THE CHEMICAL TECHNOLOGY "EUROMASTER"

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The Aims of the EUROMASTER®

The primary aims of the EUROMASTER® qualification are to provide a second cycle degree of the highest standard which will be:

- *recognised by other European institutions as being of a standard which will provide automatic right of access (though not right of admission, which is the prerogative of the receiving institution) to appropriate doctoral programmes.*
- *recognised by employers as being of a standard which fit the graduates for employment as professional chemists in chemical and related industries or in public service*
- *recognised by the European Chemist Registration Board of EuCheMS as meeting the educational standard necessary to allow the graduates to obtain the status of European Chemist.*

It must be made clear at the outset that each institution providing Master-type degree programmes in chemistry is completely free to decide on the content, nature and organisation of its courses or modules. These degree programmes must relate to the European Qualifications Framework for the European Higher Education Area (EHEA) and to the corresponding National Qualifications Framework. Chemistry degree programmes offered by individual institutions will thus logically have their own particular characteristics. The extent to which individual aspects are treated will vary with the nature of specific programmes.

The Chemical technology EUROMASTER® is a parallel quality label to the Chemistry EUROMASTER® and is aimed at those programmes where chemical technology and chemical engineering prevail to the extent that the classic Chemistry EUROMASTER® is fit for the purpose.

The ECTNA Label award is an accreditation, i.e. it is a service to institutions, which COMPLEMENTS but is in no way intended to THREATEN or COMPETE WITH national accreditation systems. It is therefore expected that programmes with labels will be accredited in the normal way, if this is required by national or local regulations.

Outcomes: The Descriptor

The goals of a second cycle study programme can be described by the "Budapest" Descriptors developed in May 2005 by the Chemistry Subject Area Group working in the project "Tuning Educational Structures in Europe". They are as follows:

Second cycle degrees in chemistry are awarded to students who have shown themselves by appropriate assessment to:

- have knowledge and understanding that is founded upon and extends that of the Bachelor's level in chemistry, and that provides a basis for originality in developing and applying ideas within a research context;
- have competences which fit them for employment as professional chemists in chemical and related industries or in public service;
- have attained a standard of knowledge and competence which will give them access to third cycle course units or degree programmes.

Such graduates will:

- have the ability to apply their knowledge and understanding, and problem solving abilities, in new or unfamiliar environments within broader (or multidisciplinary) contexts related to chemical sciences;
- have the ability to integrate knowledge and handle complexity, and formulate judgements with incomplete or limited information, but that include reflecting on ethical responsibilities linked to the application of their knowledge and judgements;
- have the ability to communicate their conclusions, and the knowledge and rationale underpinning these, to specialist and non-specialist audiences clearly and unambiguously;
- have developed those learning skills that will allow them to continue to study in a manner that may be largely self-directed or autonomous, and to take responsibility for their own professional development.

Transition to the Third Cycle

The chemical technology EUROMASTER® should, provided that his/her performance has been of the required standard, be able to continue his/her tertiary education either at his/her degree-awarding institution, at another equivalent institution in his/her home country, or at an equivalent institution in another European country. (At a later stage one can hope that world-wide acceptance of the EUROMASTER® qualification will come into being).

This continuation will take the form of a course leading to a doctoral degree, either in chemical technology, chemistry or in related fields. Any master programme must end with a Thesis, as this will generally be considered to be the necessary prerequisite for access to the Bologna third cycle.

It is of pre-eminent importance that institutions offering EUROMASTER® qualifications aim for high standards, so as to give their students good chances in the national or international job market as well as a good starting point to transfer to doctoral programmes should they wish to do so.

Master Programmes in the Context of Bologna

As a result of the Bologna Declaration, there are moves under way throughout Europe to revise degree structures. As decided at the Berlin conference in September 2003, a three-cycle structure is to be implemented ("BSc/MSc/PhD"). However, there is no general agreement on introducing the "3-

5-8" model which has sometimes been misunderstood as the Bologna "recommendation".

The Helsinki Master Conference of March 2003 provided the following recommendation: Master study programmes should involve 90-120 credits, at least 60 of which must be at Master level. This recommendation was used in defining the Second Cycle in the Qualifications Framework for the EHEA. Master programmes with a research orientation form a link between the EHEA and the European Research Area.

In this European Qualifications Framework, the length of the Bachelor degree is defined as 180 to 240 credits.

