Chemistry

Subject benchmark statements

Subject benchmark statements provide a means for the academic community to describe the nature and characteristics of programmes in a specific subject. They also represent general expectations about the standards for the award of qualifications at a given level and articulate the attributes and capabilities that those possessing such qualifications should be able to demonstrate.

This subject benchmark statement, together with the others published concurrently, refers to the ***bachelors degree with honours***.

Subject benchmark statements are used for a variety of purposes. Primarily, they are an important external source of reference for higher education institutions when new programmes are being designed and developed in a subject area. They provide general guidance for articulating the learning outcomes associated with the programme but are not a specification of a detailed curriculum in the subject. Benchmark statements provide for variety and flexibility in the design of programmes and encourage innovation within an agreed overall framework.

Subject benchmark statements also provide support to institutions in pursuit of internal quality assurance. They enable the learning outcomes specified for a particular programme to be reviewed and evaluated against agreed general expectations about standards.

Finally, subject benchmark statements are one of a number of external sources of information that are drawn upon for the purposes of academic review* and for making judgements about threshold standards being met. Reviewers do not use subject benchmark statements as a crude checklist for these purposes however. Rather, they are used in conjunction with the relevant programme specifications, the institution's own internal evaluation documentation, together with primary data in order to enable reviewers to come to a rounded judgement based on a broad range of evidence.

The benchmarking of academic standards for this subject area has been undertaken by a group of subject specialists drawn from and acting on behalf of the subject community. The group's work was facilitated by the Quality Assurance Agency for Higher Education, which publishes and distributes this statement and other benchmarking statements developed by similar subject-specific groups.

The statement represents the first attempt to make explicit the general academic characteristics and standards of an honours degree in this subject area, in the UK.

In due course, but not before July 2003, the statement will be revised to reflect developments in the subject and the experiences of institutions and academic reviewers who are working with it. The Agency will initiate revision and, in collaboration with the subject community, will establish a group to consider and make any necessary modifications to the statement.

* academic review in this context refers to the Agency's new arrangements for external assurance of quality and standards. Further information regarding these may be found in the ***Handbook for Academic Review***, which can be found on the Agency's web site.

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Letter from the Chair of the benchmarking group

UNIVERSITY *of* EXETER

SCHOOL OF CHEMISTRY

Dear Mr Randall

I have pleasure in forwarding to you the General Guidelines for the Academic Review of Bachelors Honours Degree Programmes in Chemistry, which constitutes the outcome of the work of the Agency's Chemistry Benchmarking Group.

As you will be aware, the Guidelines received wide circulation in draft form. The draft was circulated to universities and colleges offering degree courses in chemistry, to trade associations and a selection of large and small chemical and pharmaceutical companies, and to professional bodies and a number of selected individuals in various occupations. The response was encouraging both in terms of the exceptionally high response rate and in the positive tenor of comments and constructive suggestions for change that we received and to which we endeavoured to do justice in finalising the document.

We are conscious that these Guidelines are among the first of many which the Agency will be issuing. As such, they must be viewed as experimental and will no doubt need modification in the light of the trialling to be undertaken during 1999. I and the other members of the Group look forward to these developments with interest.

As required by the Agency, the Group has prepared benchmarking guidelines for BSc Honours courses in chemistry. As well as applying to broadly based specialist programmes in chemistry, we consider that they are relevant to programmes in specialised applications of chemistry (for example, medicinal chemistry, analytical chemistry, etc) and of value for courses in which chemistry constitutes the major study (which are often entitled "Chemistry with..."). The fact that the Agency is addressing the problem of benchmarking joint honours and multidisciplinary studies is well known; the outcome will have implications for a further range of chemistry provision.

In our judgement, confirmed by the consultation process, priority as far as the preparation of further guidelines of direct relevance to chemistry is concerned, should be given to those for MChem / MSci Chemistry courses (Dearing's "higher honours" courses). These courses are now beginning to enrol significant numbers of students. In some, albeit a minority of departments they are becoming the main undergraduate provision; hence the need for the production of these guidelines at the earliest opportunity.

Yours sincerely

Professor E W Abel CBE CChem FRSC
Chairman, Chemistry Benchmarking Group

Academic standards - Chemistry

Introduction

In its consultation paper entitled ***Developing the Quality Assurance and Standards Framework for UK Higher Education***, the Quality Assurance Agency for Higher Education (QAA) advocates the development of 'benchmark information on subject threshold standards' which articulates the abilities and skills expected of bachelors honours graduates in different subjects.

The purpose of such information is to assist:

- higher education institutions in designing and approving programmes of study;
- external examiners and academic reviewers in verifying and comparing standards;
- where appropriate, professional bodies in their accreditation and review of programmes relating to professional competence;
- students and employers when seeking information about higher education provision.

