctoral students interested in basic research.

Opportunities
- A reorganisation of the department's activities will soon be possible due to the retirement of four permanent staff members;
- The merger with AVH should lead to a strengthening of basic research activities.

Threats
- Continuing process of disintegration in research related to physical chemistry;
- Replacement of the retiring staff member may not be allowed;
- Sub-critical sized groups may not survive (chemometrics, quantum chemistry).

Recommendations

- The department should be put in charge of research and teaching in computational chemistry. It should establish a group in computational chemistry in collaboration with the universities of Oslo and Tromsø to provide a focal point for the various activities of the faculty in this field;

- Sub-divisions could include quantum chemistry, molecular mechanics and materials science applications (lattice dynamics, statistical mechanics). This would encourage synergies with the activities of the thermodynamics group;

- Analytical chemistry activities should be co-ordinated at the faculty level and should include chemometrics.

3.1.1.6 Department of Industrial Electrochemistry

Basic description

The department carries out research in the fields of *electrolysis* (production of metals - mainly aluminium and magnesium, electrocrystallisation, electroplating, experimental and theoretical model studies, design and optimisation, and new electrode materials), *electrochemical materials technology* (kinetics, passivity, forms of corrosion, corrosion-proofing, surface treatments, materials properties, corrosion monitoring, corrosion of light metals and steel, methods for calculating cathodic protection, inert electrodes for aluminium electrolysis, conducting polymers, electrochrome materials) and *electrochemical energy technology* (solid oxide fuel cells, transport processes, electrode reactions, modelling, sensors and hydride batteries).

Research and its evaluation

The work of the department was presented under the research topics: electrolysis, corrosion and surface technology (SINTEF), molten salts, conducting polymers, electrochromics, solar cells and energy technology (fuel cells). Light metals electrolysis was clearly identified as a "strong point". There is much evidence of good quality research with extensive industrial collaboration and funding. Several members of the department are involved in significant international collaboration efforts, including EU programmes.

The advantages and disadvantages of interaction with SINTEF are well-illustrated in this department's profile. More than 50% of the funds are channelled through SINTEF. Consequently, it is clear that the direction of research is very strongly influenced by SINTEF's and industry's own objectives. One major advantage is that the laboratories are relatively well equipped and the staff has access to expensive facilities which are well-maintained or can be replaced. Without SINTEF's contribution, it would be difficult to maintain the specialised teaching, especially laboratory training, in applied electrochemistry. This department is the major provider of trained recruits for the Norwegian magnesium and aluminium industry.

The high level of support from SINTEF and from the manufacturing industry in general has resulted in research being focused on short-term applied topics, whereas several of the staff members would like to diversify into more basic areas of research. This is especially true in the field of corrosion. With regard to light metals, long-term projects, including basic research have been pursued. It was stated that the aluminium industry is sympathetic to basic research, for instance, in relevant areas of thermodynamics and kinetics.

The panel agrees with the description that "SINTEF's support is the backbone of the department's activity". This is likely to remain the case for many years, given the importance of the light metals industry and that industry's need to remain competitive through technical excellence. However, the department's success in attracting support is perceived to count against it when competing for university resources.

One serious problem which requires urgent attention is the imminent retirement of several staff members (three of a total of 5.2). This situation may also be considered an opportunity, provided there is a clear strategic plan. The plan should identify research directions which are likely to flourish and attract support. This has to be combined with an appreciation of the teaching needs. The merger with the Rosenborg campus will have little impact for this department.

SWOT Analysis

Strengths

- The department's vitality and output are high on an international scale;
- The department derives strong technical and financial benefits from SINTEF and from Norway's light metals industry, itself a world leader;
- The light metals industry depends on NTNU for its supply of well-trained recruits;
- Strong international collaboration has been established, including projects supported by EU programmes. The department receives many visiting researchers from different countries;

- The department has good access to major items of equipment at charges which are bearable;
- There is strong internal collaboration with the Department of Inorganic Chemistry.

Weaknesses
- For a major research university, there is an imbalance between applied and basic research;
- Three of the 5.2 staff members are more than 60 years old;
- In corrosion research in particular, the dependence on industrial support is held to put constraints on publication;
- The limited supply of good students presents a constraint.

Opportunities
- Staff renewal, if successful in securing permission to recruit given the current climate.

Threats
- No significant or immediate threats. The Norwegian electrolysis industry is likely to continue at a high level and the AVH merger has had no direct effect;
- In the longer term, a "globalised" electrolysis industry might move training and research out of Norway;
- The number of staff positions might be reduced;
- The activity may come to be regarded as an old and narrow field.

Recommendations

A strategic plan should be produced by the department as a matter of urgency. Major considerations should be:

- The identification of promising research areas;
- Testing of national and international markets for candidates for professor and associate professor positions, with an emphasis on proven research excellence;
- Re-address the current imbalance between applied and basic research;
- Further improvement of co-operation between the various departments within the faculty at the University with emphasis on the efficient use of shared facilities, for example, instrumentation and specialist workshops.

3.1.1.7 Department of Industrial Chemistry

Basic description

The Department of Industrial Chemistry is divided into two groups of approximately the same size: *the Petrochemistry and Catalysis group* (homogeneous and heterogeneous catalysis, reaction kinetics, mathematical modelling, characterisation of catalysts and porous materials, chemical conversion of natural gas, upgrading of oil and environmental catalysis) and the *Polymer Chemistry group* (monodispersant polymer particles; magnetic, coloured and

radioactive particles; emulsion, suspension and dispersion polymerisation; condensation resins; other binders and polyolefins including metallocene catalysis).

A salient feature of both groups is their unusually close co-operation and interaction with the Trondheim branch of SINTEF Applied Chemistry: personnel from NTNU and SINTEF share laboratories and scientific equipment and collaborate in research and teaching. For instance, NTNU personnel is, in part, working on SINTEF projects and SINTEF employees are involved in teaching at NTNU.

At the present time, the faculty consists of four full professors (two in the Petrochemistry and Catalysis group and two in the Polymer Chemistry group) and four associate professors. In addition, there are four so-called "professors II" associated with the department, out of which two positions are vacant. The NTNU staff is completed by three technicians and one secretary.

The department is heavily involved in undergraduate teaching. Typical topics covered in the courses given by the department's professors include industrial chemical processes (mass and energy balances), plant design (project), heterogeneous and homogeneous catalysis, surface and colloid chemistry, natural gas conversion, petroleum refining, the manufacture of petrochemicals and polymer chemistry. The average number of students graduating from the department (with 'sivilingeniør' degrees) is around 25 to 30 per year. Of these, as many as 65% go to positions in related industries, approx. 15% enter R&D organisations including universities for doctoral studies and approx. 5% join governmental agencies (the career of the remaining 15% being unknown). Over the period from 1992 to 1996, the department conferred doctoral degrees on 13 candidates.

Research and its evaluation

General

The laboratory facilities for both sub-groups of the Department of Industrial Chemistry are excellent. For example, the Petrochemistry and Catalysis group has at its disposal an impressively large number of laboratory-scale units for catalytic studies, including fully computerised high-pressure apparati. Furthermore, virtually all the necessary equipment for an in-depth physicochemical characterisation of solid catalysts is available. Close co-operation with other NTNU departments, including the Department of Physics (surface science), the Department of Chemical Engineering (modelling and chemical reactor engineering) and the Polymer Chemistry group, effectively add to the group's scientific breadth, benefiting NTNU students as well. It is fully justified to assume that the research facilities in the Polymer Chemistry group are equally good, though the panel received less clear and concise information from this group.

Petrochemistry and Catalysis group

Catalysis plays a vital role in virtually all the research activities of the Petrochemistry and Catalysis group. The efforts are mainly funded by industry and governmental agencies and cover a wide range - from basic studies of ideal surfaces to the testing and development of commercial catalysts in small pilot plants. Important research topics are:

Natural gas conversion
The catalytic conversion of natural gas into liquid products has been one of the group's main thrusts. Among the most important research fields are the partial oxidation of methane to synthesis gas, Fischer-Tropsch synthesis and methanol synthesis. Direct conversion routes, such as the oxidative coupling of methane or the direct oxidation of methane to methanol, have also been studied. This group is well respected at the international level, and holds a position of scientific leadership in Scandinavia and Europe.

Petroleum refining
The group deals with an impressive number of petroleum refining reactions. These include the catalytic reforming of naphtha, the hydrotreating of heavy oil fractions, the synthesis of methyl-tertiary-butyl ether, and propane/butane dehydrogenation. These reactions are studied on various scales, with a span ranging from the most fundamental studies to pilot plant operation. The group forms the core of the national research programme for the development of more environmentally friendly fuels.

Environmental catalysis
The removal of NO_X from stack and car exhaust gases via catalytic techniques is another important field of activity. Both direct NO_X decomposition and selective catalytic reduction by hydrocarbons are pursued.

Petrochemical reactions
Ammonia oxidation, the selective oxidation of hydrocarbons and the conversion of methanol into light olefins are typical examples of petrochemical reactions studied by the group.

Fundamental studies related to heterogeneous catalysis
Considerable expertise has been accumulated by the group regarding the fundamentals of heterogeneous catalysis. Fields worthy of particular note include scanning tunnelling microscopy, transient response techniques (mainly steady state isotopic transient kinetic analysis), coke formation on solid catalysts and zeolite chemistry and catalysis.

Overall assessment

The Petrochemistry and Catalysis group is among the top chemistry groups at NTNU. Virtually all members publish prolifically in renowned international journals. Considerable expertise has been built up in a number of fields involving applied catalysis. This is highly appreciated by the scientific community and industry alike. The group has a very strong experimental background and has pioneered the use of certain instruments, e.g. the oscillating microbalance, in heterogeneous catalysis. The research topics addressed are original and highly relevant to domestic and global industries. The group forms an ideal link between basic chemistry and chemical engineering.

Polymer Chemistry group

The Polymer Chemistry group was founded in 1958 by John Ugelstad whose ideas and research interests are still clearly visible. The following research topics which are, for the most part, addressed in co-operation with the Norwegian industry, seem to predominate:

Emulsion polymerisation
Beginning with vinyl chloride, a variety of monomers have now been polymerised using this technique. Emulsion polymerisation is now one of the group's specialities.

Monodispersant polymer particles
Activated swelling, invented in 1977 by John Ugelstad, allows the tailor-making of strictly monodispersant polymer particles ranging in size from 1 to 100μm. Both compact and macroporous particles can be made, facilitating a number of applications, including pharmaceutical products, catalysts, chromatographic columns and magnetic polymers.

Polyolefin chemistry
Research in this field is mainly directed towards studying (e.g. by calorimetry) the kinetics and mechanisms of homogeneously catalysed polymerisations and co-polymerisations of various monomers.

Overall assessment

As a whole the research performed in the Polymer Chemistry group is of good quality and relevant to the Norwegian industry. The group's publication record is satisfactory.

SWOT Analysis

Petrochemistry and Catalysis group

Strengths
- Clear monopoly for academic education in the field;
- Unusually broad variety of experimental techniques available;
- Pioneering work done in the use of certain instruments;
- Know-how and expertise highly relevant to Norwegian and European industry;
- Intense interaction with and support by SINTEF;
- Sabbaticals taken relatively frequently by staff members.

Weaknesses
- Vulnerable funding due to dependence on a very limited number of companies;
- Insufficient basic funding from NTNU;
- Funding of completely new research approaches difficult because of an excessive proportion of project-bound funding;
- Difficult to attract doctoral students from abroad.

Opportunities
- Further develop its leading role as a research institution in the fields of natural gas, petroleum refining, petrochemistry and environmental catalysis;
- Expand gradually into the catalytic preparation of basic chemicals, e.g. acetic acid;
- Aim at even closer co-operation with the Department of Chemical Engineering.

Threats
- Recruiting of top scientists as faculty members getting more difficult, due to salary differences between industry and universities;

- Highly qualified doctoral students difficult to attract, due to attractiveness of positions in industry;
- Low acceptance of chemistry and chemical engineering by society at large, reducing the supply of capable students.

Polymer Chemistry group

Strengths
- Leading research group in the preparation of monodispersant polymer particles, leading in the field of magnetic polymers for medical applications, particularly for fighting cancer;
- Broad experience in emulsion polymerisation;
- Spin-offs from this research into other research areas;
- Support by and intense interaction with SINTEF;
- Ideal balance between theory and experimental work within one group.

Weaknesses
- Modelling of polymerisation reactions underdeveloped;
- Research topics dependent on very few faculty members.

Opportunities
- Closer co-operation with the Department of Production and Quality Engineering at the faculty of Mechanical Engineering;
- Open new vistas through closer co-operation with the Petrochemistry and Catalysis group;
- Formulation and preparation of new polymer-based catalysts.

Threats
- Recruitment of outstanding scientists even more difficult than in the Petrochemistry and Catalysis group.

Recommendations for the whole department

- Further strengthen the Petrochemistry and Catalysis group and its co-operation with domestic and European industry;

- Increase NTNU's basic funding to enable the Petrochemistry and Catalysis group to start more exploratory research, for example, into new catalytic routes for the preparation of basic chemicals;

- Stimulate co-operation with domestic or foreign materials research groups for the purpose of identifying new solid catalysts;

- Take measures to fill the vacant professorship in the Polymer Chemistry group without further delay;

- Identify new focal points in the field of Polymer Chemistry.

3.2 University of Bergen

3.2.1 Department of Chemistry

The Department of Chemistry is part of the Faculty of Mathematics and Natural Sciences. The three divisions are listed in the table below, along with key figures. The groups are further described in the following chapters. The department is run by an elected head, as are the various groups. The department gives lectures in chemistry to approximately 450 students who are enrolled in more than 30 courses.

Table 3.2. Key figures for the individual divisions and for the Department

Parameters	Inorganic Chemistry	Organic Chemistry	Physical/ Theoretical Chemistry	Total
Professors	7	7	9	23
Associate professors			2	2
Other scientific positions		1		1
Research assistants	2	3	3	8
Non-scientific positions	4	4	3	14¤
Dr. scient.	2	14	18	34
Graduate students	12	31	28	72
1)Total University budget Running expenditures Univ.				17.2 3.2
1)External funding	0.3	4.0	9.8	14.1

1) In MNOK
¤ Difference: technical staff for the whole department

Overall assessment and recommendations

General description

This medium-sized department covers most aspects of basic chemistry, and has groups working in inorganic, bioinorganic, organic, physical, structural, theoretical and analytical chemistry. The department is divided into three administrative divisions (Inorganic Chemistry, Organic Chemistry and Physical/Theoretical Chemistry), and sometimes regroups staff members within the different research activities.

Evaluation

Strengths

- Medium-sized department in adequate building with sufficient space to expand;
- International reputation in colloid and bioinorganic chemistry as well as in chemometrics;
- Adequate equipment in areas requiring heavy instrumentation.

Weaknesses

- Insufficient interaction between individual faculty members and few joint seminars at the department level;
- Some of the groups are below critical size, e.g. Organic Chemistry;
- Inflexible use of sophisticated instrumentation, for example, 600 MHz NMR.

Recommendations

- Rethink the structure of the department in terms of improving the grouping of staff members with close research interests and provide easier access to NMR facilities;
- Maximise opportunities at the chemistry/biology interface at the academic and industrial levels;
- Some groups should become more pro-active in securing funding from industry, for instance, by re-configuring some of their research activities;
- Build on strengths and maximise opportunities, particularly in colloid chemistry which is unique in Norway.

3.2.1.1 Division of Inorganic Chemistry

Synthetic Chemistry

Basic description

The research group in Synthetic Inorganic Chemistry is part of the Division of Inorganic Chemistry and has two members.

The group is very small because the number of students, especially at the doctoral level, is low; this lack of students concerns the whole Division of Inorganic Chemistry.

Research and its evaluation

The synthetic work focuses on the main group elements in which the Division of Inorganic Chemistry has had internationally recognised traditions for more than 40 years. Staff teaching duties involve undergraduate laboratory courses in general, and analytical and inorganic chemistry. An attempt is currently being made to reorganise and modernise the teaching of inorganic chemistry.

In line with the group's traditions, it is studying selenium and tellurium chemistry, along with other main group elements, especially phosphorus, which occurs in synthesised compounds, for instance, in the study of PF_6 salts.

The use of X-ray single crystal diffraction techniques for structural characterisation forms a weak link between the synthetic group and the rest of the Division. NMR solution studies are also used extensively even in teaching. More recently, luminescence studies have been used in international collaboration to characterise the d^8-complexes (Pt, Pd). This project is an expansion of the research activities beyond the main group chemistry. Another collaborative

project concerns thio- and seleno-substituted carboxylic acids with potential anticholesterol effects.

Considering the size of the group, its publication record, especially in recent years (1995-96), has been quite satisfactory.

SWOT Analysis

Strengths
- Long, internationally recognised research traditions in main group chemistry;
- The heavy instrumentation (NMR, XRD 1998) available to the group can be ranked as excellent, while other equipment, with the exception of magnetic balance, is good;
- Good laboratory facilities and library;
- Good co-operation with the University of Oslo in respect of Raman spectroscopy and electron diffraction, which are not available in Bergen;
- Adequate international contacts.

Weaknesses
- Internal co-operation within the division is inadequate;
- Insufficient supply of good students;
- Unfavourable age structure;
- Research topics not attractive for students or industry;
- Lack of outside funding, meagre university funding.

Opportunities
- Present and forthcoming long-term plans call for reorientation;
- Local research-oriented industry in Bergen;
- Some of the synthetic projects have good application potential.

Threats
- In connection with retirements, the group could be reduced to below critical mass.

Recommendations, see pages 70-71

Structural Chemistry and the XPES Group

Basic description

The group comprises three professors, one associate professor, one doctoral student and eight graduate students. In addition, four technical staff members are assigned to the Division of Inorganic Chemistry, although their main assignment is to help run the student laboratories in general chemistry (240 students per year).

Each member of the group pursues his or her own research projects, often in collaboration with groups outside the country. The projects are as follows:

a) *(i)* *Structural, co-ordination and bonding properties of compounds containing selenium and tellurium* (high co-ordination numbers (7,8) and hypervalent bonding have been found in several of these compounds in collaboration with three research groups outside Norway);

(ii) *Structural and magnetic properties of dinuclear copper and nickel complexes* (in collaboration with Japanese universities);

(iii) *Hybridisation of phosphorus in tris(dialkylamino)phosphine sulphide*;

(iv) *Synthesis and structure of substituted ferrocenes*;

(v) *Synthesis and characterisation of iodine-chalcogen compounds.*

The last three projects are conducted in collaboration with American universities. Future research is to be focused on projects (i) and (v).

b) (i) *Structure and magnetic interaction in copper-containing complexes.* The project implies the design of suitable bridging ligands in order to tune magnetic interaction, as well as the synthesis and crystallisation of polynuclear complexes and their characterisation by magnetic measurements and X-ray diffraction techniques. It is being carried out in collaboration with research teams in France and Spain and has led to the isolation of molecular magnets;

(ii) *Relationship between co-ordination geometry and chemical properties* (donor-acceptor interaction, redox properties) and the *design of models for bioinorganic molecules*. Both projects are planned to be continued in the future.

c) (i) *Core electron spectroscopy and chemical properties.* XPES measurements are made at the University of Uppsala, while structural investigations are performed in Bergen. Theoretical modelling for interpreting the XPES spectra is handled in collaboration with the Division of Theoretical and Analytical Chemistry. Synchrotron radiation at higher wavelengths is needed to determine the fine vibrational structure. The spectra are measured either in Daresbury (EPSRC), Lund (MAX Lab) or Berkeley (ALS);

(ii) *Molecular structure and chemical properties.* The projects aim at unravelling the relationship between reactivity and core-ionisation energies. Presently focused on substituted propenes, butenes, silanes, monosubstituted benzenes and styrene derivatives, the projects will be extended to the study of surfaces of catalytic metallocene compounds.

d) The professor was appointed recently (1 July 1996) and is responsible for X-ray diffraction and computing facilities. He has plans to develop research in the following areas:

i) *The structure, vibrational properties and electron density of silasesquioxanes;*

ii) *The structure of organic metals and superconductors;*

iii) *Multifunctional organotellurium antioxidants;*

iv) *The characterisation of zeolites containing dye molecules; and*

v) *Diffraction studies of solid state materials and biological molecules.* Several of these projects are collaborative efforts with groups in Sweden, Denmark, Germany and Switzerland. Links have also been established with Norwegian and Swedish enterprises.

Research and its evaluation

The research projects conducted by the members of the group cover a vast range of topics in inorganic chemistry, which is certainly beneficial to teaching and essential to the Department of Chemistry. Publications usually appear in peer-reviewed journals with outstanding international reputations. However, the rate of publication is not high due to the excessive scattering of the projects and the fact that the group has not been able to attract graduate students, mainly because there is a general lack of funding for basic chemistry. This is reflected in the rather primitive equipment of the laboratories, both in the area of synthesis (there is no glove-box) and of instrumental analysis (X-ray diffraction). Moreover, the absence of significant interaction between the members of the group weakens its potential productivity and renders it less attractive than other units in the department which are able to bring in better funding. Given the potential represented by each member of the group, more dynamism might be expected if joint projects were initiated.

SWOT Analysis

Strengths
- Only Norwegian group pursuing structural research in main group chemistry;
- Extensive expertise in most fields of inorganic chemistry;
- Extensive international collaboration;
- Good publications in peer-reviewed journals;
- Fair perception of own strengths and weaknesses.

Weaknesses
- The group has too few doctoral students because basic research is difficult to finance;
- Underdeveloped resources in synthesis and X-ray diffraction;
- Few connections with industry;
- Insufficient collaboration with the Division of Inorganic Chemistry. What does exist, mainly concerns the use of common equipment;
- Most of the researchers rely too much on external collaboration for preparative chemistry.

Opportunities
- A new X-ray diffractometer will be purchased in 1998;
- Renewal of staff will be made possible as positions become vacant.

Threats
- Vacant positions could be transferred to more dynamic groups within the division;
- Support for basic research is becoming increasingly more difficult to obtain.

Recommendations for the whole division

- Develop closer co-operation and joint collaborative research projects within the Division of Inorganic Chemistry to increase the impact of the research;

- Strengthen and re-orientate the research topics either towards materials and heterogeneous catalysis or towards biochemical applications, depending on the strategic plans of the Department of Chemistry and other partners;

- Make serious attempts to attract external funding and qualified students, for instance by developing industrial co-operation;

- Appoint two synthetic chemists to replace retirees. The new appointees should have expertise in the fields of transition metals and solid-state chemistry;

3.2.1.2 Division of Organic Chemistry

Basic description

This division was presented to the panel as two units: *i) Synthetic Organic Chemistry* and *ii) Analytical Organic Chemistry and Natural Products.* The first sub-division effectively consists of two staff members, one with a smallish group and the other with a larger one. The targets for synthesis are relatively small molecules with interesting properties of reactivity and stereochemistry. The second group has five staff members with interests ranging from natural products chemistry, petroleum chemistry and analytical chemistry to spectroscopy. The division's common ground is the application of analytical methods to problems involving compounds derived from organisms.