Thus any national requirement that a combination of Bachelor and Master must be necessarily equivalent to 300 credits is contrary to the provisions of the European Qualifications Framework, which foresees a "corridor" of 270 (180 + 90) to a maximum of 360 (240 + 120) credits for a combination of Bachelor and Master. Mobile students must not be penalised by not allowing a Bachelor graduate with a 180-credit degree to take a 90-credit Master.

EUROMASTER® programmes will normally require 90-120 ECTS credits.

Countries which have traditionally had "long" degrees qualifying for admission to PhD training will generally consider the Master programmes which they introduce to be similar in aim to the higher semesters in their earlier long degrees, but must of course not simply split long programmes into two (unequal) parts, which they then label Bachelor and Master.

Judging the Quality of EUROMASTER® Programmes: "Fitness for Purpose"

Since it is neither necessary nor advisable to set up stringent parameters for a Master programme in chemical technology, the question immediately arises as to how a programme can be judged when a "EUROMASTER® Label" is under consideration.

The "Budapest Descriptor" gives a global description of the aims of such a programme, and institutions are advised on the basis of this descriptor to start planning their programme by drafting a statement which defines the aims and the profile of the programme. Such a statement, which will probably run to between one and two pages of A4 text when a 12-point typeface is used, will describe the elements of the programme with reference to the above descriptor. It will describe the skills and competences which the graduate will have amassed at the end of the programme.

This statement defines the purpose of the programme, and the accreditation process will then be designed to find out whether the programme as set out in detail in the application is fit for the purpose for which it is designed.

The points which follow should be mentioned as appropriate in the statement of aims and profile, and will be the subject of questions in the Guidelines for Applicants.

Access and Entry

According to the conclusions of the Helsinki conference on Master degrees the implication is that: "All bachelor degrees should open access to master studies and all master degrees should give access to doctoral studies". Access is also considered in detail in the Lisbon recognition convention, which has so far been ratified by 40 countries and international institutions.

The prerequisite for entry will be either a qualification of EUROBACHELOR® standard or a first cycle degree in one of the disciplines defined by the institution for that particular programme.

Transnational mobility at the Bachelor/Master interface will often involve setting up admissions procedures at a level previously unknown in many European countries. While European students will be aided by their possession of the Diploma Supplement, the detailed information which the latter contains may often not be available for students from countries outside the EHEA.

If Europe wishes to compete with countries such as the USA for the best graduate students, it must offer structures and possibilities as least as good as those present in such countries. Many regret that in the USA a Master in chemistry will very often in fact be a "failed PhD", and they plan to develop high quality programmes leading to Masters who are not failed PhD's.

The Number of Credits

As stated above, Master study programmes should involve 90-120 ECTS credits, at least 60 of which must be at Master level. A normal academic year corresponds to 60 ECTS credits, a European average workload of 1500 hours and an average of 40 weeks per year during which the student will be studying.

Why the emphasis on "at Master level"? Because of the expected flexibility of Master programmes, it may for example be possible in a particular institution for a Physics Bachelor to enrol as a Chemistry or Chemical technology Master. In such a case, the Master candidate may well have to make up work (at Bachelor level) in order to be able to reach the defined learning outcomes.

Depending on the structure of the individual programme and the number of credits involved, these may be EXTRA credits or may be included in the 90 or 120 which the complete programme carries. **Such "bridging" modules or course units must be given credit and mentioned in the Diploma Supplement**.

The Master Thesis

The academic goal of the Master degree in the chemical sciences is to give graduates a research or development experience much broader and deeper than that involved in the limited Bachelor Thesis. The intention is the graduate will successfully complete a project, the outcome of which is of a quality that is potentially publishable or usable in industrial practice. **Thus the Master Thesis should normally carry at least 30 credits**. In the case of chemical technology the Master Thesis may also (in part or solely) contain the results of the student industrial placement or interim (sandwich) working period, or a part of an officially established cooperation between a university and an industrial company.

The Thesis will be written in the language prescribed by the institution and defended according to the rules of the institution. It should be remembered that Thesis presentation can be used as a tool for improving presentation skills, also in a foreign language.

The supervision (and assessment) of the Master thesis must be transparent.

Teaching Staff

The thesis supervisors referred to above bear a heavy responsibility in the Master programmes, as indeed do all members of staff involved at teaching at this level. Institutions applying for a EUROMASTER® Label will be asked to provide brief details of the members of the teaching staff involved in the degree programme and of their recent publication records, realized industrial projects, patents and other scholarly activity.

This information is necessary in order to judge the background of the programme. Naturally no outside interference in the teaching staff policy of the institution is intended.