This particular document sets out proposals for the benchmark information in chemistry. It focuses on four major aspects concerning programmes leading to bachelors honours degrees:

i. The major aims and purposes that may be associated with bachelors honours degree programmes in chemistry.

ii. The essential subject-matter components that may be expected to be covered in all study programmes leading to such degrees.

iii. The abilities, competencies and skills to be developed in students through the study of chemistry at bachelors honours degree level.

iv. Recommendations concerning procedures appropriate for the assessment of the knowledge, abilities and skills set out above and the criteria for different levels of attainment.

The specifications and criteria concerning the foregoing points, set out in the following sections of this document, are intended to provide a broad framework within which course providers can develop purposeful and challenging chemistry programmes that respond to the needs of their students, as well as to the changing nature of chemistry. Their purpose is not to impose on institutions a set of rigid conditions that would stifle innovation in programme development and in the design of learning experiences. However, in so far as they seek to articulate the key qualities expected of bachelors honours chemistry students at the end of their degree programme, it is hoped that they will make a valuable contribution to the definition of 'graduateness' in chemistry and the maintenance of the standard of chemistry degrees.

Details of the aims, objectives and content of individual programmes will be found in the programme specifications or other documentation issued by higher education institutions.

Main aims of degree programmes in chemistry

The main aims of bachelors honours degree programmes in chemistry should be:

- To instil in students a sense of enthusiasm for chemistry, an appreciation of its application in different contexts and to involve them in an intellectually stimulating and satisfying experience of learning and studying.
- To provide students with a broad and balanced foundation of chemical knowledge and practical skills.
- To develop in students the ability to apply their chemical knowledge and skills to the solution of theoretical and practical problems in chemistry.
- To develop in students, through an education in chemistry, a range of transferable skills, of value in chemical and non-chemical employment.
- To provide students with a knowledge and skills base from which they can proceed to further studies in specialised areas of chemistry or multi-disciplinary areas involving chemistry.
- To generate in students an appreciation of the importance of chemistry in an industrial, economic, environmental and social context.

Subject knowledge

Each institution providing bachelors honours degree programmes in chemistry is free to decide on the content, nature and organisation of its courses or modules. Therefore, chemistry degree programmes offered by individual institutions will have their own particular characteristics. While it is acknowledged that the depth in which individual aspects are treated may vary with the nature of specific chemistry programmes, it is expected that all programmes will ensure that students become conversant with the following main aspects of chemistry.

- Major aspects of chemical terminology, nomenclature, conventions and units.
- The major types of chemical reaction and the main characteristics associated with them.
- The principles and procedures used in chemical analysis and the characterisation of chemical compounds.
- The characteristics of the different states of matter and the theories used to describe them.
- The principles of quantum mechanics and their application to the description of the structure and properties of atoms and molecules.
- The principles of thermodynamics and their applications to chemistry.
- The kinetics of chemical change, including catalysis; the mechanistic interpretation of chemical reactions.
- The principal techniques of structural investigations, including spectroscopy.
- The characteristic properties of elements and their compounds, including group relationships and trends within the Periodic Table.
- The properties of aliphatic, aromatic, heterocyclic and organometallic compounds.
- The nature and behaviour of functional groups in organic molecules.
- The structural features of chemical elements and their compounds, including stereochemistry.
- Major synthetic pathways in organic chemistry, involving functional group interconversions and carbon-carbon and carbon-heteroatom bond formation.
- The relation between bulk properties and the properties of individual atoms and molecules, including macromolecules.
- Awareness of major issues currently at the frontiers of chemical research and development.

Abilities and skills

At bachelors honours level, students are expected to develop a wide range of different abilities and skills. These may be divided into three broad categories, viz:

a. Chemistry-related cognitive abilities and skills, ie, abilities and skills relating to intellectual tasks, including problem solving;

b. Chemistry-related practical skills, eg, skills relating to the conduct of laboratory work;

c. Transferable skills that may be developed in the context of chemistry and are of a general nature and applicable in many other contexts.