Research and its evaluation

Synthetic Organic Chemistry

The group consists of three professors. One of them came to Bergen in 1993 and seems to have brought 'life' to organic synthesis in the division and is a leader in the field. His research covers the synthesis and chemistry of halo-substituted cyclopropanes, and the use of the photons in synthesis, as related to the preparation of biologically active compounds. The present research group consists of 15 graduate and doctoral students.

One of the other professor's research is concentrated on conformational analyses of phosphorus-containing saturated heterocycles; he has two research collaborators plus a technician.

The third professor did not present himself to the visiting panel. For all intents and purposes, he is not active in research, having published only 10 scientific papers during his forty years on the staff in the division.

SWOT Analysis

Strengths

- One of the professors is dynamic, and has sound ideas for the future development of synthetic organic chemistry in Bergen;
- Although small, the group is optimistic about its future;
- Synthetic organic chemistry is popular with the students and job opportunities are very good.

Weaknesses

- The unit is below a critical size;
- There is no obvious opportunity for future expansion and development;
- There are no regular seminars, and there is little scientific interaction with the natural product groups;
- Access to higher field NMR facilities will be required as the research programmes in synthesis become more demanding.

Opportunities

- The group can only grow, having started from such a weak base;
- With the demise of synthetic organic chemistry, Bergen could become Norway's centre for this important activity;
- The group could interface with biology and natural product chemists, thereby providing greater long-term opportunities;
- There are possibilities for securing funding *via* the sale of valuable chemicals to industry, particularly the agrochemicals industry.

Threats

- One of the professors might leave Bergen at the first opportunity, if support and encouragement are not forthcoming;
- Research output is dependent on the provision of adequate laboratory, technical and spectroscopic facilities; these must be made available to the group.

Recommendations

- As a matter of urgency, formulate plans to build strength by appointing three to four young synthetic organic chemistry staff members. These appointments should interface with organometallic chemistry, asymmetric catalysis and biological chemistry, including natural products;

- Secure post-doctoral research fellows to underpin this research activity;

- Promote greater interaction with the Analytical Organic Chemistry and Natural Products staff in the division; a division of activities is totally unnecessary;

- Synthetic organic chemistry should take the lead in optimising collaboration and research support at the chemistry/biology interface in the University;

- The group must consolidate its position in the division and gain greater international visibility by publishing more primary literature.

Analytical Organic Chemistry and Natural Products

This group comprises four professors and one Dr. scient. The activities of the group were presented and included *natural products* (particularly anthocyanins, flavones, marine natural products, carotenoids and related plant pigments), *petroleum chemistry, analytical and separation science*, and *spectroscopy* (principally NMR). The anthocyanin/flavonoid group is recognised internationally, and collaborates extensively with overseas scientists; the contribution to this group of NMR expertise in the department is clear. The Dr. scient. works in the area of analysis and the characterisation of organic compounds from oil, and the conversion of biomass to petroleum-type products. This person is supported *via* soft money and appears to be reliant on successive short-term contracts in applied chemistry; this situation seems unacceptable.

SWOT Analysis

Strengths
- A reasonably cohesive group of researchers;
- Aspects of the research are addressing national needs and environment issues;
- Trained researchers have no difficulty finding employment in the chemical industry, and the subject is popular with students;
- Good international collaboration.

Weaknesses
- Somewhat 'classical' approach to modern natural product research;
- Perhaps too analytically based, thereby missing opportunities;
- There is a need to maintain state-of-the-art analytical facilities.

Opportunities
- Many possibilities for major interaction with biological and medical scientists, which could lead to enhanced research support;
- To interact better with the Synthetic Organic Chemistry group, which could lead to a more powerful unit;
- Profile can be raised by addressing issues at the interface with environmental science and nutrition;
- Realistic opportunities for funding research *via* EU programmes.

Threats
- Visibility will only be ensured if a wider portfolio of activities is secured - capitalising on the world-wide revival of interest in studies of natural products.

Recommendations

- Secure closer interaction and collaboration with the synthetic organic chemists;
- Maintain state-of-the-art separation chemistry facilities, e.g. HPLC;
- Produce a strategy group to address research opportunities for university-wide collaboration at the chemistry/biology interface;
- The particular situation of the Dr. scient in the group, who is employed on a succession of short-term contracts of an applied nature, should be reviewed and regularised.

3.2.1.3 Division of Physical/Theoretical Chemistry

Physical Chemistry at the University of Bergen shows an unusually sharp profile: It is divided into two groups named *Surface and Colloid Chemistry* and *Biophysical/Bioinorganic Chemistry*.

Surface and Colloid Chemistry

Basic description

The Surface and Colloid Chemistry group comprises two full professors and two associate professors. It became evident during the reviewing procedure that the group holds a remarkably strong and outstanding position within the Department of Chemistry. This is not only reflected in the budget, but another clear indicator is the acceptance of the group by chemistry students. Since 1990, more than 20 graduate students have been educated, and a similarly high rate has been achieved in the education of doctoral students (11 Dr. scient. since 1990). At the time of the reviewing procedure, approximately 10 graduate students and eight doctoral students were associated with the group.

Over the years, the Surface and Colloid Chemistry group has established an excellent network of contacts and co-operation with outside institutions. These include industrial enterprises, which contribute a large part of the extraordinarily high budget of the group through extra-mural funding, and university institutes around the globe. In discussions, group members impressed the panel not only by their unusually broad range of activities, but also by their dynamism and the viability and clarity of their mid-term planning. When questioned by the panel, the staff members were able to present a written strategy for the next five years. The salient features include a logical extension of the present activities into heterogeneous catalysis and engineering-oriented research, in an endeavour to be even better prepared to support and serve Norway's domestic industries.

Research and its evaluation

Highly original and innovative research is carried out by the Surface and Colloid Chemistry group. Among the topics currently covered by the four faculty members are: *Emulsions and foams and the development of instrumentation for their characterisation*; *pulp and paper*

chemistry (in co-operation with the Helsinki University of Technology); *polymers and surfactants; colloid chemistry and materials science* (e.g. preparation of oxide monolayers, microemulsions, preparation of mixed oxides and fine particles); *preparation of mesoporous materials* (in co-operation with SINTEF Applied Chemistry, Oslo); *kinetics of hydrolysis and condensation of alkylmethoxysilanes*; *colloid chemistry in offshore petroleum production*; *sol/gel processes; dielectric spectroscopy and its application to colloid chemistry; emulsions and gas hydrate formation; thermodynamics of aqueous solutions; formation of micelles, fundamentals of enhanced oil recovery; adsorption on solids; and interaction between surfactants and polymers.*

The group members have excellent visibility in the pertinent national and international literature and they publish at a high rate. One group member has published more than 100 papers within the past five years and edited or co-edited five scientific books on various aspects of colloid and surface chemistry. The topics of the group's recent publications reflect an ideal mix of basic and applied science, experimental and theoretical methods, depth of scientific insight and topical broadness. Furthermore, the group has an excellent age distribution.

In summary, the group deserves the highest marks. It is without doubt one of the few top-quality groups in chemistry at the Norwegian universities and deserves all possible support in the future.

SWOT Analysis

Strengths
- The group has a very sharp and unique research profile which is well adapted to the demands of Norwegian industry;
- Extremely high publication activity in the past five years;
- Very good acceptance by chemistry students in Bergen;
- Unusually good age distribution of staff members;
- Well defined, convincing strategic plans available for expanding and sharpening the profile even further;
- Very intense collaboration with industry and research institutions world-wide.

Weaknesses
- Lack of technical personnel, so staff members lose time with subordinate work;
- Responsibilities within the group could be better defined;
- No funding available for post-doctoral positions at the group (general weakness of Norwegian universities).

Opportunities
- The gas industry in Norway is expanding, facilitating concomitant involvement of the group in applied research related to upgrading of natural gas;
- Recognition as a centre of excellence and appropriate funding of free research by the department for a limited time.

Threats
- Inability of the group to maintain the high level of efficiency in the future, i.e. a danger of getting "burnt out".

Recommendations

- Strengthen the Surface and Colloid Chemistry group at the University of Bergen and its co-operation with Norwegian and European industry wherever possible;
- Consider adding a professorship II or even a full professorship to the group for heterogeneous catalysis;
- Consider installing a solid-state probe into one of the existing NMR spectrometers of the division;
- Encourage the two young associate professors to move gradually into research areas of their own.

Biophysical/Bioinorganic Chemistry

Basic description

This group has a clear research profile, with a common interest in the study of sequence selective interaction between metal ions or complexes and biologically important molecules and macromolecules, including oligonucleotides and proteins. Among the other biological systems studied are anthocyanin dimers, polysaccharides and phospholipid metabolisms. To these ends, they are major users of state-of-the art high-field NMR spectroscopy using both solution and solid-state measurements. The members of the group make distinctive contributions to what are often joint publications.

Research and its evaluation

The Biophysical/Bioinorganic Chemistry group is also associated with a separate group, the NMR group, which includes staff members of the organic and biochemistry community as well as an engineer, eight doctoral students and 15 graduate students. The activities are fairly well resourced, and the group has a number of valuable international connections, particularly *via* EU networks. The leader's own activities focus on metal ion binding to oligonucleotides. Two doctoral students and two graduate students are active in this area, and the whole group is part of major EU collaborations, one of which will bring a one-year post-doctoral fellowship into the system. Present facilities include 600, 400 and 200 MHz NMR instruments. A recently appointed NMR expert is important to the development of methodology and is developing links with the Department of Biochemistry for the purpose of using NMR methods to characterise biologically significant proteins and protein fragments. Special emphasis is placed on conformational aspects as related to the mechanism of biological action. One professor is active in the study, based on NMR, of metal-ion binding to DNA and similar interaction involving polysaccharides. Interesting results have been presented on the determination of interchain distances. There is significant collaboration with biochemists, biotechnologists and surface scientists.

SWOT Analysis

Strengths
- Focused research programmes using state-of-the-art facilities;
- Very good international collaboration; reasonably well-resourced;
- International visibility and a good publication record.

Weaknesses
- Perception that NMR capability is being used as a "service" by certain sectors of the university;
- Probably not always asking the right questions at the chemistry/biology interface;
- Confusion over role concerning stewardship of the department's NMR instrumentation; not clear whether this valuable asset is always deployed on the projects with the greatest scientific merit.

Opportunities
- Capitalise (scientifically) on developments in biology;
- Open up facilities to address cutting-edge scientific ideas/proposals involving the remainder of the department and university;
- Two young academics who should have a significant research impact.

Threats
- Vulnerable to charge of not making optimum scientific use of the excellent high-field NMR facilities;
- Danger of becoming scientifically isolated and protective of facilities rather than being involved in the formulation and planning of a leading-edge biology/chemistry research programme.

Recommendations

- Show more willingness and leadership with respect to co-operation and collaboration with strong groups in biology/biochemistry;
- Place more emphasis on the distance-geometry/structure work and the lipid membrane NMR studies;
- Carefully evaluate, with a view to clarifying scientific objectives, the protein structure/function collaborative programme with biochemistry;
- Provide better-defined access to the NMR facilities for researchers in other groups, e.g. those engaged in the rapidly developing and important field of synthetic chemistry

Theoretical Chemistry

Basic description

The group comprises one professor, one post-doctoral fellow, one doctoral student and two graduate students.

Research and its evaluation

The present research activities are focused on two main subjects:

Modelling of catalytic processes
The research concentrates on understanding of structure-activity relationships and on the optimisation of heterogeneous catalytic processes in the oxidative coupling of methane, in Ziegler-Natta catalytic reactions, and in the chromium-based polymerisation of ethylene. The choice of methods is dictated by the problem under scrutiny and covers top-level *ab initio* correlated procedures, semi-empirical methods and density functional theory. Existing quantum mechanical packages are used and method development is kept to a minimum and performed only when needed for solving a specific problem. The projects are selected because they are of interest to the Norwegian oil industry. Extensive utilisation is made of the national main-frame computer facilities in Trondheim, Oslo and Bergen.

Interpretation of core-electron spectra (XPES)
This project is conducted in collaboration with another professor. It facilitates the calibration of theoretical models and description of electron correlation effects. Attention has been centred on the interpretation of the vibrational structure in the C(1s) spectra of simple hydrocarbons and on the calculation of the S(2p) splitting in H_2S, SO_2, CS_2 and OCS.

Additional projects are carried out in collaboration with other groups, e.g. hydrogen bonding and packing studies in $(NR_4)PF_6$ crystals, modelling of adsorption processes, and investigation of the colour of plant pigments. The research team maintains close collaboration with groups in Stockholm, Calgary, at Oregon State University and at the Max-Planck-Institut für Kohlenforschung in Mülheim.

Overall assessment

The group was established in 1991 with a newly appointed associate professor. It is performing high quality research, distinct from the research conducted by the theoretical chemistry groups in Tromsø and Oslo. Results are published in high quality journals and, given the small size of the group, the publication rate (11 papers during the past five years) is acceptable although it certainly could be increased during the years ahead. The balance between applied aspects (catalysis) and more fundamental queries (interpretation of XPES spectra) is good and allows the group to attract external funding from Norwegian oil companies. The extent of collaborative work is also promising, both on the local and international level. However, there does not seem to be close co-operation with the related groups in Oslo and Tromsø which concentrate more on development of methodology, on metal containing systems and on the prediction of the electric and magnetic properties of molecules. The professor also has a clear strategy for his future research in which he wishes to put stronger emphasis on heterogeneous catalysis (polar surface studies), mainly for getting better financial support from the national oil industry, while increasing collaboration with academic groups that gather experimental facts.

SWOT Analysis

Strengths

- Excellent command of quantum chemical software;
- Access to modern main-frame computers in Bergen, Trondheim and Oslo;
- Connection with Norwegian oil industry;
- Openness to new problems and collaboration;
- The group attracts good graduate students.

Weaknesses

- The small size of the group prevents the development of new methods, which would be too time consuming;
- The lack of work capacity slows the development of new collaboration, both on the local and the international level;
- The group is entirely dependent on external resources for computing and for the financing of doctoral students;
- The group cannot assume all the teaching in theoretical chemistry.

Opportunities

- Moving the Department of Biochemistry near the Department of Chemistry will provide new occasions for collaboration;
- The retirement of several faculty members in the Department of Chemistry in the near future could create an opportunity for expanding the group.

Threats

- National computing resources may not be granted after 1998;
- The expansion of the Chemometrics group, created at the expense of the Theoretical Chemistry group, may hamper the development of the latter;
- The absence of a compulsory course in theoretical chemistry from the curriculum in chemistry may render the recruitment of graduate students more difficult;
- The one-man staffing at the faculty level could generate difficulties, for instance in case of sabbaticals. If the professor were attracted to another university, theoretical chemistry would become non-existent at the University of Bergen.

Recommendations

- Establish links with the Department of Informatics in order to attract graduate students able to develop methods;

- Create a "service unit" in modelling at the department level, as modelling procedures become more and more important in the various fields of chemistry;

- Explore new collaboration in the field of biochemistry;

- Provided the department wants to maintain the present level of activity in theoretical chemistry, a second faculty position should be created in this field.

Chemometrics

Basic description

The group comprises two professors, one associate professor, one post-doctoral fellow, four doctoral students and six graduate students. In addition, one technical staff member, a fully qualified chemist with a doctorate, is in charge of running the laboratories.

The group is the youngest one at the Department of Chemistry. It originated from a graduate-level project aimed at developing software for multivariate analyses on microcomputers in the early 1980s. Equipment for FTIR spectrometry was bought in the late 1980s and early 1990s. A strategic technology programme in Chemometrics was started in 1992, and a professor was appointed in this field one year later.

The group's main activity is centred on the development of multivariate analyses for industrial processes and on the use of quantitative vibrational spectroscopy: FTIR in the mid-infrared and near-infrared ranges, and, in the future, Raman spectroscopy.

The equipment in the laboratories includes a Perkin-Elmer 1720 FT IR spectrometer, a Nicolet 800 GC/FTIR spectrometer equipped with a microscope and self-developed NIR systems for on-line analysis.

The group plans the following activities from 1998 to 2002:

a) *Process development and environmental monitoring* in collaboration with industrial partners and Norway's State Pollution Control Authority (SFT). A pilot project has allowed Norsk Hydro to increase magnesium production at its Herøya plant, earning an additional MNOK 100 annually. Several collaborative projects are being initiated under national and European programmes (COMET, ESPRIT). Environmental monitoring was also initiated in connection with projects involving Norsk Hydro, translating into substantial savings. A model for forecasting the concentration of ozone at ground level is being elaborated in collaboration with SFT.

b) *Quantitative IR and NIR analysis.* The use of NIR spectrometers as on-line analysers for industrial processes is a key element in projects based on co-operation with pharmaceutical (modification of monodispersant particles) and oil (separator optimisation) companies. The planned ESPRIT project on multivariate process control also fits into this scheme.

c) *Two-dimensional and three-dimensional multi-component analysis*, an area in which the establishment of a network covering the Scandinavian countries is planned.

These activities are completed by an ample range of courses in chemometrics and by the organisation of international conferences, both in Bergen and abroad. A joint doctoral programme has been recently established with Hunan University (P.R. China). The Norwegian Chemometrics Society was created by the Bergen group.

Overall assessment

This medium-sized group appears to be quite dynamic and inventive. There is a considerable interaction between its members, leading to a beneficial synergistic effects. The group has a high productivity of good papers in peer-reviewed, internationally recognised journals. The

group also attracts considerable external funding, reflecting the very applied nature of its research. Sixty per cent of its funding comes from the Research Council of Norway, 30 to 35% from industry and 5 to 10% from European programmes. Fundamental aspects are also taken into account, for instance in the methodology of the NIR experiments, providing a basis for the development of new software. It is noteworthy that several other groups from the department make use of the laboratory facilities in chemometrics and that the software produced by the group is widely used in industry (e.g. the Sirius programme). During the past five years, nine students obtained doctorates in chemometrics, which is an above-average number, compared with the other groups in the divisions of Physical Chemistry or Inorganic Chemistry. The group maintains extensive international collaboration and several awards have been conferred on its members. A book on chemometrics, edited by the group's leader and mostly written by members of the group, is a reference book in this field in Norway.

The future development of the group will have to be tailored to the capacity of the Department of Chemistry to re-allocate vacant positions while maintaining sufficient activity in other sectors. This may present a challenge to the Chemometrics group, which proposes to hire two new professors within the next few years, one active in process development and environmental monitoring and the second working in the field of IR spectroscopy.

SWOT Analysis

Strengths

- Dynamic staff members whose contributions are distinctive, despite extensive interaction. High publication rates;
- Significant industrial and international collaboration;
- Good external funding;
- Acknowledged high-level expertise in software and instrumentational development (NIR, automated GC-IR);
- Largest Norwegian group involved in chemometrics.

Weaknesses

- The group does not benefit from the support of a group in Analytical Chemistry;
- One faculty member is sharing his time between projects in Chemometrics and Theoretical Chemistry.

Opportunities

- The Division of Inorganic Chemistry plans to hire a professor of Analytical Chemistry. This could entail more interaction with the Chemometrics group.

Threat

- Less importance attached to basic research could result in isolation of the group within the Department of Chemistry.

Recommendations

- Expand the group while keeping close contacts with other groups within the department and the University in order to maintain a broader experimental basis for its methodological developments. Within the context of a clear chemistry research strategy, the appointment of new staff members should be considered;

- Maintain a healthy balance between applied and basic research, and avoid excessive dependence on industrial funding.

3.3 University of Oslo

The University of Oslo comprises a number of different faculties. One is the Faculty of Mathematics and Natural Sciences, which is subdivided into various departments/sections. The evaluation has focused on the Department of Chemistry and a few groups at the Institute of Pharmacy.

3.3.1 Department of Chemistry

With 133 employees, the Department of Chemistry is one of the largest departments at the Faculty of Mathematics and Natural Sciences. The 14 largely autonomous research groups are organised into four Sections as specified in Table 3.3, accompanied by key figures. The various research groups are described in further detail in the following chapters. The department is run by an elected head, a Board and a Council, supported by committees for education and finances. The sections are run by elected section heads. The department has centralised separate units for administration, chemical storage, workshop, glass blowing facilities and electronics/data being used by the various sections.

The department is heavily involved in teaching, teaching about 60 courses in chemistry at different levels. In 1996, these courses were attended by approximately 1700 students.

Table 3.3. Key figures for the individual sections and for the Department

Parameters	Inorganic Chemistry, Materials Science and Catalysis	Organic Chemistry	Physical Chemistry	Analytical, Nuclear and Environmental Chemistry	Total
Professors	8	10	19	9	46
Associate professors	2			2	4
Other scientific positions	5	5	4	1	15*
Research assistants	4	11	8	5	28+
Non-scientific positions	6	6	7	9	55¤
Dr. scient. (total for five years)	24	21	18	18	81
Graduate students	26	27	14	79	146
[1)]Total University budget Running expenditures Univ.					62.4' 10.7
[1)]External funding					3.2

Other scientific positions: other fixed positions, emeritus, post-doctoral fellows
* Include 11 emeriti
+ All are doctoral students
¤ Difference: nine administrative officers, 18 at workshops, store room
1) In MNOK, incl. salaries
' Includes an extraordinary allocation of MNOK 7.5 for X-ray equipment from the university and the Research Council, and the ordinary allocation for instruments from the year before of MNOK 1

Overall assessment and recommendations

General Description

The Department of Chemistry conducts research in all areas of traditional chemistry. The 14 research groups accommodated within the four sections differ greatly in size. Research in medicinal chemistry is carried out within the Institute of Pharmacy.

Evaluation

Strengths

- Strong traditions and pronounced strengths, particularly in solid state chemistry, synthetic organic chemistry, theoretical chemistry and analytical chemistry;
- Sound infrastructure and up-to-date instrumentation;
- Significant international collaboration.

Weaknesses

- Poorly developed research strategy for the department as a whole and lack of succession planning;
- The maintenance of the strong traditions in certain areas has led to an arbitrary division of the sections and inhibited the development of new activities;
- Underdeveloped collaboration and interaction between the sections within the department; some groups appear detached from the rest of the department;
- The lack of post-doctoral research fellows prevents rapid progress in certain key research areas.

Recommendations

- Give urgent attention to producing a Strategic Research Plan for the future structure and development of the department, building on strengths, maximising opportunities, and aiming to become a "Centre of Excellence" in Norway;

- Develop multidisciplinary research programmes, particularly at the biology/chemistry interface and with groups in the Institute of Pharmacy, and forge closer interaction with the chemical industry;

- Provide greater opportunities for younger staff members to establish independent research portfolios at a more rapid pace; this could be achieved *via* more selective funding at the expense of the less active, older researchers.

3.3.1.1 Section 1: Inorganic Chemistry, Materials Science and Catalysis

There are four principal areas of activity within Inorganic Chemistry, Materials Science and Catalysis: *the synthesis and characterisation of inorganic materials*, *structural determination*, *characterisation of properties*, and *studies of structural stability*. These headings cover a number of different methods of synthesis, analysis and the characterisation of inorganic compounds and materials, powder X-ray and neutron diffraction (routine and high quality, as a function of high/low temperature and pressure), magnetic and thermal properties, multi-component phase diagrams, phase transitions, high/low temperature calorimetry and thermodynamic simulation. In electrochemistry and materials science, research is being carried out with corrosion and electrochemistry in aquatic environments, high temperature corrosion, synthesis and characterisation of materials, electrical conductivity (ionic and proton conductors), fuel cells and sensors. In petrochemistry and catalysis, the group is engaged in the synthesis and characterisation of materials, structure determination, measuring catalytic activities and selectivities of zeolites as well as studies directed towards optimal exploitation of natural gas.

Inorganic Chemistry and Materials Science

Basic description

Since January 1996, the group's permanent scientific staff has consisted of three professors and one assistant professor. The total number of permanent staff members has shown a strongly declining trend since 1993, but there will be a new position created as of June 1997. The number of undergraduates (3) and doctoral students (2) per staff member corresponds to the average figure for the whole department. The loss of permanent personnel has been partly offset by retired staff members who contribute to research but not to teaching. Teaching duties, which consist of 10 courses in inorganic solid state (materials) chemistry and characterisation, are considerable.

Research and its evaluation

The group has an internationally recognised position in synthesis and the characterisation of functional inorganic materials, which have potential applications, for instance, as magnetic materials, ion- and superconductors and catalysts. The compounds studied here have been mostly chalcogenides, although phosphides, arsenides and other binary systems have also been investigated.

As regards the characterisation of systems, the structural methods used by the group have been brought up-to-date during the past few years. The group members have actively contributed to the development of the facilities in Kjeller and Grenoble. Another area in which the facilities and know-how are of high international quality is high-temperature calorimetry.

The group's research profile and international co-operation are reflected in the list of publications, which shows an impressive and prolific production of articles for well-known journals.

SWOT Analysis

Strengths

- A national centre of excellence in solid state chemistry;
- Up-to-date instrumentation, especially in structural research (X-ray diffraction) and calorimetry. Know-how in the use of this instrumentation and the interpretation of results;
- Special expertise in magnetic materials;
- Fully adequate international contacts.

Weaknesses

- The running costs of some equipment (e.g. helium for the SQUID magnetometer) cannot be met. Consequently, the full capacity of the available instrumentation cannot be exploited;
- Some key items of equipment necessary for synthesis and characterisation are still lacking;
- The teaching (and administrative) load is heavy. Some areas of inorganic chemistry cannot be covered in teaching due to the lack of personnel.

Opportunities

- Co-operation with SINTEF will be improved through an agreement (model: Trondheim);
- Use of the synchrotron ring (Norwegian - Swiss beam line) in Grenoble will add a new dimension to existing facilities;
- The extension of materials studies from powders to thin films will offer new possibilities.

Threats

- The number of permanent positions is gradually diminishing due to budget cuts;
- Employment opportunities for those with graduate degrees can be difficult at times and they depend on too few companies.

Recommendations

- Further exploit the high application potential of the group's fundamental research to finance the group and improve employment opportunities for students;

- Seek research funding from outside sources to more activities. Teaching obligations restrict the enhancement of research activity and its reorientation by the present staff.

Electrochemistry and Materials Science

Basic description

The staff comprises two professors (one of whom will retire in July 1997), one senior professor, one professor II (20 %), one senior engineer, one research technician (who teaches part time), eight graduate and seven doctoral students. In addition, the group benefits from the

collaboration of two - four researchers engaged on projects specific to the Centre for Materials Research.

Research activities are divided between two areas: *high temperature electro- and materials chemistry* and *electrochemistry and corrosion in aqueous environments.*

a) *High temperatur · electro- and materials chemistry.* High temperature studies include the investigation of defect structures and properties in oxide ceramics. One particular point has been the study of protons as defects, which led to the development of a method for measuring partial proton conductivity. Measurements of electrical properties, non-stoichiometry and diffusion as a function of gas combinations and other parameters can be performed thanks to the development of advanced gas-mixing cells. Another topic deals with the oxidation of metals and alloys at high temperatures, especially with alloys relevant to electrical connections (for instance, the bipolar plates in fuel cells).

b) *Electrochemistry and corrosion in aqueous environments.* In aqueous electrochemistry, research has been focused on electrochemical kinetics, the passivity of metals and the properties of passive films. These topics are often developed in connection with practical problems, for instance, the study of corrosion in oil wells and in alkaline environments (e.g. steel reinforcement in concrete) and the behaviour of titanium in mammalian osseous tissues. These efforts have led to the development of sensors for use in the human body.

Research and its evaluation

The research unit, which resulted from the merger of two groups, *high-temperature defect- and electrochemistry* and *aqueous electrochemistry*, has seen many administrative rearrangements during the 1990s. The group joined the Centre for Materials Research in 1990, with administrative attachment to Physical Chemistry. When the Department of Chemistry was reorganised, the group was included in Section 1, together with Inorganic Chemistry, Surface Chemistry and Catalysis (Petrochemistry). The Centre for Materials Research is currently under evaluation and will be reorganised in the near future. This does not provide a serene climate for developing long-term research projects.

The group maintains indisputable leadership in defect chemistry. The books written by the group's leader, *Non-stoichiometry, Diffusion and Electrical Conductivity in Binary Metal Oxides* and *High Temperature Oxidation of Metals,* are used as textbooks world-wide. Most of the foreign researchers involved in this field have visited the Oslo laboratory, and the 8th International Conference on Solid State Protonic Conductors was held at the Department of Chemistry in 1996. The equipment for surface testing at the Centre for Materials Research is adequate and of high quality. It has been possible to assemble specific (and sometimes unique) equipment, thanks to the skilled workshops of the department. The level of expertise in aqueous electrochemistry and corrosion studies is high and has led to interesting instrumentational developments as well as to collaboration both with industry and medical centres. As regards personnel, the group appears to be somewhat understaffed. The filling of vacant positions appears to be essential for maintaining its expertise.

SWOT Analysis

Strengths

- The group is among the few units in the world which deal with defect chemistry and has a leading position in the field of proton transport;
- The group possesses modern, high-quality instrumentation. Particular mention is made of the unique instrumental set-ups for diffusion measurements and measurements in unusual environments (*in vivo*, corrosive, multiphase oil-water-sand);
- Substantial collaboration with other groups in Norway (SINTEF Oslo, Centre for Materials Research, NTNU) and in Europe (Denmark, Sweden, Russia, the UK, the EU's JOULE programme).

Weaknesses

- The size of the group appears to be small compared with the projects conducted;
- Insufficient interaction with other groups in Section 1;
- Insufficient strategic planning (one professor should be replaced soon).

Opportunities

- The group's location in the Research Park provides opportunities for external funding;
- The fields covered by the group (ionics, functional ceramics) will sustain growing importance with the development of chemical sensors;
- The reorganisation of the Centre for Materials Research and filling a vacant position at the professor level should provide a chance to strengthen the qualifications of the group and to increase its influence.

Threats

- The group does not get sufficient support from the Department of Chemistry;
- The funding for maintaining and renewing the equipment for surface testing (e.g. SEM, XPS/Auger, AFM) at the Centre for Materials Research needs to be granted on a long-term basis;
- Continuing erosion of the number of permanent staff members.

Recommendations

- Fill vacant positions by people able to strengthen the group's expertise;

- In high-temperature chemistry, the emphasis should be placed on the relationship between structure and properties. Some thought has been given to the development of a field between high- and low-temperature studies. This could represent an important addition to the expertise of the group;

- Strategic planning should be conducted with respect to the forthcoming new organisation of the Centre for Materials Research and increasing the interaction with the other research groups in Section 1.

Catalysis and Surface Chemistry

Basic Description

There has been some ambiguity concerning the official designation of the group. While the term "Catalysis and Surface Chemistry" has been used in the past, more recent descriptions of Section 1 (e.g. the strategic document of 4 March 1997) seem to prefer the name "Petrochemistry and Catalysis". A clear-cut decision on the official name of the group should be taken soon, and the chosen designation should then be used consistently.

The group is rather small, especially given the importance of its work and the relevance of that work to Norwegian industry. At present, the staff consists of one full professor (who is expected to retire within the next five years), one professor II (who has abandoned this position because he recently moved into a non-chemical position elsewhere), one associate professor and seven doctoral students.

Since its foundation in the 1980s as a direct consequence of Norway's prospering petroleum industry, the group has co-operated closely with scientists inside and outside the University of Oslo. Particularly intense and fruitful collaboration exists with the nearby SINTEF Applied Chemistry, with a group in Inorganic Chemistry and with Norsk Hydro, Norway's largest enterprise. Through such co-operation, the group has not only alleviated disadvantages stemming from its modest size, but gained access, as a whole, to an excellent assortment of materials, instruments and techniques. Being linked through Section 1 of the Department of Chemistry to the group in Inorganic Chemistry and Materials Science strongly enhances the group's access to advanced inorganic materials with a potential in heterogeneous catalysis; at the same time, this organisational feature inevitably brings about some disadvantages, for example, a certain remoteness from Physical and Organic Chemistry, whose theoretical background and techniques are vital for catalysis, surface chemistry and petrochemistry.

Research and its evaluation

The group has developed a remarkable skill in selecting highly topical research areas which are of considerable interest within the world-wide catalysis community while being most relevant to the domestic chemical and petroleum industries. This is true of the catalytic materials applied and the chemical reactions investigated.

The catalysts being studied are predominantly microporous materials. This is to be understood, in the broadest sense, as the generic term for zeolites, zeolite-like materials with a chemical composition different from aluminosilicates, and the recently discovered non-crystalline materials usually named M41S with an ordered channel system in the mesoporous range. Very recently, the group has been remarkably successful in the synthesis of novel microporous materials which were named after the University of Oslo (internationally accepted acronym: UiO). The materials UiO-6 and UiO-7 deserve particular mention as potential catalysts. Other thrust areas in the group are structure determination and the physico-chemical characterisation of microporous materials. The success and international reputation of the group in this area is clearly reflected by approximately 15 high-quality publications that have appeared in renowned, peer-reviewed journals within the past three years.

Among the catalytic reactions studied are the conversion of methanol to hydrocarbons (MTH), which includes methanol-to-gasoline (MTG) and methanol-to-olefins (MTO), the interconversion of various hydrocarbons and the manufacture of methanol from natural gas (either via synthesis gas or by the direct oxidation of methane). The general objective, as reflected clearly in recent publications, is to arrive at a fundamental understanding of the complex reaction mechanisms involved in catalytic processes of industrial importance. Studies of diffusion in the pores of MTO catalysts, mainly by means of NMR spectroscopic techniques, also play a role. In this area, too, the group has published continuously over the past five years.

Within the niches discovered and occupied by the group, it has acquired an indisputable world-wide reputation and established intense, long-lasting scientific contacts over the world. The co-editorship of one group member in the Proceedings of the Natural Gas Conversion Symposium, Oslo, 1990, made the University of Oslo even better known among scientists in a modern sub-field of heterogeneous catalysis.

SWOT Analysis

Strengths

- Intense co-operation with other groups inside the University of Oslo, research institutions in Norway and abroad, and Norwegian industry;
- Strong benefits from the excellent instrumentation available within the group or at partner institutions;
- Remarkable success of a very small group in the discovery and structure determination of new microporous materials;
- The group occupies attractive niches in heterogeneous catalysis;
- Strong international position in the science and catalytic application of zeolites.

Weaknesses

- No technicians available, hence professors waste part of their time on routine work;
- The group is somewhat too small, especially in view of the interdisciplinary nature of catalysis, surface chemistry and petrochemistry;
- Remoteness from Organic and Physical Chemistry;
- High-quality students are somewhat reluctant to join the group, in part because they consider the research topics to be "too applied".

Opportunities

- SINTEF Applied Chemistry should be encouraged to outsource more basic research in catalysis to the group;
- Norwegian industry might change its research policy somewhat, e.g. a shift towards discovering the need for fundamental studies in heterogeneous catalysis;
- Intensified teaching in catalysis at the University of Oslo.

Threats

- Declining acceptance of the group by chemistry students;
- Insufficient funding for software, while more and more techniques of importance to the group rely on advanced computer programmes.

Recommendations

- Encourage the group to continue and intensify its search for novel microporous materials;
- Make sure that the professorship becoming vacant within the next five years is occupied by a renowned scientist with a strong background in studying catalytic reactions, kinetics, and mechanisms;
- Encourage the group to extend its catalytic equipment to high-pressure apparatuses;
- Enhance the role of teaching in the chemistry curriculum.

3.3.1.2 Section 2: Organic Chemistry

The primary focus of the research is on *synthetic organic chemistry*, *organometallic chemistry* and *physical organic chemistry*. Among the main areas are heterocyclic chemistry, carbene chemistry, medicinal chemistry (anticancer and anti-HIV drugs, cell proliferation-regulating molecules and antioxidants), agricultural and forestry related chemistry (synthesis of pheromones and plant growth hormones), metal catalysts in organic chemistry, synthesis, physical and reactivity studies of organometallic compounds and synthesis of new catalysts in polymer chemistry. The conformational analysis of cyclic systems has been a target area in physical organic chemistry. Reaction mechanisms are being studied in solution and in the gas phase, the latter in collaboration with the group for Theoretical Chemistry. The section has laboratories for advanced mass spectrometry and NMR spectroscopy.

Basic description

The section is active in the field of research, placing special emphasis on synthesis, including small target natural products combined with synthetic methodology, especially organometallic and heterocyclics. Other significant activities concern applications of NMR spectroscopy applied to special biological effect molecules and electrochemical methods applied to organometallics, as well as studies of reaction pathways and mechanisms. One relatively minor activity involves carbohydrate chemistry. There are other studies on thiophene chemistry and on analyses within environmental chemistry.

The section includes a group which works on gas phase ion chemistry and focuses on the application of mass spectrometry to physical-organic problems.

Research and its evaluation

The panel met with four members of the section. Unfortunately, three staff members were away on sabbaticals or examining duties and two, who are soon to retire, chose not to participate.

An overview of the section's structure and research activities was presented by the elected head of section. It is clear that there is world class research output from this section in the area

of synthetic organic chemistry, particularly of target natural products and methodology. The methodology group is the largest (currently 10 doctoral, 10 post-doctoral fellows and five graduate students). Unfortunately, one professor will retire in four years and the retirement of another is imminent.

The NMR group is carrying out its own research within the areas of organometallic reagents and heterocycles of biological significance, as well as providing valuable specialist backup for colleagues from other parts of the department, Pharmacy, the Agricultural University and other outside bodies. Unfortunately, the panel did not get the chance to meet the most recently appointed staff member and to ascertain her research plans and aspirations.

The section is vulnerable, especially because of the approaching retirement of its most distinguished and active researchers.

The gas phase ion chemistry is based on state-of-the art equipment. It is also concerned with important problems in physical organic chemistry, is productive and has good prospects for the future. The group has a clear focus, is well-managed, well-equipped and involved in a range of significant international collaborative projects.

In the view of the panel, the professors form a good team on which to base future developments.

SWOT Analysis

Strengths

- High international visibility in many areas;
- Good publication rate in highly respected journals;
- Strong instrumentational base and support staff;
- Good examples of cross-disciplinary collaboration;
- Significant and increasing international collaboration;
- Encouraging number of foreign visitors and collaborators.

Weaknesses

- Lack of succession planning and strategy;
- Inflexible system for dealing with changing patterns of demand for spectroscopic services, especially NMR;
- No regular seminars, e.g. with outside speakers, or group meetings;
- No obvious enthusiasm for taking advantage of targeted research programmes which entail funding (e.g. by the Research Council).

Opportunities

- Imminent retirements allow the group the opportunity to build on its already established world-wide reputation in synthetic organic chemistry;
- To develop closer links with natural products chemists (synthetic and structural) in pharmacy, thereby strengthening collaboration at the chemistry/biology interface.

Threats

- The present strong reputation could rapidly evaporate unless action is taken immediately;
- The research output is dependent on the retention of skilled technical assistance. Recruitment and training of junior technical staff could guard against this.

Recommendations

- As a matter of urgency, formulate a succession plan so that there is continuity in the world-class effort in synthesis. This may well mean ear-marking a vacancy soon and taking time to fill it, possibly by head-hunting;

- Similarly, guard against loss of skilled technician support for research services, especially those in NMR and mass spectrometry;

- Seek a more formal connection with the organic chemistry community in pharmacy;

- Introduce a programme of regular group meetings and seminars, bringing in outside speakers. Attendance should be expected by all members of the Organic section, regardless of speciality. This would help build an enthusiastic and mutually encouraging group of organic and physical organic chemists of significant size. The leaders of individual research groups would have to lead by example.

3.3.1.3 Section 3: Physical Chemistry

The Theoretical Chemistry group is involved in the development of new quantum chemical computational techniques. In polymer, colloid and surface chemistry, the group is engaged in synthesis, characterisation and theoretical studies of polymers as well as in the measurement of their physical properties. Gas phase electron diffraction is used for the determination of molecular structures with special regard to bond distances and co-ordination geometry. The spectroscopy group is involved in solid phase NMR studies (structure and dynamics), vibrational spectroscopy (IR/Raman, studies of chemical reactions in the atmosphere) and microwave spectroscopy (conformational analysis and intramolecular hydrogen bonds). Using single crystal X-ray diffraction, crystal structure determination is carried out for biologically active compounds (potential drugs, natural substances and peptides) and the properties of hydrogen bonds. The structural determination of organic and inorganic compounds is carried out in co-operation with researchers from other sections.

Theoretical Chemistry

Basic description

The staff comprises two professors, one of whom is serving as Pro-rector of the University of Oslo. At present, a Dr. scient. holds the temporary full time substitute position, made available by the original professor's election as a Pro-rector. In addition, the group includes three doctoral students and four graduate students.

Research and its evaluation

The group's activities are centred on the development of new models and computational methods which can lead to an improvement in the theoretical description of the chemical and physical properties of molecules. Most of the computations are performed on the central supercomputers. Available computer time does not appear to limit research activities.

The main emphasis of the group is on developing methods for first principle computations of different molecular properties. The aim is to develop a set of black box programmes that can be used for this purpose. In addition, the group is involved in studies of specific chemical problems.

The group is part of an extensive national and international scientific network. As a result of its international collaboration, the group has developed three major programme packages which can be used for the theoretical *(ab initio)* calculations of several molecular properties. The programmes have now been publicly released.

The achievements of this group are internationally recognised. Despite the uncertainty of its staff situation, the group has maintained a high publication rate.

SWOT Analysis

Strengths
- High-level expertise in developing programmes and offering new tools to chemists;
- The group attracts good students and is staffed by active, young scientists;
- Several national and international collaborative efforts;
- Access to sufficient computing facilities.

Weaknesses
- Except for computing time, the financial situation of the group within the Department of Chemistry is not strong due to overly complicated administrative procedures;
- The group has no post-doctoral fellows from outside its ranks.

Opportunities
- The release of group's proprietary programmes will increase the group's audience and attract new collaboration;
- Well-equipped Norwegian computing centre.

Threats
- The future of the professor who is serving as Pro-rector is uncertain;
- The teaching of theoretical chemistry could be replaced by thermodynamics on student curricula;
- The growing availability of user-friendly quantum chemistry packages;
- The development of the Norwegian central computing facilities is uncertain after 1998.

Recommendations

- More interaction with experimental groups at the Department of Chemistry;
- Hire a post-doctoral fellow who specialises in dynamics.

Spectroscopy

Basic description

The staff comprises three professors (one of whom is close to retiring), one senior professor, one associate professor, one senior engineer, one research technician, one part-time engineer (50%), five undergraduate and 12 doctoral students. In addition, the group benefits from collaboration with one or two visiting scientists.

The research activities are divided among three subgroups: a) *NMR spectroscopy, b) microwave spectroscopy* and *c) vibrational spectroscopy:*

a) The NMR staff consists of one professor (retiring within six years), one research technician (part-time) and four doctoral students. The group, which has recently obtained a new NMR spectrometer, focuses on four projects: *(i) the determination of the pore structure in cement* (in collaboration with groups at NTNU and the Norwegian Building Research Institute (NBI)), *(ii) the study of the diffusion properties of small organic molecules in microporous systems* (zeolites) (in collaboration with the catalysis group in Section 1), *(iii) the characterisation of polyolefins in solution and in solid state* (in collaboration with SINTEF Oslo) and (iv) *the determination of organic intermediates in oscillating reactions* (in collaboration with a group at Stavanger College).

In addition, one professor focuses on chemistry education projects, writing textbooks and manuals, and producing multimedia material in general chemistry.

The NMR group has fruitful co-operation with the Catalysis group in Inorganic Chemistry and with SINTEF Oslo, which provides requisite access to unique materials which have been thoroughly described using other methods. The group also collaborates closely with the NMR group in Organic Chemistry on software development and implementation.

b) The Microwave group consists of one professor, one associate professor, one graduate student and one guest scientist. The group has developed its own specific instrumentation and is pursuing several research projects. The field in which the group has published the most articles is the investigation of intermolecular hydrogen bonds and their influence on the conformational and dynamic properties of the molecules. Other projects include unravelling the influence of one or more fluorine atoms on conformational properties, the structure and dynamics of amides, the conformational properties of 4- and 5-membered rings and the rotational isomerism of molecules with heteroatoms.

c) The Vibrational Spectroscopy group consists of one professor, one senior professor, one associate professor, one guest scientist, one researcher, three graduate students and six doctoral students.

The group is large and possesses high quality instrumentàtion in UV-vis, FTIR, and mass spectrometry. Current research interests include nine different projects, ranging from studies related to atmospheric, stratospheric and interstellar chemistry to investigations pertaining to protein secondary structure, *in situ* studies of catalysts and conformational equilibria of organic molecules. The first group of projects covers laboratory studies and the modelling of heterogeneous chemical reactions and molecule-radical reactions, the investigation of aerosols and heterogeneous nucleation, the application of high resolution spectroscopy to stratospheric chemistry, and vibrational studies of a substitute for the chlorofluorocarbons presently in use. Most of these projects are conducted in collaboration with Norwegian and European departments or industrial enterprises.