The main abilities and skills that students are expected to have developed by the end of their bachelors honours degree programme in chemistry, are as follows.

a. Chemistry-related cognitive abilities and skills

- Ability to demonstrate knowledge and understanding of essential facts, concepts, principles and theories relating to the subject areas identified above.
- Ability to apply such knowledge and understanding to the solution of qualitative and quantitative problems of a familiar and unfamiliar nature.
- Ability to recognise and analyse novel problems and plan strategies for their solution.
- Skills in the evaluation, interpretation and synthesis of chemical information and data.
- Ability to recognise and implement good measurement science and practice.
- Skills in presenting scientific material and arguments clearly and correctly, in writing and orally, to a range of audiences.
- Computational and data-processing skills, relating to chemical information and data.

b. Chemistry-related practical skills

- Skills in the safe handling of chemical materials, taking into account their physical and chemical properties, including any specific hazards associated with their use.
- Skills required for the conduct of standard laboratory procedures involved in synthetic and analytical work, in relation to both inorganic and organic systems.
- Skills in the monitoring, by observation and measurement, of chemical properties, events or changes, and the systematic and reliable recording and documentation thereof.
- Competence in the planning, design and execution of practical investigations, from the problem-recognition stage through to the evaluation and appraisal of results and findings; this to include the ability to select appropriate techniques and procedures.
- Skills in the operation of standard chemical instrumentation such as that used for structural investigations and separation.
- Ability to interpret data derived from laboratory observations and measurements in terms of their significance and the theory underlying them.
- Ability to conduct risk assessments concerning the use of chemical substances and laboratory procedures.

c. Transferable skills

- Communication skills, covering both written and oral communication.
- Problem-solving skills, relating to qualitative and quantitative information, extending to situations where evaluations have to be made on the basis of limited information.
- Numeracy and computational skills, including such aspects as error analysis, order-of-magnitude estimations, correct use of units and modes of data presentation.
- Information-retrieval skills, in relation to primary and secondary information sources, including information retrieval through on-line computer searches.
- Information-technology skills such as word-processing and spreadsheet use, data-logging and storage, Internet communication, etc.
- Interpersonal skills, relating to the ability to interact with other people and to engage in team-working.
- Time-management and organisational skills, as evidenced by the ability to plan and implement efficient and effective modes of working.
- Study skills needed for continuing professional development.

Assessment procedures and performance criteria

a. Assessment procedures

It is essential that the procedures used for the assessment of students' achievement in chemistry should correspond to the knowledge, abilities and skills that are to be developed through their degree programme.

Evidence on which the assessment of student achievement is based, should include:

- Formal examinations, including a significant proportion of 'unseen' examinations
- Laboratory reports
- Problem-solving exercises
- Oral presentations
- Planning, conduct and reporting of project work.

Additional evidence of use for the assessment of student achievement may be derived from:

- Essay assignments
- Portfolios on chemical activities undertaken
- Literature surveys and evaluations
- Collaborative project work
- Preparation and displays of 'posters' reporting project work
- Reports on external placements (where appropriate).

b. Performance criteria

Although all students graduating at bachelors honours level in chemistry are expected to demonstrate that they have acquired knowledge, abilities and skills in the areas identified in the foregoing sections, it is accepted that there will be significant differences in their attainment. The following criteria are suggested as indicators of different levels of attainment in these performance areas. These attainment levels are not meant to reflect the traditional degree classifications.

Attainment Level A (highest):

- Knowledge base is extensive and extends well beyond the work covered in the programme. Conceptual understanding is outstanding.
- Problems of a familiar and unfamiliar nature are solved with efficiency and accuracy; problem-solving procedures are adjusted to the nature of the problem.
- Experimental skills are exemplary and show a thorough analysis and appraisal of experimental results, with appropriate suggestions for improvements.
- Performance in transferable skills is generally very good.

Attainment Level B:

- Knowledge base covers all essential aspects of subject matter dealt with in the programme and shows some evidence of enquiry beyond this. Conceptual understanding is good.
- Problems of a familiar and unfamiliar nature are solved in a logical manner; solutions are generally correct or acceptable.
- Experimental work is carried out in a reliable and efficient manner.
- Performance in transferable skills is sound and shows no significant deficiencies.

Attainment Level C:

- Knowledge base is sound, but is largely confined to the content of the programme. Level of conceptual understanding is generally sound.
- Problem-solving ability is sound in relation to problems of a familiar type or those that can be tackled through the straightforward application of standard procedures and / or algorithms.
- Experimental work is generally satisfactory and reliable.
- Performance in transferable skills is largely sound.

Attainment Level D:

- Knowledge and understanding of the content covered in the course are basic.
- Problems of a routine nature are generally adequately solved.
- Standard laboratory experiments are usually carried out with reasonable success though significance and limitations of experimental data and / or observations may not be fully recognised.
- Transferable skills are at a basic level.

Attainment Level E: (lowest)

- Knowledge base is acceptable in relation to some of the content covered in the programme.
- Problem-solving ability extends to simple 'standard' problems, following routine procedures.
- Experimental skills are rudimentary.
- Transferable skills are rudimentary.

c. Threshold performance for bachelors honours degrees

Students who are awarded a bachelors honours degree in Chemistry are expected to demonstrate knowledge, abilities and skills corresponding on balance to at least attainment level D.

Chemistry benchmarking group membership

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