Research and its evaluation

The groups maintain excellent experimental skills in their respective fields, despite a large number of research projects (20 for 25 academic staff members, technicians and students). Instrumentation is of high quality and is operated by talented staff members. Unique instrumentational set-ups, for instance, in the Microwave and Vibrational Spectroscopy groups, have been assembled, thanks to the expertise of the workshops at the department level. Two of the groups appear to be somewhat sub-critical, given their national importance (solid state NMR, Microwave Spectroscopy). The group for Vibrational Spectroscopy is the largest, and is particularly active. It has initiated numerous collaborative efforts and work in fields which attract students (atmospheric chemistry).

SWOT Analysis

Strengths

- Two of the groups are the only Norwegian laboratories active in their respective techniques (solid state NMR, Microwave Spectroscopy) ;
- High quality instrumentation and strong expertise in building specific instrumentational set-ups (Microwave Spectroscopy, Vibrational Spectroscopy) ;
- Many collaborative efforts with Norwegian and European laboratories and industrial partners;
- One group (Vibrational Spectroscopy) attracts good doctoral students.

Weaknesses

- Two of the groups appeared to be understaffed, both at academic and student levels, considering their specificity in Norway (NMR, Microwave Spectroscopy);
- Recruiting students is not an easy task given the triple background needed (mathematics, physics, chemistry);
- Little interaction among the three groups or with other groups within the Department of Chemistry.

Opportunities

- Positions will become vacant in the near future;
- The prospects for developing new collaborative projects are good;
- Renewed interest in microwave spectroscopy and techniques.

Threats

- Lack of money for buying expensive instrumentation (in the NOK 2 to 4 million range);
- Continuity is difficult to maintain when doctoral students leave;
- Good basic research projects are difficult to finance;
- The groups appear somewhat isolated within the Department of Chemistry.

Recommendations

- The Department of Chemistry should support the efforts of the groups to find adequate financing for equipment which needs to be renewed or acquired (molecular beam instrument, multi-channel Raman spectrometer with tuneable laser);

- Basic training in spectroscopy (at the theoretical and practical levels) should be maintained in the student curriculum;

- Strategic thinking should include questions about the location of the NMR group (it might be wise to increase collaboration with Inorganic Chemistry and the development of Microwave Spectroscopy technology).

X-Ray Diffraction

Basic description

The group comprises one professor, two associate professors, one senior professor, one research technician, four graduate students and one doctoral student. One professor formally appointed by the Institute of Pharmacy is also a member of this group.

Research and its evaluation

Single crystal X-ray diffraction experiments are the common basis for the research conducted by this group. It experienced a significant improvement in its experimental facilities in the autumn of 1996, when an old unreliable diffractometer was replaced by a modern state-of-the-art instrument equipped with a CCD detector.

The research traditions of the group originated in the pioneering work performed by Nobel Prize winner Odd Hassel. At present, research interests range from systematic studies of intermolecular interaction in crystals containing smaller molecules to structure determinations for macromolecules.

Whereas the group is recognised for its achievements in the study of smaller molecules, complemented by database searches, *ab initio* calculations and conformational analyses, their studies of macromolecules are still in the preparatory state, meaning no specific projects were presented. The success of this new activity is heavily contingent on the collaboration with groups of biochemists and biologists at the University of Oslo.

With the new diffraction equipment, it is possible to collect the data needed for an accurate structure determination in less than a day. Though the increased potential of this instrumentation is to some extent used by other chemists in the department, it also places additional demands on the staff of the group.

The general standard of the structure determinations performed by the group is high. This is to a large extent attributable to their experience with low-temperature data collection. Though the group is aware of the potential of synchrotron radiation, it has not yet become heavily engaged in the activities at the Swiss-Norwegian beam line at the European Synchrotron Radiation Facility (ESRF). The group shows a good publication record.

SWOT Analysis

Strengths
- Excellent experimental facilities and competent technical staff;
- Expertise in the collection of high quality diffraction data;
- Expertise in the use of databases and theoretical calculations that complement diffraction studies.

Weaknesses
- Very unfavourable age distribution; four of the permanent staff members are over the age of 60;
- Little interaction with other groups at the department;
- Small number of graduate students.

Opportunities
- New equipment with increased data collection capacity;
- Serious involvement in studies of macromolecules in collaboration with biologically-oriented groups.

Threats
- If vacant positions are not filled, the group will fall below critical size;
- Routine structure determinations could come to predominate the research activities.

Recommendations

- The staff should be maintained at a minimum of three permanent positions to make adequate use of the new equipment;

- The group should be encouraged to exploit the potential of synchrotron radiation through grants to doctoral students and post-doctoral fellows;

- Positive results with respect to the crystallisation of macromolecules should be a prerequisite for the strengthening of research in protein crystallography.

Polymer, Colloid and Surface Chemistry

Basic Description

The staff consists of three full professors, one associate professor, five graduate students and four doctoral students.

The laboratory facilities are good. Instruments which are at the group's disposal include those for static and dynamic light scattering, multi-angle time-resolved light scattering, zeta potential determination and axial-symmetric drop shape analysis. Furthermore, a rheometer, a gel permeation chromatograph, a microscope for image analysis, a Langmuir surface balance, an NMR spectrometer with a diffusion probe head, a disc centrifuge and a gamma-counter are available. The combination of polymer and colloid chemistry is unique in Norway and is reflected in both research and teaching. However, the lecture courses are not compulsory in chemistry education at the University of Oslo, and they have won only limited acceptance.

In summer 1995, the group attracted international attention by organising, for the first time, an international symposium on "Associating Polymers" in Loen, Norway. About 80 participants from numerous countries took part in this symposium, which was generally considered a remarkable success. It has been decided to continue with meetings on this topic, and the second symposium in the series will take place 1997 in France.

While all four professors were present at the meeting with the two panel members, the panel gained a limited amount of information on and insight into the group due to poor preparations for the meeting.

Research and its evaluation

The research activities centre around various physico-chemical topics related to polymers and colloids. Among the problems studied are the conformation, structure, dynamics and viscoelastic properties of polymers in solution and in gels, the statics and dynamics of polymer solutions, modelling of gel formation and the association of hydrophobic polymer chains, the dynamics and diffusion of polymer chains in connection with the transition from sols to gels, the conformation and dynamics of polymer films at air/water and oil/water interfaces, mass transfer of surface active substances between water and model oils, the characterisation of the surfaces of solid polymer particles and various kinetic and mechanistic questions related to emulsion polymerisation.

Several of these topics entail considerable potential for the domestic industry and questions related to the production of oil in marine environments. There is probably room for closer co-operation between the group and relevant industries in Norway and abroad.

As a whole, the group has a good publishing record over the past five years. A considerable proportion of their recent papers have appeared in internationally renowned, peer-reviewed journals. For unknown reasons, however, one faculty member virtually ceased to publish in 1992.

SWOT Analysis

Strengths
- Combination of polymer and colloid science unique in Norway;
- One of the few research groups with a clear focus on basic polymer research;
- Above average publication rate for the group as a whole.

Weaknesses
- Unsatisfactory integration into the Department of Chemistry;
- The lack of technical staff absorbs part of the group's time on mundane activities;
- Relatively few undergraduate and doctoral students;
- No clear leadership or research strategy within the group.

Opportunities
- Active relationships should be intensified with relevant industries.

Threats
- Ongoing and accelerating separation from the Department of Chemistry.

Recommendations

- Promote integration of the group into the Department of Chemistry wherever possible (e.g. catalysis, surface chemistry, spectroscopy, organic chemistry);

- Take measures to encourage enhanced interaction between the group and Norwegian or European industry (e.g. consulting, continuing education of industrial employees in the fundamentals of polymer chemistry).

Electron Diffraction

Basic description

The group comprises three professors, one associate professor and two research technicians. At present, three doctoral students and three Russian visitors are conducting research in the group.

Research and its evaluation

Together with the group in Trondheim, this group constitutes the "Norwegian Electron Diffraction Group". The equipment and associated measurements are all conducted in Oslo where competent technical assistance is available.

Gas phase electron diffraction has strong and long traditions in Norway. The Norwegian group is the only one in the Nordic countries with this research expertise. On a world-wide basis, there are 10 to 15 groups performing gas phase electron diffraction experiments.

Experiments limited to systems which can be studied in the gas phase are performed almost exclusively to obtain information on the structural chemistry. The group does not possess expertise in chemical synthesis, which limits its investigations to systems that are available commercially or are a result of co-operation with other research groups. This has led to extensive international collaboration. The group took the initiative to establish the European Symposium on Gas Phase Electron Diffraction.

The systems investigated cover a fairly wide range, from organometallic and inorganic to organic compounds. The experimental studies are frequently supplemented by *ab initio* calculations. Interaction between this group and other groups in the department is very limited and it appears the equipment has some available capacity.

Despite this, the group has only attracted a very limited number of graduate students.

SWOT Analysis

Strengths
- Much experience collected by studying an unusually broad range of compounds;
- Technical expertise and skill accumulated in a demanding field of experimental physical chemistry;
- The group is part of an extensive international research network.

Weaknesses
- The age distribution within the group;
- Old equipment;
- No expertise in constructing up-to-date equipment;
- Little expertise in electronics;
- Pronounced difficulties in attracting students.

Opportunities
- Including results from a few other experimental techniques would enhance the group's scientific potential.

Threats
- Unforeseen breakdown of existing equipment;
- Leading international role is likely to disappear in the event of a significant reduction in staff size.

Recommendations

- Take a political decision at the national level regarding whether or not research based on gas phase electron diffraction should be maintained in Norway at the international level.

In case it is decided to maintain gas phase electron diffraction in Norway:

- Make sure that no significant staff reductions take place;
- Ensure that the group has the latest equipment at its disposal;
- Recruit a person with a professional background in adjacent scientific fields (physics and electronics) who can contribute to the proper design and construction of modern apparatus;
- Provide the necessary funding for building the appropriate equipment.

3.3.1.4 Section 4: Analytical, Nuclear and Environmental Chemistry

Within metal speciation analysis/trace element analysis, the group is engaged in inductively coupled plasma atomic emission spectrometry (ICP-AES), slurry sampling in electrothermal atomic absorption spectrometry, and inductively coupled plasma mass spectrometry (ICP-MS coupling of electrothermal vaporisation/hydride generation with ICP-MS and with liquid chromatography/capillary electrophoresis-ICP-MS). The chromatography group is working with electrochromatography, capillary electrophoresis, liquid chromatography, high temperature liquid chromatography (HTLC), supercritical fluid chromatography (SFC) and supercritical extraction, light scattering detection, mass spectrometry (GC-MS, SFC-MS), radiofrequency modulated plasma atomic emission and RF-plasma atomic ionisation-MS related to industry, environmental chemistry and medicine.

In nuclear chemistry, the group is involved with the separation of exotic elements by solvent extraction (SISAK), on-line mass separation for studies of short-lived nuclei (ISOLDE), nuclear spectroscopy (OSIRIS), active compounds (especially ^{211}At) in cancer therapy and radio-analytical chemistry.

In environmental chemistry, the group is engaged in the long-distance transport of air pollution and the effects thereof (with special regard to acid precipitation and metals in soil and water). In collaboration with the Centre for International Climate and Environmental Research (CICERO) in Oslo , cost-benefit analyses are being developed with the aim of reducing pollution.

Analytical Chemistry

Basic description

The section consists of two teams which do research on analytical chemistry, based on problems involving organic and inorganic compounds. The organic team consists of two professors, as does the inorganic team. An impressive number of modern techniques has been researched and applied to an equally impressive number of analytical problems which currently includes the examination of DNA fragments, novel polymers, speciation of trace metals, foodstuffs and beverages, and of environmentally important samples. One important

function of the group is that it is the leading group in Norway as regards the production of graduates in analytical chemistry at the graduate and doctoral levels.

Research and its evaluation

The panel met with two professors. The organisation of the small group, its staffing, and distribution of doctoral and graduate students was outlined and both professors gave accounts of their own current research. It became clear that this was an active and enthusiastic part of the Department of Chemistry and that it was attractive to students and involved in significant collaboration with colleagues from other sections, including an active "Strategic Programme" in polymer chemistry. There is also clear evidence of international recognition. There is significant demand for graduates trained by this group, but it appears that the number admitted onto the graduate programme will have to be curtailed in future. This is a consequence of the demands placed on staff time, on equipment and on funds to meet everyday running costs. The department's method for allocating consumables and money for equipment does not benefit an activity growing as fast as this one has; requests are passed through a central committee and there are no "up front" allocations. There are good external contacts and a high proportion of the graduate students are working on projects in outside laboratories with external supervisors. This is financially beneficial, but it is perceived that such work is not always equally scientifically rewarding.

There was a clearly expressed intention to maintain a good balance between development (more basic research) and applied research. There is a healthy desire to move into new areas. For instance, the group is working more and more on problems of biological importance. The panel raised the possibility of expanding the group through more interaction with the rather less visible bioanalytical group in Pharmacy. The panel was again reminded of the inertia in the Norwegian system and the difficulty in moving or creating positions in response to developments.

The panel also wanted to gauge the independence of the two assistant professors who were not present. They have distinct areas of research within organic and inorganic analysis, and they publish as individuals as well as in collaboration with their senior colleagues. Nevertheless, this group is vulnerable to the loss of one or both of its energetic, enthusiastic leaders.

SWOT Analysis

Strengths

- Enthusiastic and scientifically ambitious leadership;
- Maintains a high level of research activity; prolific and enjoys international recognition;
- Leading group in Norway training graduate and doctoral candidates in analytical chemistry;
- Steady supply of good students who are in demand after graduation;
- Cutting edge research in a considerable variety of analytical methods;
- Reasonably well funded and equipped;
- Good external contacts;
- Good internal collaboration.

Weaknesses

- Only two faculty members in each group, therefore not possible to exploit new opportunities; not all aspects of the subject covered.

Opportunities

- Expand into other relevant areas, e.g. environmental analytical chemistry;
- Develop further the work relating to polymer chemistry;
- Be involved in even more multidisciplinary research.

Threats

- Given the size of the group, its success is dependent on too few people. There is no succession planning and, although good, it is not obvious that either of the two assistant professors could yet maintain the excellence of the group as a whole.

Recommendations

- Recognise the strength of the activity in analytical chemistry in the Department of Chemistry's Strategic Plan and seek the means to increase its size. The group could usefully incorporate the bioanalytical group from the Institute of Pharmacy and take the lead in aspects of environmental chemistry;

- Modify the department's present budgetary arrangements to accommodate successes such as the rapid growth of this group. It cannot be good, for either research or morale, that a significant number of graduate students with good job prospects have to be turned away because of inflexibility in the financial arrangements.

Nuclear Chemistry

Basic description

The group is involved with the separation of exotic elements by solvent extraction, on-line mass separation for studies of short-lived nuclei, nuclear spectroscopy, α-active compounds in cancer therapy and radioanalytical chemistry.

The staff comprises two professors, one senior professor (who will retire by July 1997), one associate professor, 12 graduate and three doctoral students (two other doctoral students are scheduled to start in spring 1997).

Research and its evaluation

The research activities are divided among four projects:

a) SISAK

The SISAK project, supported by the Research Council of Norway, is a system for the rapid chemical separation of elements using liquid/liquid extraction in high-speed centrifuges. SISAK has been developed in collaboration with nuclear chemists in Sweden, Germany,

Switzerland and the United States. It is presently being installed on the cyclotron in Oslo. The system is used for the separation of short-lived radionuclides prior to spectroscopic investigations and to study the chemical properties of the heaviest transuranium elements.

b) ISOLDE and OSIRIS
The group has implemented a chemical method using CF_4 and allowing the production of radioactive molecular ion side-bands for several elements. This facilitates the production of pure mass-separated beams. The work is done in connection with the ISOLDE facility at CERN in Geneva. The group is actively involved in four different experiments: the study of octupole distorted actinide nuclei, the development of new radioactive beams, the investigation of single-neutron states in ^{133}Sn and the production of neutron-rich isotopes of Bi, Pb and Tl. There is also collaboration with the mass separator facility OSIRIS in Studsvik, Sweden, for the study of neutron-rich and short-lived nuclei.

c) Cancer therapy
Over the past five years, the group has been producing and testing α–active compounds intended for cancer therapy, in collaboration with the Norwegian Radium Hospital and close contacts with groups at Duke University and Bethesda Hospital. The nuclei used are ^{211}At and ^{212}Bi, which are inserted into monoclonal antibodies and into small molecules with affinities for different types of tissues (e.g. bone seekers).

d) Environmental chemistry
Methods have been developed for the pre-concentration and separation of plutonium in sea water and for ^{210}Po analysis. Although relatively small, the Nuclear Chemistry group has developed unique methods that have been implemented by large nuclear facilities in Norway and in Europe. The group receives sufficient financial support from the Research Council of Norway and publishes papers in well-refereed journals. It has, however, proved difficult to finance medium-size projects and to attract outside money (for instance, the production of sources of ^{211}At for therapy requires a modification of the Oslo cyclotron which will cost about NOK 2 million). The group maintains international collaboration and has access to the main European facilities. The projects related to SISAK, ISOLDE and cancer therapy appear to be the most worthwhile.

SWOT Analysis

Strengths
- Availability of a production facility for radionuclides and of laboratories dedicated to the handling of radioactive samples (Class B);
- High-quality research results in nuclear chemistry and physics;
- High-performance instrumentation can be developed thanks to existing workshops (e.g. centrifugation system in SISAK project);
- Collaboration gives access to large-scale facilities (CERN, Duke University) and to medical partners (cancer therapy);
- This is the only centre in Norway which educates students in radiochemistry; the laboratory attracts good students.

Weaknesses

- No funding from industrial or medical partners;
- Difficulty in getting beam time on large facilities due to strong international competition;
- A small number of permanent staff members, each working on different projects;
- The group has difficulty in attracting financially self-sufficient post-doctoral fellows, despite the presence of unique research facilities.

Opportunities

- Clinical applications offer interesting perspectives;
- Several spin-offs could emerge from the development of sensitive analytical instrumentation (SISAK project) ;
- The filling of a vacant position will strengthen the permanent staff.

Threats

- Basic chemistry courses do not include radiochemistry. In the long run, this could render student recruitment more difficult;
- The research activities depend on a cyclotron belonging to the Department of Physics: its maintenance does not depend upon the Nuclear Chemistry group;
- Experiments have to be planned and prepared far in advance and the group has no influence over the long-term strategy for some projects (ISOLDE, cyclotron);
- The lack of doctoral stipends weakens the research potential.

Recommendations

- The group should concentrate on the more prominent projects it is currently conducting and should try to strengthen them;

- The skill developed in some projects (SISAK, cancer therapy) should be used to attract industrial and medical partners willing to finance parts of the projects. In particular, the possibilities available through EU-sponsored programmes, which are not exploited at all, should be explored (the 5^{th} framework programme);

- The vacancy which will soon arise in the permanent staff should be filled with the above recommendations in mind.

Environmental Chemistry

Basic description

The group currently has only two full-time employees, both at professorial level. In addition, a professor of Occupational Hygiene with strong medical and toxicological background formally belongs to the group, although there appears to be no research co-operation with the others. The activities of the group's leader are divided between the group (80%) and CICERO (20%).

Research and its evaluation

The main research activity, in which the group has years of experience, involves investigation into the acidification of soil and water. In addition, due to strong ties with CICERO, the group studies the damage caused by pollution and environmental policies. International co-operation is an important, if not pre-dominant, component of the studies. This is demonstrated by co-operation with four groups in Poland, five in China and five in other countries (Hungary, Germany, the USA). From the ongoing research programmes, it appears that the focus of research has now been moved from Europe (three projects) to China (four projects).

The group members have carried out some pioneering studies of acid rain and related phenomena. More recently, they have also studied other important environmental problems, such as mercury translocation and evaporation from the soil. They have also continued to study aluminium. In many instances, pollution and measures to reduce it have been evaluated with models.

In summary, the group's research activities have closely followed the main stream of environmental chemistry as far as topics are considered. Understandably, the emphasis has been on the inorganic side, although, more recently, organic matter and its interaction with metal and other species have also been discussed.

Considering the size of the group, its publication activity is acceptable although strictly scientific papers in refereed journals are not many, when counted on a *per annum* basis.

SWOT Analysis

Strengths

- Long-term experience in environmental projects;
- Comprehensive approach to problems: from field data collection to the implementation of corrective measures;
- Good supply of motivated students who find jobs relatively easily;
- Adequate equipment for chemical analyses and the skills to use it;
- Pioneers in teaching environmental chemistry at university level (since 1974);
- Good international contacts with research partners;
- No significant overlapping with other laboratories in Norway.

Weaknesses

- Group too small for all interdisciplinary tasks;
- Funding of interdisciplinary work sometimes difficult.

Opportunities

- Problems and projects will continue to be available;
- Level of sophistication in environmental analytical chemistry can be raised from qualitative to quantitative (speciation).

Threats

- Some equipment (AAS) will require replacement in the near future.

Recommendations

- Co-operate more closely with the Analytical Chemistry group for the purpose of specifying environmental species;

- Apply the expertise gained on projects in Poland and China to pollution problems in neighbouring countries (Russia) in co-operation with other groups;

- In general, considering the size of the group, its teaching obligations and limited resources, it would be advisable to focus on fewer projects.

School Chemistry

This is the smallest of the 14 groups which form the Department of Chemistry at the University of Oslo. The group consists of one associate professor with a background in organic chemistry, mass spectrometry and analytical chemistry, one temporary staff member and three graduate students. There is intense co-operation with a group at the Department of Teacher Education and School Development at the University of Oslo, resulting in a group overall size of about 10 people. This creates a good situation for internal discussions on all questions related to chemistry education at Norwegian schools. Among the group's main activities are training and advising chemistry teachers, e.g. on how to equip school chemistry laboratories. Research projects focus on the development and optimal use of molecular models for teaching chemistry in schools, the evaluation of the topics used on examination papers over the past 10 years, new ideas for modernising chemistry textbooks and the proper introduction of electronic media for teaching chemistry at schools.

The group has obviously been able to acquire considerable external funding, e.g. by developing teaching materials and making videos for sale. This enables the group to cover the cost of equipment and travel, e.g. for attending relevant meetings and exchanging ideas with researchers in chemical education at other Norwegian or Scandinavian universities.

As a whole, the group has strong roots in and close connections to chemistry research. At the same time, it is clearly above the critical size required for creative discussions and problem solving. The panel understands that, thus far, the results of the group's research have been published exclusively in Norwegian journals. Regular publication activities at the international level, e.g. in the *Journal of Chemical Education*, seem to be within the range of possibilities and remain desirable. However, the panel came to the conclusion that the group fulfils important tasks in the Norwegian educational system. The group represents an efficient link between one of the major universities and the domestic school system in the field of chemistry. Its international standing could, perhaps, be strengthened.

3.3.2 Institute of Pharmacy
(Chemistry-related activities)

The institute is part of the Faculty of Mathematics and Natural Sciences and educates about 280 students annually in the field of Pharmacy (cand. pharm.) and some cand. scient. and doctorates. There are 56 employees, divided between 14 professors, 15 associate professors and 27 in other positions. Twenty-three other people were associated with the institute through various types of grants, including doctorates. The institute is led by a head and a Council, and is organised into six sections, each led by a section head.

Part of the institute works in the field of chemistry, and has been selected for this review. This is: a) the section of Pharmacognosy, b) the section of Drug Analysis and c) the section of Medicinal Chemistry. Key figures for these units are given in the Table 3.4, and further details of the research are presented below.

Table 3.4. Key figures for the individual sections

Parameters	Pharma-cognosy	Drug Analysis	Medicinal Chemistry	Total for the sections
Professors	4	4	4	12
Associate professors	1	0		2
Other scientific positions				
Research assistants				
Non-scientific positions	2	2	1	5
Dr. scient.	9[1]	2	3	14
Graduate students	4	9	7	16
[2)]Total University budget Running expenditures Univ.	0.54[3]	0.35[4]	0.34[5]	[6]
[2)]External funding	0.4[7]	0.4	0.2	[8]

1 Of which three are external students
2 In MNOK
3 Includes at least MNOK 0,25 to cover running costs in connection with teaching and general expenditures
4 Includes at least MNOK 0.1 as for [3]
5 Includes approx. MNOK 0.05 in general expenditures
6 Not given, as the sums contain expenditure on research, teaching and other running costs
7 Includes the EU account with money to be shared with other partners in the network. It also includes funding for salaries
8 Not given due to problems given under [7]

Basic description

The Institute of Pharmacy is divided into several sections. Activities in pharmacognosy, drug analysis and medicinal chemistry were reviewed. In pharmacognosy, major activities include studies of glycoproteins from plants with traditional uses as wound healers, ethnopharmacological studies and investigations of polyphenols, radical scavengers and antioxidants. Bioanalytical research is concentrated around drug analyses, forensic analyses and quality control with some effort invested developing instrumentation. The section of Medicinal Chemistry specialises in contrast agents for medical imaging. In some cases, the programmes rely heavily on the Department of Chemistry for key instrumentational facilities.

Research and its evaluation

The panel met with representatives from each of the sections. One professor described the group's work on glycoproteins, emphasising the importance of overseas collaboration, including an EU network of which she is co-ordinator. Including collaboration and part-time personnel, the group has five doctoral and four graduate students. Another professor presented his activities in the area of flavonoids and other phenolics with emphasis on arachidonic acid metabolism. His group consists of one doctoral and one graduate student. Another professor who has only recently joined the section was present, but one who is soon to retire chose not to attend. The research of this group is clearly worthwhile and well-regarded. Nevertheless, the researchers felt disadvantaged in seeking funds to support their activities falling, as they do, between chemistry and medicine. In the panel's view, there was sound basic chemistry in what was presented.

Bioanalytical chemistry is more of a problem. It is a small group with only two doctoral students and six at graduate level. As discussion proceeded, it became difficult for the panel to appreciate why this group is separated from the strong analytical group in the Department of Chemistry. The panel met with three professors, while the fourth member of the section had earlier indicated his unwillingness to co-operate in the evaluation process. However, judging from his publication record, as given in the department's Annual Report, he is not significantly research active. Three presentations were given and, particularly from the younger people, the panel received the impression that the group is doing competent development work using advanced separation methods on samples of considerable medical and forensic interest. There appear to be opportunities for commercial exploitation of the expertise and facilities of this group but, as it stands, they are gaining little from their outside contacts.

Medicinal chemistry was represented by three professors, while one professor was absent and did not make any information available. It appears that the latter has not produced any scientific publications over the years. This is a strong section, with a leading position in the development of contrast agents for medical imaging. Opportunities for commercial exploitation seem significant, and the university should seek to benefit from this. The unit is well supported by the crystallographic expertise of one of the professors and the advent of the Department of Chemistry's new diffractometer. The group's leader demonstrated clear leadership qualities.

SWOT Analysis

Strengths

- Multidisciplinarity in the case of pharmacognosy;
- Leaders in the fi ld of medical imaging.

Weaknesses

- Too broadly based (bioanalytical and pharmacognosy) and a lack of identity with the Norwegian research community;
- The units are below critical size;
- Probably carrying two staff members who are not active researchers;
- Low level of funding for equipment and consumables. An apparent lack of motivation to seek external support;
- No evidence of regular group meetings or joint seminars featuring outside speakers.

Opportunities

- Many possibilities for raising funds through the commercialisation of inventions, sale of services and applications to sources such as medical charities;
- Work more effectively, possibly formally, with strong groups in the Department of Chemistry.

Threats

- The vulnerability inherent in small size.

Recommendations

- Increase the size of the research units by merging or establishing closer affiliations with corresponding activities in the Department of Chemistry;
- Participate fully in the Department of Chemistry's Strategic Plan;
- Use vacancies from expected retirements, and possibly from the loss of inactive staff, to introduce high calibre staff from the outside with proven track records in research and fund raising.

3.4 University of Tromsø

3.4.1 Department of Chemistry

The university was established in 1968, and the Department of Chemistry was set up in 1972. The three groups are shown in Table 3.5 below, together with key figures. The department, now part of the Faculty of Mathematics and Natural Science, has an elected head, as have the research groups. The department offers 22 different courses in chemistry to some 300 students.

Table 3.5. Key figures for the individual sections and for the Department

Parameters	Organic Chemistry	Physical Chemistry	Theoretical Chemistry	Total
Professors	5	5	3	13
Associate professors	1		1	2
Other scientific positions		2		2
Research assistants				
Non-scientific positions	5	2		9*
Dr. scient.	3	8	1	12
Graduate students	10	6	1	17
[1)]Total University budget Running expenditures Univ.	1.17*	1.47*	0.95*	3.59*
[1)]External funding	1.9*	3.2*¤	0.9*	6.0*

* Includes data costs and central administration
[1)] In MNOK
¤ Includes the strategic research programme

Overall assessment and recommendations

General description

The department is the smallest in Norway. It has good premises and is reasonably well equipped. There is a strong *esprit de corps*, a healthy age distribution, and a lively research atmosphere.

Evaluation

Strengths

- Well led, well managed small department with good intra- and inter-departmental collaboration;

- The department as a whole promotes a research culture, e.g. by running departmental seminars and attracting international conferences to the university;
- Good research strategy focusing on few, but potentially rewarding areas (e.g. cold-resistant proteins);
- Leading national position in protein crystallography;
- Good outreach into the local community, e.g. through interaction with schools.

Weaknesses

- Many disadvantages stemming from geographical isolation, e.g. travel costs, the availability of jobs for spouses and the cost of maintaining instrumentation, difficulty in attracting staff members and students;
- The department is barely of critical size and is unlikely to be able to develop into a fully balanced Department of Chemistry;
- Several large pieces of equipment need to be replaced.

Opportunities common to the whole department

- The region and the university have a great deal to offer. Based on the output of good quality graduates, the strength of chemistry-related activities in medicine and pharmacy, combined with the vigour and growing reputation of the Department of Chemistry itself, it should be possible, given the political will, to attract supportive research-led industry to the region;
- More could be done to forge links with the powerful Norwegian College of Fishery Science. There is some common interest in the chemistry of antibiotics and antioxidants of marine origin. The imminent collapse of the carotenoid chemistry effort at Trondheim, based largely on marine-derived synthetic and structural targets, could open up an opportunity for a natural products chemist at Tromsø;
- The proportion of the relevant population age-band involved in higher education is lower in the northern part of Norway than in the rest of the country.

Threats common to the whole department

- The poor availability of jobs for spouses in the Tromsø area makes it difficult to attract and retain good staff;
- There are no longer special funds earmarked for Tromsø in grants and other support now that the university is regarded as established;
- It appears that there is a national decline in the number of students attracted to science, and a small department such as the one in Tromsø is especially vulnerable to small fluctuations.

Recommendations

- The Department of Chemistry has developed a clear identity which includes extensive internal collaboration. The panel recommends that the unit be preserved much as it is now, but it should be encouraged to develop even stronger links with chemical activities in pharmacy and medicinal chemistry elsewhere on campus;
- The department has established a strong national position in protein crystallography. This excellence should be safeguarded;

- The department wishes to pursue its ambition to hire a professor of Inorganic Chemistry. The panel wishes to recommend an alternative strategy. The panel recommends the appointment of two associate professors, one with expertise in organometallic chemistry and one with expertise in bioinorganic chemistry. This would strengthen the growing effort in organic synthesis and provide support for existing promising activities in bioinorganic chemistry (started in Physical Chemistry);
- The establishment of an instrument centre should be addressed. Perhaps there is an opportunity, on the relatively small campus, to organise an efficient service in common with the groups in pharmacy and medicinal chemistry.

3.4.1.1 Section of Organic Chemistry

Basic description

The Section of Organic Chemistry is actively engaged in research and has, as a matter of policy, developed common interests and activities within organic synthesis, although members of the section make distinct, independent contributions. Thus there is complementary activity on methodology (catalytic hydroxylation, routes to chiral sulfoxides, aziridine chemistry, and the use of readily available chiral starting materials, including treitol and abietinic acid). A major effort is directed at the analysis, design and optimisation of organic synthetic reactions for applications to important examples of specific reactions, including catalytic ones.

Research and its evaluation

The section's structure and research activities were described to the panel. The fully established size of the section is one full professor, four associate professors (one to be appointed), one professor-at-large (who is working part-time and based at Bergen) and five engineers. There are currently three doctoral and 10 graduate students. Of the four professors, three have been appointed within the past four years. The age-distribution is healthy and the panel received an impression of vigour and enthusiasm. There is a clear departmental strategy, pursued through the recent appointments, to establish a group with broad collective coverage of synthetic organic chemistry. The group will aim to make recognisable individual contributions and mutually reinforce interests. This approach has been enthusiastically accepted by the staff members. The *esprit de corps* extends throughout the department and the university. There was strong evidence of significant cross-disciplinary research collaboration with other groups in the department and the university (notably the biochemists). One professor is publishing at a healthy rate in respected journals, while another professor's publishing record must have been adversely affected by the period prior to recent appointments, when he carried a disproportionately high administrative and teaching load. His rate of publication has now picked up. Two professors are still settling in, but the prognosis for publications is good.

The Section of Organic Chemistry is extensively involved in teaching courses, ranging from large first-year general chemistry courses, which have a strong element of service, to advanced

courses relevant to the section members' research interests which are offered as advanced undergraduate or graduate-level courses.

The panel learned of the section's concern over the potential constraints posed by the limited number of doctoral students (synthesis is labour-intensive), lack of space in which to grow, limited funds for the research consumables, travel and small equipment, the need for a high-field NMR machine and access to routine GC-MS facilities and of worries concerning the maintenance of existing but ageing instrumentation. On the positive side, it appears that the mass spectrometer is excellently run by a skilled, relatively young technician who is also training a junior technician. Similarly, the NMR instruments are well cared for. The running costs of key instrumentation services are taken 'off the top', and researchers have no trouble obtaining crucial measurements, including X-ray crystallographic structures. The laboratories have an acceptable ratio of fume cupboards to bench space, and there is more than adequate office space for graduate and doctoral students. It would appear that the space is sufficient for current research activities and there seems to be room for modest expansion.

Another constraint was said to be a lack of post-doctoral fellows, although the section appears to be successful in attracting overseas visitors, including foreign post-doctoral researchers. The level of international collaboration is good, entailing formal and informal links with high-quality laboratories outside Norway. Similarly, the five-year cycle of sabbaticals is used as a serious research resource. Stays at major foreign laboratories are undertaken regularly.

The panel was impressed by the department's plans to advertise the attraction of the University of Tromsø as a place to visit and to study science. Specifically, a Norwegian meeting on synthesis, featuring invited international speakers, will be held at Tromsø in January 1998. A mass spectrometry meeting is also planned for 1999. An application to hold a Euchem meeting in June 2000 is in process, and, similarly, the group intends to arrange a series of summer school programmes in synthetic methodology. These outreach programmes are admirable and likely to be effective. An application will also be submitted for a strategic university programme in synthetic methodology, a venture involving collaboration between the university and the Research Council of Norway.

The programme on asymmetric synthesis is proceeding well. It was clearly boosted by a post-doctoral visit to Professor Sharpless (then at MIT). One professor is heavily involved in the chemistry of lactoferricin peptides in a well-funded collaborative project which also involves groups from the Tromsø Regional Hospital and the Department of Biochemistry.

One of the recently appointed professors has already initiated a well-conceived, timely programme on the synthesis of nitrogen-containing natural products using asymmetric Diels-Alder and aziridine chemistry. For a small group, the 16-step synthesis currently underway is ambitious. The group is awaiting the result of an application for doctoral student support. It recently presented a clear research plan for the next five to seven years.

The other newly appointed professor, who has an industrial background, has only been at Tromsø since September 1996, so his presentation to the panel concerned his plans for future research. He will be dealing with potentially useful conversions of abundant chiral materials, specifically, terpenoid by-products of the timber/paper pulp industries and of tartaric acid. It was noted that financial support has been sought from a major Norwegian paper-pulp company for this imaginative plan.

The section has earned an international reputation in reaction modelling and in developing strategies for the optimisation of synthetic organic reactions. An outline of the group's work was presented, and this has clearly had a strong impact.

SWOT Analysis

Strengths

- Healthy age profile, enthusiasm and vigour;
- The establishment of a research group broadly specialising in organic synthesis, but with individual members that make distinct contributions;
- Good collaboration within and outside the section. This reflects department-wide efficiency and willingness to co-operate;
- The small size of the classes in advanced courses aids communication with potential research workers (graduate and doctoral level);
- Good international collaboration;
- Participation in departmental and regular research seminars;
- Energetic and imaginative attempts are being made to raise the national and international profile of organic chemistry at Tromsø;
- Good co-operation with groups outside chemistry - e.g. potentially biologically active compounds are being tested by the groups in pharmacy and medicinal chemistry;
- Serious and effective use of sabbaticals;
- Good quality graduates who are highly employable.

Weaknesses

- Poor access to modern on-line literature and other data bases;
- Common problems maintaining sophisticated but ageing major instruments;
- One common problem, for Tromsø, is the expense of securing visiting speakers, especially travel expenses;
- The perception that instrument capacity, e.g. for NMR spectroscopy, is limited and the related need for a high-field instrument. (The panel was not entirely convinced by the arguments presented.) There is considerable difficulty in renewing and expanding instrumentation in a situation where a new department received much new equipment at its inception.

Opportunities

- The appointment of an additional staff member is imminent.

Threats

- The very success of a young group of organic chemists makes them vulnerable to head-hunting by other universities where retirements are imminent.

Recommendations

- The panel noted that much of the synthetic methodology in use and under development involves organometallic chemistry. The department wishes to appoint a professor of inorganic chemistry; this would clearly be beneficial to the organic chemists and possibly of direct interest to other sections of the department. Perhaps it would be possible to appoint an organometallic chemist with organic chemical leanings, or perhaps a bioinorganic chemist as this would provide in-house expertise without it being necessary to make several inorganic appointments to support a full professor;

- The possibilities for the establishment of an instrument centre do not appear to have been thoroughly addressed. Even with existing equipment, much could be accomplished by the purchase of an automatic sample changer. Perhaps there is an opportunity, on this relatively small campus, to organise an efficient service in common with the groups in pharmacy and medicinal chemistry.

3.4.1.2 Section of Physical Chemistry

Basic descriptions

The permanent staff comprises three professors and two associate professors. At present, three post-doctoral fellows also belong to the section, which attracts a number of doctoral (8) and graduate students (6).

The research conducted by the section focuses on determining the structure of biological macromolecules, studies of intermolecular interaction, bioinorganic chemistry and biophysical studies, and biophysical studies of proteins. These investigations are supported by different computational methods. The section's main focal point is on a selected area of physical chemistry concerned with biological macromolecules. Until recently, the research mainly concentrated on the first two research areas. The latter three topics are activities which the group has taken up more recently.

The section has adequate equipment for its diffraction work and has been successful in obtaining funding for the necessary instrumentation for the spectroscopic studies. This is the only Norwegian group which actively performs research in protein crystallography. These activities have been supported by the Research Council through a substantial grant from 1995 to 1998.

Research and its evaluation

After a general presentation of the research programme, each staff member described his or her individual research activities. All the presentations were well co-ordinated and provided the panel with very useful information. They left the impression of a smoothly functioning, dynamic research section, where good interaction between the staff members helps provide a

stimulating atmosphere for the research students. The excellent physical facilities, for instance, in term of office and laboratory space, represent additional assets.

Structure determinations by X-ray crystallographic methods play a key role in most of the research conducted by the section. Initially, the focus was mainly on smaller molecules, where the most significant contribution has been and is to further the understanding of intermolecular interaction. The section subsequently became engaged in the structure determination of proteins. This provides the essential basis for studying structure-function relations for proteins, many of which have been isolated from marine organisms as a result of successful collaboration with other research groups in Tromsø.

The protein crystallographic investigations conducted by the section represent state-of-the-art research and form a coherent research programme. In addition to the functional aspects of psychophilic enzymes, an interesting research programme has been initiated to elucidate the structural factors of protein stability.

Another new research activity for the section is in bioinorganic chemistry, where, apparently with great enthusiasm, a recently appointed staff member pursues his work on co-ordination compounds of relevance to catalysis and biological systems. These investigations require the application of several experimental techniques in synthesis and spectroscopy.

The individual presentations demonstrated the sincere enthusiasm which motivates the research conducted by this section and leads to a fairly high number of publications in international peer-reviewed journals. The section is unique in having a very clear concept of its own strengths and weaknesses. The initiation of new research areas can be attributed to the desire to introduce broader perspectives into the protein crystallographic investigations, especially in view of the importance of fisheries to Tromsø. The new equipment allocated to the section means that it will be well equipped on the experimental level. Considering the size of the section, a minor point of concern can be raised with respect to the maintenance of the equipment, especially since there are only two technical staff members associated with the team.

The university's remote geographical position could easily have led to an isolated scientific group, so it was very positive to learn about the extensive national and international network of research in which staff members take part. It is also noteworthy that staff members take advantage of opportunities provided by sabbaticals.

SWOT Analysis

Strengths

- A smoothly functioning, active section which conducts research at a high international level;
- Extensive national and international collaboration;
- Creative research environment attractive to the students;
- Good use is made of the funding provided by the Research Council.

Weaknesses

- Geographical remoteness from synchrotron radiation facilities;
- The supply of proteins is heavily dependent on collaborative efforts.

Opportunities

- Collaboration with other groups provides a good basis that should be strengthened by reorganising the university;
- The traditional and the new research activities of the section should exert synergistic effects on each other;
- This is the only Norwegian research group in protein crystallography.

Threats

- The ageing diffraction equipment may not be replaced;
- Research Council funding may not be continued after 1998;
- There is a minimal number of technical staff;
- The diversity of experimental techniques may exhaust the group.

Recommendations

- Maintain activities in protein crystallography and support them at least at their present level, which implies the acquisition of state-of-the-art new equipment prior to 2000;
- Increase technical staff to ensure good maintenance and efficient use of the equipment, possibly by reallocating existing position(s).

3.4.1.3 Section of Theoretical Chemistry

Basic description

Theoretical Chemistry is unusually strong in Tromsø, especially in the light of the modest overall size of the Department of Chemistry. The staff consists of three full professors and one associate professor. One of the professors will retire within the next five years. It is a salient feature of research in theoretical chemistry that no laboratories are needed for experimental work. Instead, high-performance computers are the main research tool. The section relies, in part, on high-performance PCs and work stations of their own, in part on computing centres located elsewhere, especially in Trondheim. The Research Council has traditionally covered the cost of these external computing services, and is likely to do so in the future.

The limited size of the Department of Chemistry in Tromsø and its geographical remoteness have, to a certain extent, hampered the exchange of ideas and general chemical knowledge between the group and other experimentalists. The section has, however, compensated for these logistical disadvantages by building up efficient, long-standing contacts with renowned chemistry communities in Norway and abroad. This has been achieved, *inter alia*, by making repeated use of the possibility for sabbatical stays. The host groups for such stays were

selected most carefully from among leading experimentalists covering the synthesis of substances in which the group became interested from a theoretical viewpoint.

Research and its evaluation

While quantum chemical calculations are applied by the whole section, two different directions are clearly discernable. One deals with molecules and short-lived intermediates containing lighter elements, such as silicon, carbon, boron and nitrogen. At the present time, some emphasis is being placed on the structure and chemistry of silicon-organic compounds, such as silacyclopropane, or silacyclobutane, and related intermediates, such as silene (silacarbene). Another branch belonging to this field is devoted to organic intermediates like radicals and diradicals, multi-centre and donor-acceptor bonding, boron-silicon compounds, non-classical boron compounds and the important field of aromaticity.

The second field is concerned with the chemistry of heavier elements, the development of new quantum chemical methods and their application to, e.g. homogeneous and heterogeneous catalysis. Among the methods under development are cluster approximation, Douglas-Kroll approximation and Dirac-Fock calculations. Examples of systems which have been calculated are platinum/gold or rhenium tetroxide, which play an important role as solid catalysts.

The section has continuously published its research results in high-quality, peer-reviewed international journals. Convincing proof of the outstanding quality of the section's recent research stems from their most recent papers in the *Journal of Physical Chemistry*, the *Journal of the American Chemical Society*, the *International Journal of Quantum Chemistry* and the like. One section member is currently serving as head of the faculty. Altogether, this is convincing evidence of the high overall quality and acceptance of the section for Theoretical Chemistry. The presentations given to the panel members were completely in line with the overall ranking; exactly the right amount of information was given to the two panelists at the right time, facilitating a very efficient meeting.

SWOT Analysis

Strengths

- All the resources available to the section for high-quality research (provided that support by the Research Council of Norway is maintained at the present level);
- The section has systematically established contacts and fruitful co-operation with outstanding scientists elsewhere;
- The section members have taken full, regular advantage of the possibilities for sabbaticals;
- Funding at a reasonable level available for creating and preserving contacts with colleagues abroad;
- Remarkably broad expertise in theoretical chemistry available in Tromsø (theoretical methods are also applied by the section for Physical Chemistry). This not only creates an excellent climate for top-quality research in theoretical chemistry, it also contributes significantly to the sharp research profile of the university.

Weaknesses

- Geographical remoteness from European research centres;
- Limited interaction with scientists in Tromsø;
- No regular funds available for post-doctoral fellows from abroad;
- Very few graduate students.

Opportunities

- All the weaknesses mentioned above tend to lose importance through enhanced use of modern telecommunication techniques;
- Reorganisation of the University of Tromsø in 1998 could further strengthen the section and its research;
- Industry is more frequently recognising the importance of results and insight obtained by theoretical methods;
- Students who graduate in theoretical chemistry, i.e. with combined expertise in chemistry and computer techniques, are becoming more and more attractive for the industry.

Threats

- The general tendency of governments to reduce funding for research is particularly threatening because of the small size of the Department of Chemistry as a whole;
- Funding institutions are becoming increasingly prone to sponsor research with short-term usefulness to industry;
- The section's size will probably be reduced in connection with retirements within the next five years;
- The Research Council of Norway may no longer be willing to cover the cost for the section's computational time.

Recommendations

- Make sure that this well functioning section can continue its outstanding research in the future;

- Whenever possible, select new professors in such a way that a reasonably broad field of theoretical chemistry is covered in Tromsø as a whole;

- Encourage and enable the section to cultivate its excellent international contacts and co-operation, both with theoreticians and experimentalists, and to develop it even further.

3.5 Agricultural University of Norway

3.5.1 Laboratory for Analytical Chemistry

The Agricultural University of Norway (AUN) has about 450 scientific employees and about 2500 students. It is organised in 12 institutes and two scientific centres. One of the centres is the Laboratory for Analytical Chemistry (LAK). LAK's activities include education and research within analytical chemistry as well as analytical services, especially to other AUN institutes. Chemistry has been regarded as an important support for the biological research at AUN, especially as related to agriculture and environmental sciences.

Table 3.6. Key figures for the Laboratory

Parameters	Total for the Laboratory
Professors	1
Associate professors	2
Other scientific positions	2
Research assistants	
Non-scientific positions	21
Dr. scient.	4
Graduate students	3-4
[1)]Total University budget Running expenditures Univ.	6.5 0.63
[2)]External funding	3.0

1) In MNOK, salaries and infrastructure included
2) In MNOK, included 0.38 for running expenditures

The key figures for the laboratory are:
One professor, two associate professors, two in other scientific positions (heads of sections) and 21 in technical and administrative positions. On average, there are three to four graduate students each year. In 1997, there are four doctoral students at LAK, and LAK is supervising three doctorates at other institutes. AUN's budget for 1996 was about MNOK 430. The internal budget of LAK in 1996 was about MNOK 6.3, which covers salaries and infrastructure. The service budgets are approximately MNOK 0.65 from internal sources and MNOK 0.38 from external sources. External research funding is about MNOK 3 per year.

Basic description

The laboratory works with analytical chemistry, including radioecology, in the areas of environment and natural resources. The main research objectives cover inorganic analytical chemistry, organic analytical chemistry, radiochemistry and electron microscopy. The

laboratory contributes in total to research (40%), teaching (10%) and services (50%). Based on internal funding the figures are 10, 10 and 80, respectively.

Research and its evaluation

In its present organisational form, the Laboratory for Analytical Chemistry (LAK) is a product of a merger in 1993 between the Laboratory for Chemical Analysis (KA) and the Isotope and Electron Microscopy Laboratories (ISEM). This structure is still reflected in the organisation of LAK, which consists of four sections, namely: 1) Inorganic Analytical Chemistry, 2) Organic Analytical Chemistry, 3) the Electron Microscopy Laboratory and 4) the Isotope Laboratory. The board of LAK, having representatives from different AUN institutes, is responsible to the president of the university. The director of the laboratory (professor) is head of LAK's administration. The expertise in chemical analysis dates back to the past century (1859), but the Isotope Laboratory also has long traditions, having been established in 1952 immediately after the installation of the first nuclear reactor in Norway. In addition to teaching and research duties, LAK has an important service mission to assist the institutes of AUN and other institutes by carrying out chemical analyses, tracer and electron microscopic studies, etc. These services form an important part of the total activity of the LAK, regardless of the method of calculation: man-years of labour (18.5 in 1996) or number of analyses (70 000 to 80 000 in 1996).

Research efforts are invested in the development of new methods for the determination/ characterisation of trace metals, organic compounds, radionuclides and ultrastructures. Special emphasis is placed on physico-chemical forms, transformation processes and kinetics that are relevant for the mobility and bioavailability of key variables in different ecosystems.

LAK has activities and international expertise in the following areas:

1) Determination of low-level radionuclides (alpha, beta, gamma spectrometry, tracer techniques) or stable elements (neutron activation analysis, GF-AAS, and ICP-MS in 1997) as well as structure analysis (SEM, TEM).

2) Methods of fractionation for the determination of physico-chemical forms of radionuclides and trace elements (*in situ*/at site size fractionation techniques, on line ion chromatography, extraction techniques).

3) Radioecology and preparedness research is focused on processes which influence mobility and biological uptake of radionuclides (^{137}Cs, ^{90}Sr and Pu isotopes) in the case of fallout or discharges from nuclear installations.

Although the majority of ongoing research projects (15 out of 24) and scientific publications deal with radionuclides and isotope techniques, the Electron Microscopy Laboratory is potentially (instrumentation) capable of independent research. Even though the section appears to be tied up with services/support work, its contribution to particle research has been well documented. In addition to its enormous service activity, the Section of Inorganic Analytical Chemistry and the Isotope Laboratory are involved in seven projects in which aluminium speciation and toxicity in mixing zones are clearly the main research areas. In contrast to the other sections, the Section of Organic Analytical Chemistry has not yet

demonstrated significant activity beyond routine service tasks. However, the scientific personnel will be strengthened in 1998.

Research performed at the Isotope Laboratory has recently been internationally evaluated.

SWOT Analysis

Strengths

- Activities and expertise covering a broad spectrum of environmentally oriented analytical chemistry including modelling;
- Traditions and high-level expertise in radiochemistry and electron microscopy;
- Good support through external funding;
- Advanced equipment and competent technical staff in major sections;
- Increasing interest from students (graduate and post-graduate students);
- Interdisciplinary collaboration, low level of bureaucracy;
- Good national and international contacts and networks including participation in several EU, bilateral and Nordic-funded projects.

Weaknesses

- Weak scientific and technical competence in one section;
- No internal research funding;
- Heavy administrative load for the top management;
- Some laboratories require maintenance/new laboratory facilities;
- Some figures of merit out of balance (too few scientists).

Opportunities

- The reorganisation to the Ministry of Education will probably enhance basic research and teaching;
- Vacancies to be filled in 1997-98 will improve the level of expertise among the personnel in the organic and inorganic sections;
- The new organisation of chemistry planned for the university will offer possibilities for improving, strengthening and focusing chemistry research and education;
- Accreditation will offer new possibilities for research and its financing.

Threats

- Organisational changes of chemistry within AUN without a strategic plan;
- Further splitting of research into separate, small projects;
- Limited supply of competent personnel to meet research and service activity;
- Research is mainly funded through relatively short-term external programmes (three years);
- Continuing internal research activities without internal funding.

Recommendations

- The relative role of research and teaching should be strengthened in the three fields of activities: research/teaching/service analyses;

- A strategic plan should be worked out together with the university, taking into account
  - the balance and focus of activities
  - long-term financing (internal/external) and the availability of personnel;

- The present organisational structure, which is largely due to historical development, should be reconsidered in order better to focus the research and to activate the present (scientifically) inactive sections;

- Focus on fewer research projects because the projects are currently too scattered, even though they are all within the area of competence;

- Senior staff levels should be strengthened. This would lower the current heavy administrative and research load of the director.

3.6 Colleges

Overall assessment and recommendations

General description

There are about 20 colleges within Norway's higher education system. Of them, the three visited are engaged in chemistry research. Their research is almost entirely applied in nature. Graduate degrees may be undertaken by students at all three colleges, but only Telemark has the authority to grant a graduate degree on its own; doctoral degrees taken at Telemark must be validated by other universities. Stavanger and Kristiansand need validation and collaboration with other universities in order to award graduate and doctoral degrees.

Evaluation

Strengths

- Characteristic of these colleges are their strong links to their local regions and regional industries;
- Above average enthusiasm and ambition to improve their status;
- Proven ability to attract industrial support for very applied projects.

Weaknesses

- In terms of both education and research, each college covers only very narrow areas of chemistry. Topics of applied research are generally not supported by broader education in modern chemistry;
- For most staff members at colleges, there is a low rate of publication in international peer-reviewed journals;
- The links with other universities which are necessary for validation of postgraduate degrees are not well-defined;
- Except for areas in which there is close collaboration with industry, the infrastructure of research equipment and facilities is poor.

Recommendations

- Formalise research links with the universities, including aspects of postgraduate training and the use of major facilities;

- The Research Council should seek to encourage the development of more basic research at the colleges by pump-priming funding individuals who show particular merit or promise in their attempts to perform chemistry research under difficult circumstances.

3.6.1 Agder College

The six colleges in Agder were reorganised into one organisational unit on 1 August 1994. Consisting of eight departments in the towns of Kristiansand, Grimstad and Arendal, the new unit has approximately 6000 students and 600 staff members.

3.6.1.1 Department of Sciences, Chemistry group

The field of chemistry is organised as a group under the Department of Sciences, one of the two departments under the Faculty of Mathematics and Sciences.

Table 3.7. Key figures for the Chemistry group

Parameters	Total for the group
Professors*	2 (3)
Associate professors	1
Other scientific positions	4
Research assistants	-
Non-scientific positions	3.5
Dr. scient.	-
Graduate students	4
[1)]Total College budget Running expenditures College	0.57
[1)]External funding	≈0.1

* One vacant position
[1)] In MNOK

Basic description

The staff of the Chemistry group within the Department of Sciences comprises two professors, one associate professor and four senior lecturers (a third professor is being appointed). Prior to 1978, staff members had no opportunities to do research. As part of the merger with several smaller colleges, Agder College has obtained a status that opens new possibilities for the staff to supervise graduate students and to perform research. However, graduate and postgraduate education is still carried out in collaboration with the universities in Oslo and Bergen. The group has close interaction with the Regional Water Quality Laboratory.

Research and its evaluation

The group's research focuses on analytical chemistry, environmental chemistry and geochemistry. The activities in analytical chemistry have mainly been based on problems experienced by local industry. The geochemical studies have been associated with projects within the Ocean Drilling Program. The most significant and visible activity of the group is related to the study of organic matter in aquatic ecosystems.

The group is active in international collaboration that serves to characterise Natural Organic Matter (NOM) isolated from different aqueous sources, i.e. the NOM-Typing project. This project is supported by the Research Council. The group gave a clear presentation of its research plans. In addition to the investigations of dissolved organic matter, the group is now focusing on research activities in analytical chemistry and has recently developed a method to determine the iodine content in water by flow-injection analysis.

The group has very good contacts with local industry. One newly appointed staff member comes from an industrial position, while another staff member is working part-time in industry.

The group appears to have access to a wide selection of equipment for analytical chemical investigations. Electronic networking ensures on-line access to relevant literature.

The group as a whole does not have strong research traditions and has limited experience in publishing results in international peer-reviewed journals. The complete lack of scientific publications for some of the staff members may be attributed to the previous status of Agder College as a teaching-only institution.

SWOT Analysis

Strengths

- The group is confident, and has a well-focused research plan. It has strong, energetic leadership;
- The group has established an international profile through the NOM-Typing project;
- Good contacts with local industry;
- The close interaction with the Regional Water Analysis laboratory is an asset and a source of shared equipment;
- The laboratory is well equipped with analytical instruments and members of the group have on-line access to modern chemical and analytical databases;
- The size and structure of Agder College provide low barriers between complementary disciplines.

Weaknesses

- Lacks a strong tradition for publications in international peer-reviewed journals;
- Too high a proportion of staff members who do no research;
- Low number of graduate students.

Opportunities

- Change to university status with consequent better access to better students and funding;
- Strong support from the local community;
- The move to new buildings should give better facilities and conditions for research.

Threats

- Retiring staff will not be replaced, bringing the group to sub-critical size;
- Should such a replacement of staff take place, the college may find it difficult to attract candidates of a sufficiently high scientific calibre who focus on the appropriate area.

Recommendations

The group should improve its research profile in several ways including:

- A significant increase in the rate of publication in high impact international journals;

- Adoption of a group name which describes clearly its research focus in analytical chemistry and the environmental chemistry of aquatic systems.

3.6.2 Stavanger College

Stavanger College is one of the largest regional colleges in Norway, with close to 6000 students and 550 employees. It is organised in seven departments and two centres of competence.

3.6.2.1 Institute of Mathematics and Natural Sciences, Chemical Engineering group

Table 3.8. Key figures for the Chemical Engineering group

Parameters	Total for the group
Professors	3
Associate professors*	5 (6)
Other scientific positions	
Research assistants	
Non-scientific positions	5
Dr. scient.	3
Graduate students	30
[1)]Total College budget Running expenditures College	0.5
[1)]External funding	0.4

* One vacant position
[1)] In MNOK

Basic description

The college has developed through a series of mergers since its inception in 1960 as a result of the impact of the oil industry on the region. The college's chemistry activities have always supported the engineering studies. Consequently, chemistry research at Stavanger College is slanted towards applied projects. There is a significant output of two-year graduates (a maximum of 30 per year) who spend approximately 25% of that period on a research project, usually based in industry. The number of doctoral students is small (three at present). Doctoral degrees must be validated by other universities.

The research topics being pursued include kinetics, corrosion, analytical chemistry, toxicology, plant physiology, and separation technology, including biological and artificial membrane separation. The college has ambitions to achieve full university status.

Research and its evaluation

One of the staff members presented the history of the college and department and, later, his own research. An organic chemist with significant industrial experience, he has supervised several graduate students and one doctoral student, mainly on topics related to corrosion. He has also been an examiner for students in the field of antioxidants and lipids. Another professor is perhaps the one who undertakes the most basic research. He has supervised six doctoral students and four graduate students on various kinetic studies, including oscillating reactions, precipitation, the oxidation of small organic molecules, stirring effects, polymer cross-linking and, in collaboration with another professor, biologically significant reactions such as those of nitrate reductase, polymerase and circadian rhythms. With approximately 75 papers in respected journals and 35 conference presentations, this professor has a research profile comparable to those in full universities. The group is also involved in an ambitious programme of basic research on synthetic and stereochemical aspects of self-assembly reactions. The group's leader was recently invited to the prestigious Burgenstock Meeting on stereochemistry, but her publication rate is rather thin. Her work has to be carried out in collaboration with groups in Oslo and Nijmegen because it is so dependent on NMR facilities which are lacking in Stavanger. One recent recruit to the staff has not yet completed his doctoral thesis. He will be working in the field of colloids and micelles with applications to surfactants and biosurfactants. The professor who is the longest serving member of staff has published about 26 papers in international journals since 1973, in addition to a number of other reports and articles. His work in Stavanger focuses on membrane separations. Separation activities are of great importance to local industry and attract significant financial support. However, the activities are fairly applied in nature and linked more to the environmental engineering side of the department than to chemistry.

The department is adequately equipped for analytical chemistry and has access to some equipment (e.g. GC) in the Petroleum Department. Funding for a GC-MS is imminent. There was much discussion about the need for an NMR instrument for research as well as teaching. The panel understands that an application for this to the Research Council of Norway was rejected. The views expressed seemed to be those of individuals rather than of the department. The college appears to have little money for the provision of major equipment and, although it has a research committee, this does not appear to concern itself with the broader aspects of research strategy.

On the positive side, the computing facilities are adequate and, although the library does not subscribe to an adequate number of journals, it is possible to retrieve published research by on-line searches. Research-based seminars are generally organised by a single staff member, with a smaller budget. The Norwegian Chemical Society also organises regular lectures in the region. The panel was told that the standard of the graduate students was good and that many of them are recruited from outside the college.

SWOT Analysis

Strengths

- Ambition, enthusiasm and energy;

- Good-quality graduate students with adequate job prospects;
- Good contacts with industry, although in highly applied subjects;
- A policy of fostering research collaboration and a research culture, as evidenced by the organisation of seminars;
- One or two staff members who are very active researchers.

Weaknesses

- Difficult under the present circumstances to run more "academic" graduate and doctoral programmes;
- Poor infrastructure in terms of instrumentation and library facilities. The department is probably too small to justify large-scale investments for its sole use;
- As regards university status, there is a lack of basic research programmes;
- Several staff members have little research activity;
- Poor level of funding in the less applied areas;
- There does not seem to be a coherent departmental view on several key issues. The department's research strategy did not seem to be clear.

Opportunities

- To strengthen environmental engineering with an imminent appointment. This would provide a nucleus of three staff members in one strong area;
- To develop further teaching, R&D and consulting links with industry.

Threats

- Continued and possibly growing discrimination in the distribution of funds to colleges through the universities. A particular danger is that there are 20 colleges, only four of which (including Stavanger) run graduate programmes. Stavanger is associated more with the other 16 colleges than with the universities;
- Funding trends for the college, in an industry-dominated region, will further favour applied rather than basic research.

Recommendations

- As a matter of urgency, the department's groups should work together to produce a convincing strategic plan which addresses the fragmentation of effort and arrives at a balanced research programme, utilising strengths in basic and applied areas, existing facilities and facilities for which funding might realistically be obtained;

- Likewise, if it hasn't already done so, the college should produce a strategic plan for the development of its research and the role of chemistry and chemists within that plan;

- The departmental staff should undertake a realistic self-appraisal with a view to considerably increasing its publication rates and research profiles in general;

- As a follow-up of this report, it would be timely for the department/college to discuss research plans and profiles with members of key committees of the Research Council of Norway and to obtain detailed feed-back about rejected applications.

3.6.3 Telemark College

With more than 4000 students, Telemark College is one of the largest regional colleges in Norway. It is divided into six departments which are spread across five campuses in Telemark County. Chemistry-related research programmes are being pursued by the Department of Technology, located on the campus in the city of Porsgrunn. Currently, it accommodates a total of 625 students, approximately 410 of whom follow undergraduate courses in engineering (three years). Approximately 185 students are engaged in graduate studies in engineering (two additional years for a graduate degree). They specialise either in Process Technology, Process Automation or Industrial Environmental Technology. In addition, a small number of students (currently 22) take part in the three-year doctoral programme in engineering. This doctoral degree has to be validated by other universities. This is usually done by the Norwegian University of Science and Technology in Trondheim or by foreign universities.

3.6.3.1 Department of Technology

Four research groups in the Department of Technology were evaluated: The Technical Termodynamics group, the Industrial Fluid Flow Processes group, the Membrane Research group (MEMFO) and the Chemometrics group.

Table 3.9. Key figures for the Department

Parameters	Total for the Department
Professors	8
Associate professors	19
Other scientific positions	2
Research assistants	2
Non-scientific positions	2
Dr. ing.	8[2)]
Graduate students	185
[1)]Total College budget Running expenditures College	30
[1)]External funding	~0

[1)] In MNOK (incl. salaries, goods, services)
[2)] The eight students belong to the four evaluated groups. There are more students at the Department of Technology.

Basic description

Adjacent to the Department of Technology is the Telemark Technological Research and Development Centre (Tel-Tek), an independent contract research institute sponsored, in part, by the Research Council. With about 30 employees and a turnover of approximately MNOK 15 per year, Tel-Tek co-operates closely with Telemark College in the fields of process technology, process automation and industrial environmental technology.

Research and its evaluation

One panellist met with the staff members who are active in chemistry-related research. As an introduction, the dean presented an overview of Telemark College as a whole and, then of its Department of Technology. Subsequently, the department reported on its research areas. The whole meeting was unusually well prepared. The documents given to the panellist were most instructive, which enabled an in-depth discussion of the research situation at the Department of Technology.

One professor has a strong educational background in chemical engineering and is now using many elements of theoretical physics in his research. He is currently active in two major areas, i.e. the structure and thermodynamics of polar solutions, and the stability and mechanisms of formation of gas hydrates, which includes the search for inhibitors of gas hydrate formation. Obviously, the latter topic is most relevant to the natural gas industry. The main tools in this research include statistical mechanics, molecular simulations and advanced computer techniques. One advantage is that all these techniques can be handled at a very high level in a group which is, of necessity, limited in size. One student recently finished his doctorate, two new ones are expected to join the group soon. In the past five years, the professor has published about 20 significant papers in first class international journals or important conference proceedings. This compares very well with professors supervising much larger groups at full universities. At the international level, the professor is a leading theoretician in the fields of gas hydrates and polar solutions, and in view of his age (43 years), his prospects as a scientist seem very bright. Considering the relevance of his research areas to the Norwegian gas and petroleum industries, every effort should be made to enhance his research facilities and interaction with top Norwegian groups, especially those which experiment on the same or similar topics.

Another professor performs research devoted to fluid flow processes and combustion hazards. One particular strength of the group is the computer simulation of these processes. The group is, by local standards, relatively large. It comprises one senior researcher and six doctoral students or research assistants. The professor performs a large portion of his research in co-operation with Tel-Tek, and is heavily involved in a number of strategic national research programmes. He has a remarkable publication record, with more than 20 papers in outstanding international journals within the past five years and, in addition, about the same number of papers in conference proceedings. In recognition of his scientific achievements, the professor was offered an attractive position at a Technical University in Denmark, and it seems likely that he will move away from Telemark College late this year. Even if he agrees to continue working at the Department of Technology at Telemark College in an advisory capacity, the position should be re-filled as soon as possible.

Another group, led by an associate professor, performs experimental research on gas separations by membranes. Membranes fabricated from polymeric materials are predominantly used. The medium-sized group comprises a total of approximately seven people, and puts emphasis in its experimental work on the measurement of membrane permeabilities for research gas components. The scientific scope and expertise of the group is much broader through intense co-operation with academic groups in foreign countries. In addition, the group explores the potential of polymer membranes for gas separations of interest to the Norwegian chemical industry. One industrial enterprise has scaled up the group's membrane technology for the purification of chlorine gas to the pilot plant stage. The

leader's publication record in the open scientific literature was not overwhelming during the past five years (less than 10 written papers), but a considerable portion of the group's results has apparently been documented in confidential reports to industry. It should be stressed that the membrane group at Telemark College/Tel-Tek fits the domestic research demands in separation science excellently, providing an ideal supplement to related research on liquid membrane separation carried out at other Norwegian universities.

Another group also performs experimental research and has specialised in chemometrics, especially acoustic chemometrics, and on multivariate calibration. Prior to joining Telemark College in 1995, the professor had gained very broad research experience at a number of renowned academic institutions in Denmark, Sweden, Norway and Canada. He maintains good contacts with the Norwegian chemical industry as well. Even though he has shown a considerable professional mobility up till recently, he has a good publishing record, with approximately 20 papers in the past five years.

While the chemistry-related research at the Department of Technology is not comparable in size to the programmes at established universities, the research topics were all very attractive. The research profile is well defined and unique in the country. It appears that the equipment is satisfactory (although not more) for carrying out relevant research on the topics selected. However, somewhat more sophisticated instruments are very difficult to acquire since the college apparently has limited funds for investments and the Research Council of Norway is reluctant to approve such applications when they come from colleges. Taking all these handicaps into consideration, very remarkable and, in some cases, even outstanding chemistry research has been performed at Telemark College in recent years.

SWOT Analysis

Strengths

- Very sharp profile covering attractive niches in Norwegian chemistry research;
- Competent, ambitious, well-organised faculty;
- Good mixture of modelling/computer simulation and experimental research;
- Selective, but very intense co-operation with academic research institutions in Norway and abroad;
- Proximity to and good contacts with the local chemical industry;
- Good publication rate for the professors;
- The existence of Tel-Tek makes all kinds of contract research easier.

Weaknesses

- The small size of chemistry-oriented research and the resultant relatively poor infrastructure;
- Reluctance of the Research Council of Norway to finance major investments;
- Lack of routine interaction with basic chemistry research, by comparison with traditional universities;
- Lack of personnel, faculty loses much time performing subordinate work;
- The college administration is largely unfamiliar with the research demands in natural sciences and engineering, resulting in bureaucracy and unnecessary administrative difficulties;

- The lack of university status results in numerous disadvantages for research;
- Sometimes conflicts of interest result from the relatively high portion of contract work (e.g. the ratio of free publications to confidential reports).

Opportunities

- Considerable reservoir of dedicated students available for research; if proper funding were available, many more good students could perhaps be persuaded to start a research career;
- Existing know-how on modelling and simulation could be utilised in additional research areas and for novel applications;
- International co-operation, especially within Europe, could be improved further.

Threats

- Increasing reluctance of national funding institutions to support research at colleges as opposed to universities;
- Telemark College might claim higher financial compensation for contract research executed at Tel-Tek;
- The demand for contract research in Norway diminishing.

Recommendations

- Reconsider funding policy so that individual scientists with excellent records feel encouraged to apply for funds for their own basic research projects, even if they happen to hold a position at a college;

- Make sure that the computer capacity at the Department of Technology continues to be maintained at a sufficiently high level to enable outstanding modelling and simulation work;

- Upon one professor's move to Denmark, recruit a new professor who guarantees the continuation of computer simulations and modelling in an attractive subfield of chemistry at a high level.

Appendix

MANDATE FOR THE REVIEW OF CHEMISTRY RESEARCH AT NORWEGIAN UNIVERSITIES

Purpose of the review

The Division of Science and Technology at the Research Council of Norway (RCN), which funds basic research at the universities and technological institutes in Norway, has decided to draw up strategic plans for the research being performed in its various fields of interest. A general review covering chemistry research at Norwegian universities is now being planned as a part of this process in order to obtain necessary background information.

Research in Norway is normally founded on traditions built up by researchers in various fields, often in close contact with foreign colleagues. In some fields of research, the best strategy will be to continue the efforts, in other cases it might be more prudent to reduce activities in order to strengthen other fields, or to get into new fields which will be important in the future. It is of particular interest to put an international spotlight on questions like these. And since the Research Council is not the only financing agency for basic research in Norway, it is equally valuable to get a good picture of chemistry at Norwegian universities, including the research activities funded by other external sources or directly by the universities.

The review should therefore lead to a set of concrete recommendations to the Research Council concerning future developments in the field of chemistry and chemistry research in Norway.

Aims of the review

A general review should clarify which fields are represented in Norwegian chemistry research, the structure of the academic departments of chemistry, the personnel at different levels, age structures, the funding of the research groups, the situation concerning equipment, publications and citations, and degree of mobility. Other aspects to be considered are:

1. Scientific activity and quality

- Which fields of research have a strong scientific position in Norway?
- Which have a weak position?
- Is there a reasonable balance between the different fields within Norwegian chemistry research?
- Is research lacking in any particular fields, while other fields are underrepresented?
- Are some fields overrepresented in view of the quality or scientific relevance of the research performed?
- How is the balance between theoretical and experimental research within the various fields? How does it compare with the situation in other countries?
- Do the research groups have a strategy/plans for the research carried out?

- Are the size and organisation of the research groups reasonable?

2. International and national collaboration

- Do the research groups take part in international programmes or use facilities abroad, or could utilisation be improved by introducing special measures?
- Is there sufficient contact and co-operation with other research groups at the national and international levels?
- Which role do Norwegian groups play in international co-operation in various sub-fields? Is there any significant difference between Norwegian chemistry research and research in other countries?
- Is there reasonable co-operation and a reasonable division of research activities at the national level? Is there room for improvement?
- Is there any co-operation related to the use of expensive equipment?

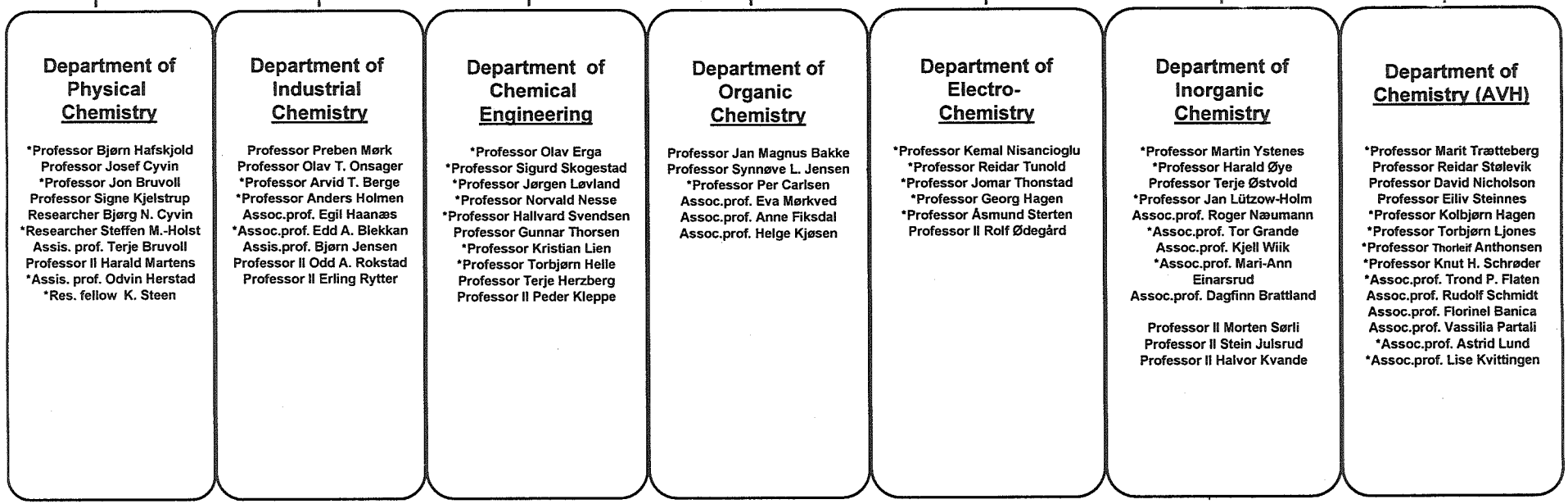
3. Training and mobility

- Is there satisfactory recruitment to doctoral-level training?
- Should recruitment be emphasised more strongly in the future?
- Are there education and training opportunities for doctorates in industrial research?
- Where do the candidates go after graduating?

4. Relevance of the scientific research

- Do the research groups have contacts with the Norwegian technical institute sector or Norwegian industry?
- Is today's chemistry research of relevance to the needs of Norwegian industry and society at large?
- Are the research groups prepared to solve tomorrow's problems at both the national and international levels?

Faculty for Chemistry and Biology
Norwegian University of Science and Technology



* Present in the review subgroup meetings

Review subgroup

Professor Jean-Claude G. Bünzli Professor Sine Larsen	Professor Jack W. Ponton Professor Jens Weitkamp	Professor Jack W. Ponton Professor Jens Weitkamp	Professor Sine Larsen Professor James H.P. Utley	Professor Lauri Niinistö Professor James H.P. Utley	Professor Jean-Claude G. Bünzli Professor Lauri Niinistö	All panel members

Norwegian University of Science and Technology, 19 - 20 February 1997

Agenda

Wednesday 19 February

08.30 Presentation of the Faculty of Chemistry and Biology
Dean Bjørn Hafskjold

09.30 Panel meeting

10.30 Review of subgroups
Chemical engineering
Reviewers: *Professor Jack W. Ponton and Professor Jens Weitkamp*

Inorganic chemistry
Reviewers: *Professor Jean-Claude G. Bünzli and Professor Lauri Niinistö*

Organic chemistry
Reviewers: *Professor Sine Larsen and Professor James H.P. Utley*

14.00 Chemistry Department, Rosenborg Campus
Reviewers: *All panel members*

16.30 Panel meeting

Thursday 20 February

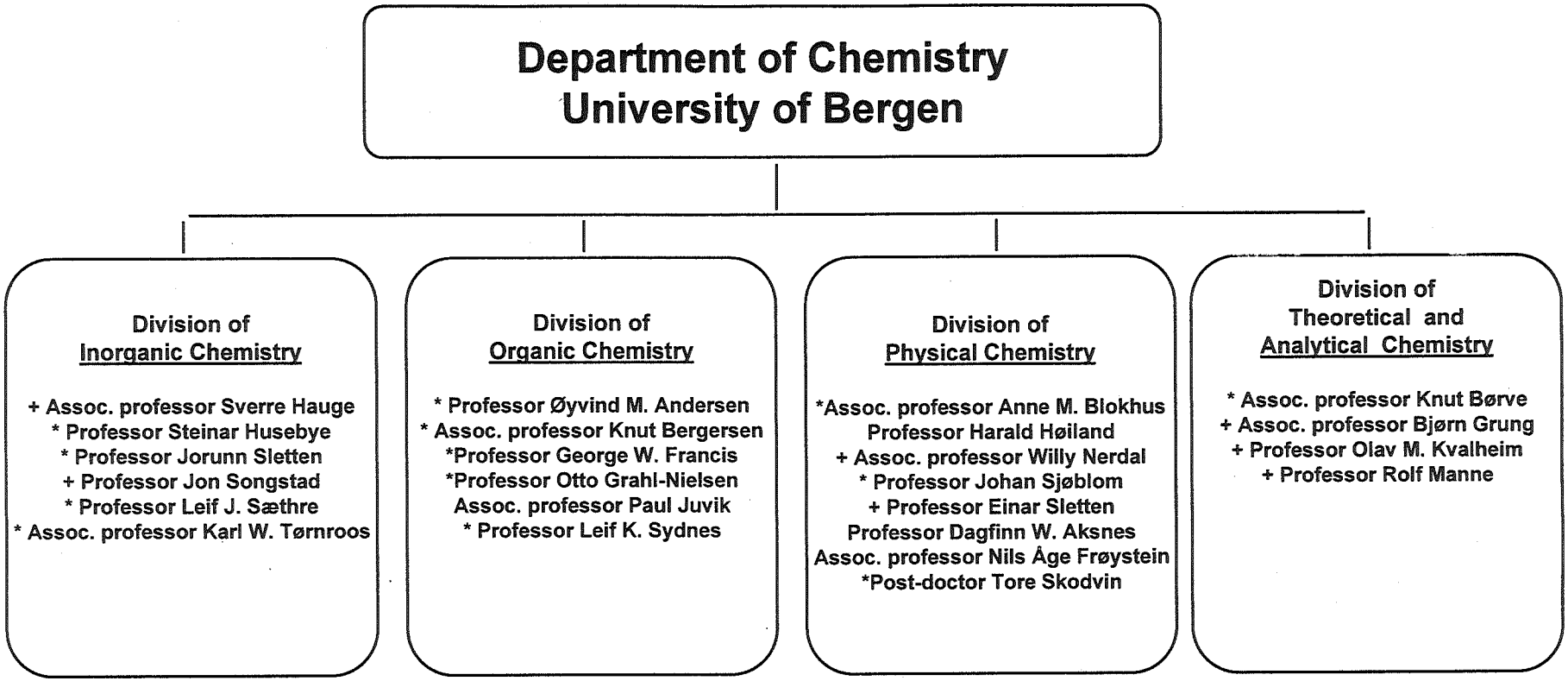
08.30 Review of subgroups
Physical chemistry
Reviewers: *Professor Jean-Claude G. Bünzli and Professor Sine Larsen*

Electrochemistry
Reviewers: *Professor Lauri Niinistö and Professor James H.P. Utley*

Industrial chemistry
Reviewers: *Professor Jack W. Ponton and Professor Jens Weitkamp*

13.00 Subgroups summary

15.30 Panel meeting
- Conclusions
- Planning of further meetings and tasks



+ * Present in the review subgroup meetings

* Review subgroup:			
Professor Jean-Claude G. Bünzli	Professor Gerald Pattenden	Professor Lauri Niinistö	Professor Jean-Claude G. Bünzli
Professor Sine Larsen	Professor James H.P. Utley	Professor Jens Weitkamp	Professor Sine Larsen
+ Review subgroup:			
Professor Lauri Niinistö		Professor Gerald Pattenden	Professor Jean-Claude G. Bünzli
Professor Jens Weitkamp		Professor James H.P. Utley	Professor James H.P. Utley

University of Bergen, 21 May 1997

Agenda

08.30 Presentation of the Department of Chemistry
Head of Department Einar Sletten

09.45 Review of subgroups

Synthetic Organic Chemistry
Analytical Organic Chemistry and Natural Products
Reviewers: Professor Gerald Pattenden and Professor James H.P. Utley

Synthetic Inorganic Chemistry
Reviewers: Professor Lauri Niinistö and Professor Jens Weitkamp

Structural Chemistry and ESCA Spectroscopy
Reviewers: Professor Jean-Claude G. Bünzli and Professor Sine Larsen

13.45 Review of subgroups

Physical chemistry: Surface and Colloid Chemistry
Reviewers: Professor Lauri Niinistö and Professor Jens Weitkamp

Biophysical/Bioinorganic Chemistry
Reviewers: Professor Gerald Pattenden and Professor James H.P. Utley

Theoretical Chemistry
Reviewers: Professor Jean-Claude G. Bünzli and Professor Sine Larsen

15.45 Review of subgroups

Chemometrics
Reviewers: Professor Jean-Claude G. Bünzli and Professor James H.P. Utley

Department of Chemistry
University of Oslo

Section 1

Inorganic Chemistry and
Materials Science
*Professor Helmer Fjellvåg
Professor Sigrid Furuseth
*Professor Arne Kjekshus
Assoc. professor Svein Stølen
Guest researcher Sven Svendsen

Catalysis and Surface Chemistry
Professor II Ole Henrik Ellestad
*Professor Stein Kolboe
*Assoc. professor Karl-Petter Lillerud

Electrochemistry and
Materials Science
Senior researcher Per Kofstad
*Professor Truls Norby
*Professor Ketil Videm
Professor II Torstein Våland

Section 2

Organic Chemistry
Professor Tore Benneche
Assoc. professor Ove Kjølberg
*Professor Per Kolsaker
*Assoc. professor Frode Rise
Professor Lars Skattebøl
*Professor Jan Skramstad
Professor Mats Tilset
Professor Kjell Undheim

Gas Phase Ion Chemistry
Professor Georg Hvistendahl
*Professor Einar Uggerud

Section 3

+Theoretical Chemistry
Professor Knut Fægri
*Professor Trygve Helgaker
*Wil Klopper

¤Polymer, Colloid and
Surface Chemistry
*Professor Finn Knut Hansen
*Professor Bo Nystrøm
*Professor Jan Roots
*Assoc. professor H. Walderhaug

¤Electron Diffraction
*Professor Grete Gundersen
Professor Anre Haaland
*Professor Svein Samdal
*Assoc. professor Tor G. Strand

+Spectroscopy
Assoc. professor Just Grundnes
Senior researcher Peter Klæboe
Assoc. professor Karl-M. Marstokk
*Professor Harald Møllendal
*Professor Claus Jørgen Nielsen
*Professor Bjørn Pedersen
Other scientific personnel Ole W. Saastad

+X-Ray Diffraction
Pharm. professor Berit Fjærtoft
*Assoc. professor Carl H. Gørbitz
Assoc. professor Bernt Klewe
*Professor Arvid Mostad
Senior researcher Chr. Rømming
Senior researcher Knut O. Strømme

Section 4

+Environmental Chemistry
Professor II Tore Sanner
*Professor Hans Martin Seip
*Research fellow Rolf Vogt

#Nuclear Chemistry
Senior researcher Jorolf Alstad
Professor Einar Hagebø
*Professor Per Hoff
*Assoc. professor Jon P. Omtvedt

¤Analytical Chemistry
Professor II Georg Carlberg
*Professor Tyge Greibrokk
*Professor Walter Lund
Assoc. professor Elsa Lundanes
Assoc. professor Grethe Wibetoe

+School Chemistry
Assoc. professor Truls Grønneberg

* Present in the review subgroup meetings

Review subgroup:

Professor Lauri Niinistö
Professor Jens Weitkamp

Professor Gerald Pattenden
Professor James H.P. Utley

+ Professor Jean-Claude G. Bünzli
Professor Sine Larsen

¤Professor Sine Larsen
Professor Jens Weitkamp

+ Professor Lauri Niinistö
Professor Jens Weitkamp

¤ Professor Gerald Pattenden
Professor James H.P. Utley

Professor Jean-Claude G. Bünzli
Professor Lauri Niinistö

University of Oslo, 10 - 11 March 1997

Agenda

Monday 10 March

08.30 Presentation of the Department of Chemistry
Head of Department Per Kolsaker

09.45 Review of subgroups
Section 1:
Inorganic Chemistry and Materials Science
Electrochemistry and Materials Science
Catalysis and Surface Chemistry
Reviewers: *Professor Lauri Niinistö and Professor Jens Weitkamp*

Section 2
Organic Chemistry
Gas Phase Ion Chemistry
Reviewers: *Professor Gerald Pattenden and Professor James H.P. Utley*

13.45 Review of subgroups
Section 3
Theoretical Chemistry
Spectroscopy
X-Ray Diffraction
Reviewers: *Professor Jean-Claude G. Bünzli and Professor Sine Larsen*

Section 4
Environmental Chemistry
School Chemistry
Reviewers: *Professor Lauri Niinistö and Professor Jens Weitkamp*

Institute of Pharmacy (parts)
Reviewers: *Professor Gerald Pattenden and Professor James H.P. Utley*

17.00 Panel meeting

Tuesday 11 March

08.30 Review of subgroups

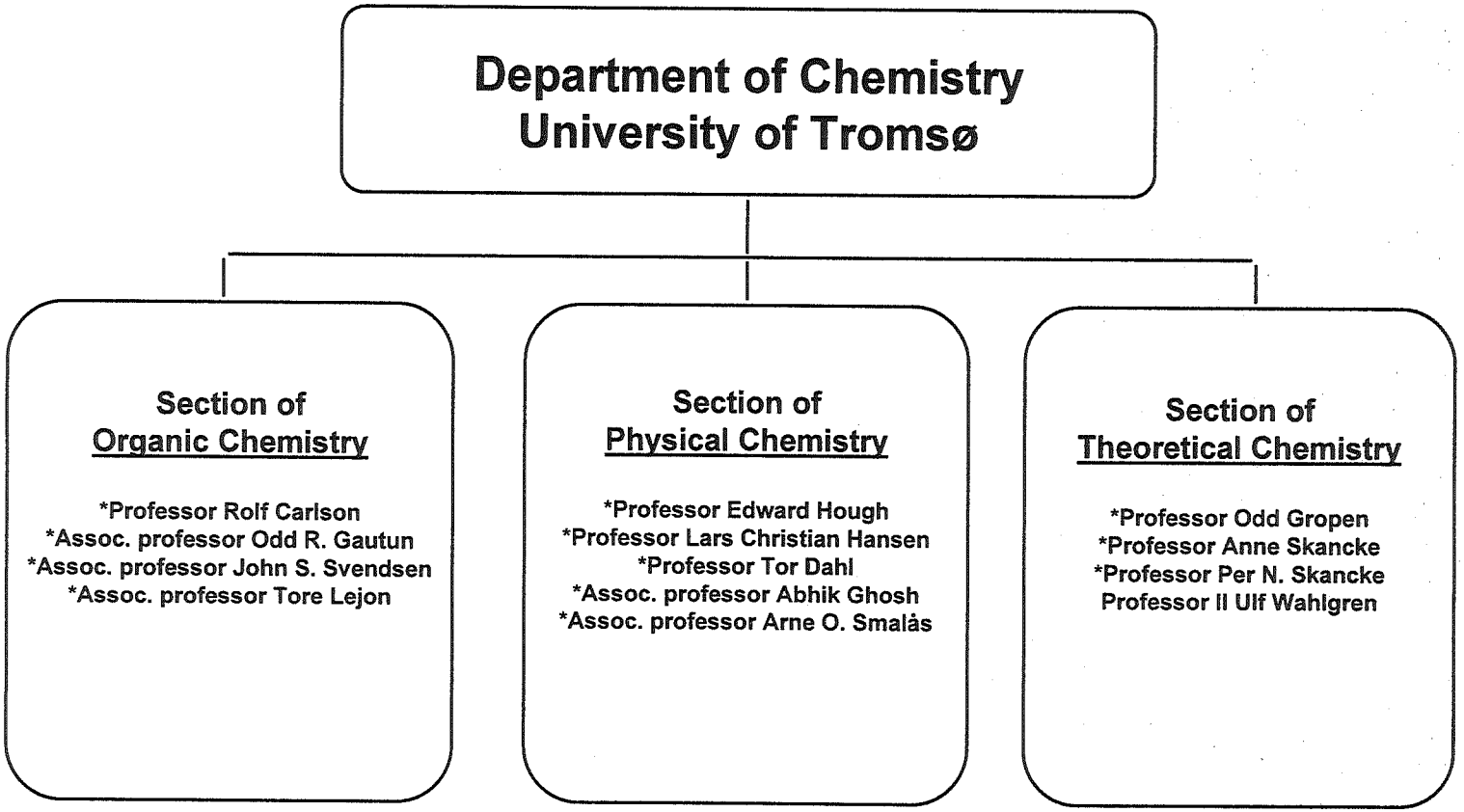
Section 3
Polymer, Colloid and Surface Chemistry
Electron Diffraction
Reviewers: *Professor Sine Larsen and Professor Jens Weitkamp*

Section 4:
Analytical Chemistry
Reviewers: *Professor Gerald Pattenden and Professor James H.P. Utley*

Section 4:
Nuclear Chemistry
Reviewers: *Professor Jean-Claude G. Bünzli and Professor Lauri Niinistö*

10.30 Meeting in subgroups

13.30 Meeting in subgroups/ panel meeting



* Present in the subgroup review meeting

Review subgroup:

Professor James H.P. Utley
Professor Jean-Claude G. Bünzli
Professor Jean-Claude G. Bünzli
Professor Sine Larsen
Professor Sine Larsen
Professor Jens Weitkamp

University of Tromsø, 15 April 1997

Agenda

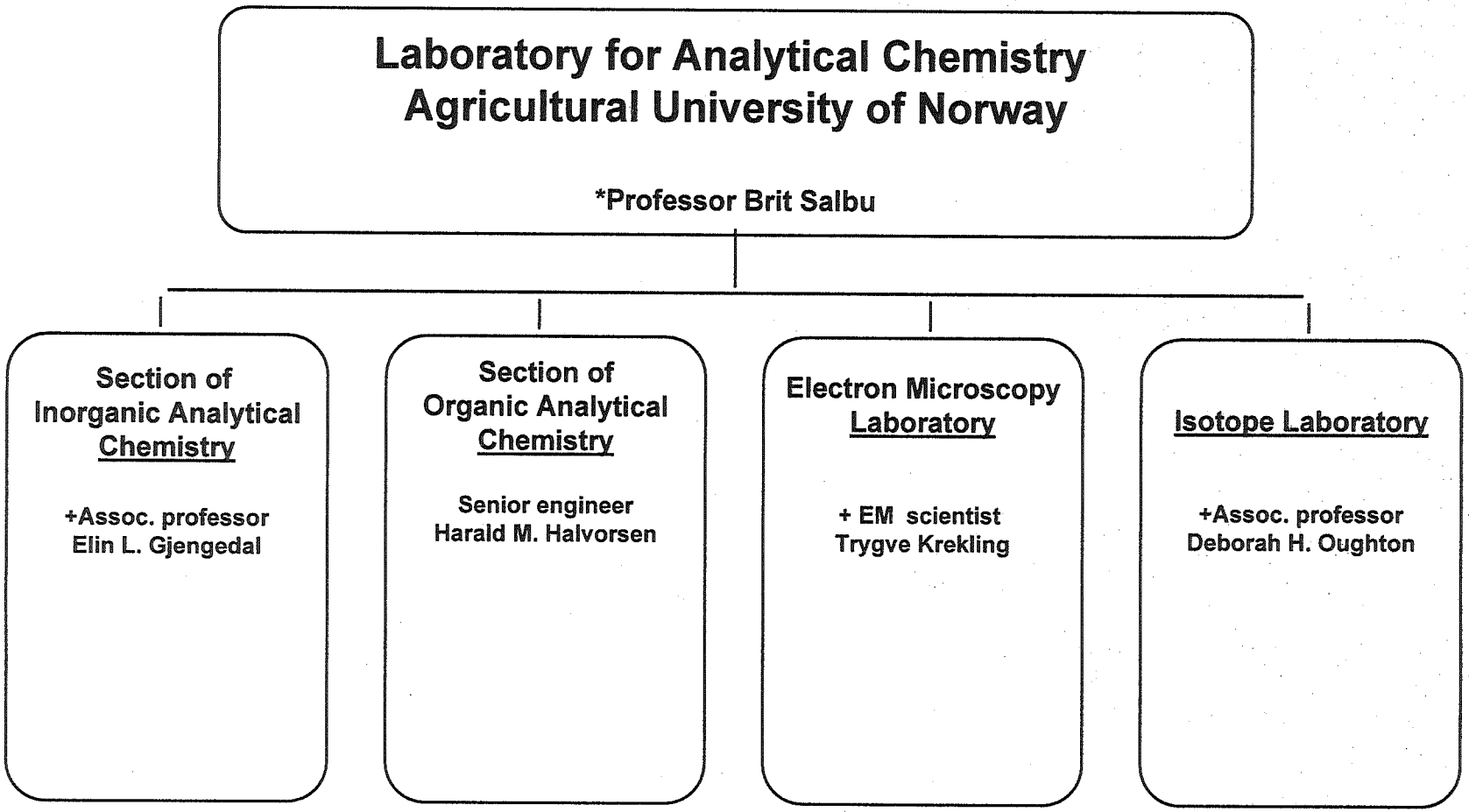
08.30 Presentation of the Department of Chemistry
Head of Department Rolf Carlson

09.45 Review of subgroups
Organic Chemistry
Reviewers: *Professor Jean-Claude G. Bünzli and Professor James H.P. Utley*

Theoretical Chemistry
Reviewers: *Professor Sine Larsen and Professor Jens Weitkamp*

12.00 Tour of the institute

13.45 Review of subgroups
Physical Chemistry
Reviewers: *Professor Jean-Claude G. Bünzli and Professor Sine Larsen*



Present in the review subgroup meetings

*11 March 1997
+22 May 1997

Review subgroup:
11 March 1997
Professor Lauri Niinistö
Professor Jean-Claude G. Bünzli

22 May 1997
Professor Lauri Niinistö

Agricultural University of Norway

Agenda

11 March 1997
08.30 - 10.30 Meeting at the University of Oslo

22 May 1997
13.00 - 17.00 Meeting at the Agricultural University of Norway

- **Chemistry at the Agricultural University of Norway (AUN)**
  Research director Sissel Rogne

- **Research at Laboratory for Analytical Chemistry (LAK)**
  Director, Professor Brit Salbu
  Head of section, EM scientist Trygve Krekling
  Head of section, Associate professor Deborah H. Oughton

- **Discussions**

- **Visiting AAS, ICP-MS**

- **Visiting Electron Microscopy Laboratory**

- **Visiting alpha, beta, gamma laboratories**

Present at the review meetings:
Tuesday 11 March 1997
Director, Professor Brit Salbu

Thursday 22 May 1997
Research director Sissel Rogne, AUN
Head of section, EM scientist Trygve Krekling, LAK
Head of section, Associate professor Deborah H. Oughton, LAK
Head of section, Associate professor Elin L. Gjengedal, LAK

Reviewers:
11 March 1997
Professor Jean-Claude G. Bünzli
Professor Lauri Niinistö

22 May 1997
Professor Lauri Niinistö

Agder College, 23 May 1997

Agenda

13.30 - 16.30 Meeting

- Overall presentation of the Chemistry group
- The aim of the evaluation by the representative from the Research Council of Norway
- Presentation of the activities by individual staff members
- Questions, discussion, SWOT analysis

Present at the review meeting:
Professor Per Kr. Egeberg
Senior Lecturer Terje Ekeland
Senior Lecturer Terje Østensen
Associate Professor Eldar Dingsøyr
Senior Lecturer Jon Håkedal

Reviewers:
Professor Sine Larsen
Professor James H.P. Utley

Stavanger College, 23 May 1997

Agenda

8.00 - 11.15 Meeting

- Welcome by Tor Hemmingsen
- Presentation of the Chemical Engineering group members
- Presentation of the Chemical Engineering group activities
- Introduction by the Research Council of Norway about the aim of the visit and SWOT Analysis
- Presentation of the activities from the staff in Chemistry
- Discussion

Present at the review meeting:
Professor Torleiv Bilstad
Assistant professor Tor Hemmingsen
Assistant professor Mohamad Osaman
Professor Peter Ruoff
Assistant professor Rachel Suissa
Lecturer Leif Ydsteboe

Reviewers:
Professor Sine Larsen
Professor James H.P. Utley
Professor Jens Weitkamp

Telemark College, 20 May 1997

Agenda

10.00 – 14.00 Meeting

- **Presentation of Telemark College and Department of Technology**
  Dean Olav Torsholt

- **Technical Thermodynamics group**
  Professor Bjørn Kvamme

- **Industrial Fluid Flow Processes group**
  Professor Bjørn Helge Hjertager

- **MEMFO (Membrane Rearch group)**
  Associate professor May-Britt Hägg

- **Chemometrics group**
  Professor Kim Esbensen

Present at the review meeting:
Dean of Department, Associate professor Olav Torsholt (part time)
Professor Kim Esbensen
Associate professor May-Britt Hägg (part time)
Professor Bjørn Kvamme (part time)
Professor Bjørn Helge Hjertager (part time)
Senior Scientist Tron Solberg (part time)
PhD student Vidar Mathiesen (part time)

Reviewer:
Professor Jens Weitkamp

Professor Jens Weitkamp
Curriculum Vitae

Professor Jens Weitkamp received an education in chemistry and a Ph.D. in chemical engineering from University of Karlsruhe, Germany. In 1986 he was appointed Professor for Chemical Technology at the University of Oldenburg, and in 1988 Head of the Institute of Chemical Technology I at the University of Stuttgart. He has been in this position ever since.

Professor Weitkamp's research focuses around heterogeneous catalysis, zeolites and related microporous materials and separation science through adsorption. He has acted as elected Dean of the Faculty of Chemistry at the University of Stuttgart (1992 to 1994) and as one of the elected Vice-Rectors of the same University (1995 to 1996) with the responsibility for strategic planning. He is the author or co-author of some 200 research papers and has presented about the same number of scientific seminars. He is currently a member of the Editorial Boards of the journals Catalysis Letters and Chemie Ingenieur Technik. Since 1993, he has served as the main editor of the international Journal Microporous Materials. Besides, he was a co-editor of a number of monographs, conference proceedings and books, e.g. of the recently published five-volumes Handbook of Heterogeneous Catalysis.

Other experience of Professor Weitkamp includes the organization of various conferences and international congresses. For example, he was the chairman of the Organizing Committee for the 10th International Zeolite Conference held in 1994. Since 1991 he has been a member of the Board of Directors of the German Society for Petroleum and Coal Science and Technology (DGMK) and the Chairman of its Petrochemistry Division. For many years he has been a member of the Council of the International Zeolite Association and a Co-Chairman of its Catalysis Commission. From 1994 to July 1997, he served as elected Vice-President of the International Zeolite Association, and in July 1997, he was elected President of the same Society.

Professor Jean-Claude G. Bünzli
Curriculum Vitae

Professor Jean-Claude G. Bünzli is a physical-inorganic and analytic chemist by training and an active researcher in the field of co-ordination and supramolecular chemistry of the lanthanide ions. His research focuses mainly on the relationship between structural and luminescent properties, on the use of europium and terbium ions as luminescent probes, and on the design of self-assembled building blocks for the synthesis of materials with predetermined photophysical and magnetic properties.

Since 1980, he holds a chair of Inorganic and Analytical Chemistry at the University of Lausanne (Switzerland). He has acted as the elected Dean of the Faculty of Sciences (1990-1991) and as one of the elected Vice-Rectors of the University (1991-1995), in charge of students' affairs (including social and cultural affairs and student mobility) and of joint research programmes, especially in the field of biomedical sciences. He has held a position of invited professor at the Université Louis Pasteur, Strasbourg (1996). He is the author of 150 research papers, 75 contributed communications and has presented 90 invited conferences and seminars. He is a member of the Editorial Boards of the journals Spectroscopy Letters and Acta Chemica Scandinavica.

Other experience relevant to the Panel's activities includes attending workshops on the management of Higher Education (Leicester 1990, organised by the Standing Conference of rectors, presidents and vice-chancellors of the European Universities; Paris 1994, Programme de gestion des établissements d'enseignement supérieur, OCDE, 12e conférence générale; Epinal 1995, Swiss representative at the 1st European workshop on doctoral studies). He has also served as a World Bank Project Specialist within the frame of the Chinese Provincial Universities Development Project (Northwest China, 1989) and has been active in promoting the image of sciences for the general public (member of the steering committee of the Heureka exhibition, Zürich, 1991; Swiss representative, 1st European Week for Scientific Culture, Amsterdam 1993).

Professor Sine Larsen
Curriculum Vitae

Professor Sine Larsen is a structural chemist with background in X-ray crystallography and physical chemistry. Her present research interests include basic studies of intermolecular interactions in particular among chiral molecules and investigations of the relations between protein structure and function.

She has been the Director of the Centre for Crystallographic Studies since 1994, when this centre was established at the Department of Chemistry, University of Copenhagen, as one of the 23 centres funded by the Danish National Research Foundation. She was the Head of the Department of Chemistry 1977-1978, and chaired the Laboratory for Physical Chemistry 1987-1992. Serving as an external examiner at the University of Ghana can be mentioned among her other academic assignments. She is a member of the Editorial Boards of the journals Crystallography Reviews and Journal of Biological Inorganic Chemistry.

She was a member of the Danish Natural Science Research Council 1989-1993, and its Deputy Chairman 1991-1993. In addition she has chaired the Research Council's Committee for Supercomputing 1993-1996, and their ad hoc committee that made a "Review of Scientific Equipment in Denmark", published in 1995. She was the deputy chairman in the Danish Natural Science Research Council's committee for Synchrotron Radiation 1993-1994. Related international experience includes membership of CERC3, chairperson of European Research Councils Chemistry Committees 1990-1994, and member of the CERC3 executive committee 1992-1994.

Since 1985 she has been a member of the Danish National Committee for Chrystallography. In 1996 she was elected General Secretary and Treasurer for the International Union of Crystallography, and is as such a member of its Executive Committee and an ex officio member of all commissions of the union.

Professor Lauri Niinistö, M.Sc. (Eng.), D.Techn., D.Techn.h.c.
Curriculum Vitae

Professor Lauri Niinistö was trained in inorganic, structural and analytical chemistry and is currently actively engaged in the synthesis and characterisation of inorganic materials, especially thin films for advanced applications. He is the author or coauthor of more than 200 research papers and reviews.

He is Head of the Laboratory of Inorganic and Analytical Chemistry at Helsinki University of Technology. He has acted as Dean of the Faculty of Process Engineering and Materials Science (1987-90). He has had longer research stays at the University of Stockholm, CNRS in Meudon, Technical University of Vienna and University of Florida, Gainesville.

Other international experience includes participation in EU-sponsored research projects, editorship of Acta Chemica Scandinavica (1982-90) and membership in editorial boards of several other journals in materials science and analytical chemistry. He has acted as referee for filling professorships in inorganic and analytical chemistry in Sweden, Norway, Denmark, Estonia and Hungary. Within the Federation of European Chemical Societies (FECS) he has acted as chairman of the Working Party (now Division) of Analytical Chemistry (1987-93) and is currently President of the Federation for the three-year period starting 1995. He is also chairman of the European Rare Earth Research Society (ERES) and board member of the Nordic Society of Thermal Analysis and Calorimetry (NOSTAC).

Professor Gerald Pattenden, BSc PhD DSc CChem FRSC FRS
Curriculum Vitae

Professor Gerald Pattenden is Sir Jesse Boot Professor of Organic Chemistry and Head of Organic Chemistry at Nottingham University. From 1988-1996 he was Head of the Department of Chemistry, and recently he was appointed Pro-Vice-Chancellor at the University. He researches in the broad area of design and development of novel organic synthesis methods, addressing the total synthesis of natural products of biological importance. He has published nearly 400 papers and written several review articles. His contributions have been recognised by numerous Awards including, recently, the Tilden Medal of the Royal Society of Chemistry (1991/92), the 1992 Royal Society of Chemistry Award in Synthetic Organic Chemistry, the Royal Society of Chemistry Award for Heterocyclic Chemistry in 1994 and the Pedler Medal (1994/95). Gerald Pattenden was elected Fellow of the Royal Society, FRS, in 1991. He is President of the Perkin Division of the Royal Society of Chemistry (1995/97), and Scientific Editor for J. Chem. Soc. Perkin Transactions 1. He has served as Chairman of the EPSRC Organic Chemistry Panel, and from 1992 to 1994 he was Chairman of Sectional Committee 3 of The Royal Society. At this time he is an elected member and Chairman of the EPSRC Synthesis and Biological Chemistry Panel, a member of the EPSRC panel for Innovative Polymer Synthesis, and Chairman of the Management Panel of the EPSRC National Spectroscopy Centre.

Professor Jack W. Ponton, FEng, FIChemE, FRSA, BSc, PhD
Curriculum Vitae

Position: Professor of Chemical and Process Systems Engineering, University of Edinburgh (personal chair). Previously ICI Professor of Chemical Engineering and Head of Department of Chemical Engineering. Director of the Ecosse process systems research group and consortium. Past Chairman of School of Engineering and Informatics.

Research interests: process design, innovation and computer aided process engineering.

Academic and professional service: External examiner for research degrees at universities including Cambridge, London, Manchester, Sydney Australia, NTH Trondheim. Vice-President of the Institution of Chemical Engineers (IChemE). Member of UK Science and Engineering Research Council panels.

Recent industrial collaboration and consultancy: ICI, DuPont, BP, Air Products, Mitsubishi, BNFL, AspenTech, QuantiSci.

Other relevent information: Fellow of Royal Academy of Engineering and of IChemE. Associate Editor of 'Computers and Chemical Engineering'.

Professor James H.P. Utley, BSc PhD DSc(Lond) CChem FRSC
Curriculum Vitae

Professor James H.P. Utley is a physical-organic chemist by training and an active researcher in organic electrochemistry applied to synthetic methodology to the study of reaction mechanism and to the conversion of renewable organic resources. These activities have often involved collaboration with other major groups in Europe (including Denmark), Brazil and the USA.

He currently holds the established (University) Chair of Organic Chemistry at Queen Mary & Westfield College (University of London) and is Head of the Organic Section in the Department of Chemistry. He has acted as Head of Chemistry (1987-91), as Dean of the Faculty of Natural Sciences (1991-94) and as a member of the QMW Council (1991-94). He has held positions as Professeur Invité at the Ecole Normale Supérieure, Paris, (1995) and as Guest Professor at the Universities of Texas at Austin (1995), Westfälische Wilhelms-Universität Münster (1985) and of Aarhus (1973).

Other experience relevant to the Review Panel's activities includes being an elected member of the UK's Engineering and Physical Sciences Research Council (EPSRC) Synthesis College, an immediate past member of the Bonding, Structure and Reactivity College and a member of the EPSRC's panel for the Innovative Polymer Synthesis Initiative. He has also served as a member of the Science and Engineering Research Council (SERC/EPSRC) Organic Chemistry sub-Committee (1993-95); Member, Advisory Panel, Association of Commonwealth Universities Scholarships and Fellowships Commission (1992-); Deputy Chairman (and Chairman-designate), University of London Central Research Fund Expert Advisory Committee (Science, Engineering, Medicine); Member, Steering Committee, University of London Intercollegiate Research Service (1987-92); Member, External Advisory Board, University of Southern Mississippi, USA (1986); World Bank - Project Specialist, Chinese Provincial Universities Development Project (South China, 1988).

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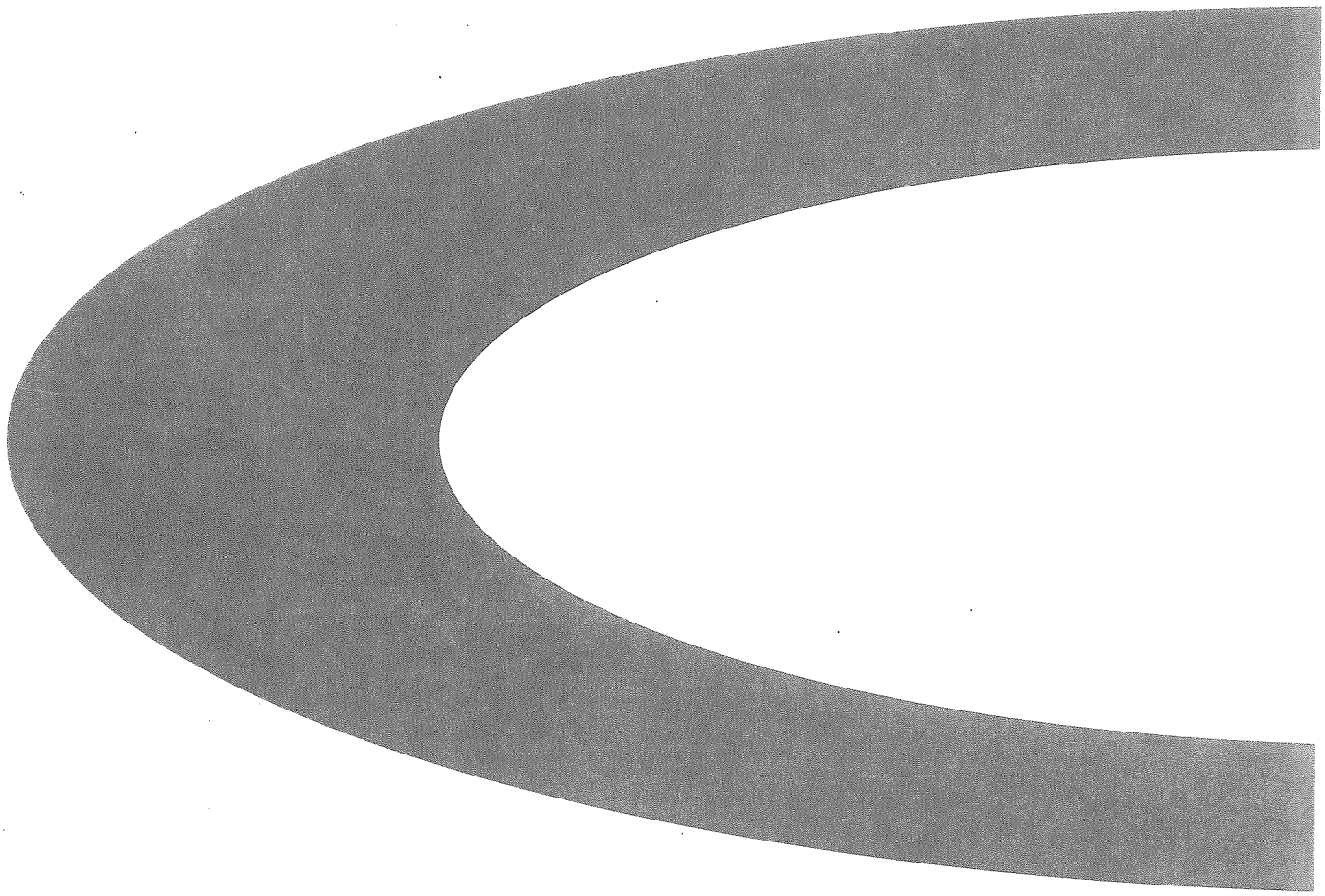

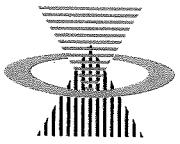

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