Outcomes: Subject Knowledge

By its very nature, a Master programme will be much more flexible than a Bachelor programme. It is therefore neither necessary nor advisable to list areas of subject knowledge which the programme should cover. According to the needs of the institution, such programmes will be either broadly-based or specialised. Thus the second cycle graduate will often have an in depth knowledge of an area of specialism in chemical science.

EUROMASTER® programmes will have NO defined "core" comparable to the "core" of 90 credits in the EUROBACHELOR® framework. However, the chemical technology Master programme is expected to include content from the main areas of analytical, inorganic, and organic chemistry, chemical technology, chemical engineering, physical chemistry, biological chemistry, and materials science.

Outcomes: Abilities and Skills

In addition to the aspects covered in the Descriptor, the following points should be taken into account.

At EUROMASTER level, students coming from a chemistry EUROBACHELOR® background are expected to develop further the range of abilities and skills already gained in the EUROBACHELOR® programme. If they come from a different undergraduate background, these abilities and skills may not always be present, but may need development during the Master phase.

The abilities and skills may be divided into three broad categories:

a. Chemistry and chemical technology-related cognitive abilities and skills, i.e. abilities and skills relating to intellectual tasks, including problem solving;
b. Chemistry and chemical technology-related practical skills, e.g. skills relating to the conduct of laboratory work;
c. Generic skills that may be developed in the context of chemical technology and are of a general nature and applicable in many other contexts. The generic skills defined in the Eurobachelor® document, which need to be developed further as appropriate during the Master phase, are listed in **Appendix 1**.

The main abilities and skills that students are expected to have by the end of their EUROMASTER® programme in chemical technology, are as follows.

a. Chemical technology-related cognitive abilities and skills

Ability to demonstrate knowledge and understanding of essential facts, concepts, principles and theories relating to the subject areas studied during the chemical technology master programme.

Ability to apply such knowledge and understanding to the solution of qualitative and quantitative problems of common nature.

Ability to adopt and apply methodology to the solution of unfamiliar problems.

b. Chemical technology-related practical skills

Skills required for the conduct of advanced laboratory or pilot plant procedures and use of instrumentation in synthetic and analytical work.

Ability to practically apply the principles of systemic problem solving, e.g. to design and carry out experiments efficiently and independently, to be self critical in the evaluation of experimental and measuring procedures, processes and outcomes, to use understanding of the limits of accuracy of experimental or monitoring data, to use mathematical models or application software for real technological optimization, innovation or revamping tasks.

Ability to take responsibility for laboratory or production facility work. Ability to demonstrate work in safety regulated together with good manufacturing practice environment.

c. Generic skills

Study skills needed for continuing professional development.

Ability to interact with scientists from other disciplines on inter or multidisciplinary problems.

Ability to assimilate, evaluate and present research results objectively

Curricular Structure

It is highly recommended that the EUROMASTER® course material should be presented in a modular form, whereby modules should correspond to at least 5 credits. The use of double or perhaps triple modules can certainly be envisaged, the Master Thesis requiring at least 30 credits. Apart from the Master Thesis, it appears logical to define modules as being compulsory, semi-optional (where a student is required to select one or more modules from a limited range), and elective (where the student may choose one or more modules from a normally much wider range).

Students must be informed in advance of the expected learning outcomes for each module.

Each individual institution will of course make its own decision as to the distribution of credits between compulsory, semi-optional and elective modules.

Because EUROMASTER® programmes will often allow the student a considerable amount of freedom of choice when selecting course units or modules, institutions should provide

study advisers to give guidance on course unit/module selection.

Language

At EUROMASTER® level, where the research or development component forms a main component of the programme, language proficiency must include communication competences in English, the lingua franca of scientific communication. Competences in reading and understanding English should be achieved automatically, since the vast majority of the chemical literature to be consulted and communication in multinational companies is now in this language.

ECTS and Student Workload

A European average for the total (expected) student workload per year is close to 1500 hours; this figure refers to full-time students in a standard academic programme. For most institutions, this is based on a working week of 40 hours. Thus it is important to have clear guidelines on student workload distribution. These should always include definition of pre-examination study periods and examination periods separate from the teaching period, as these periods form an integral part of the total workload.

When defining workload for the different teaching/learning elements of a degree course it must be taken into account that, for example, the total workload connected with a 1-hour lecture is different than that corresponding to 1 hour of practical work.

Initial institutional estimates of workload for the average student will of course not necessarily be correct; thus there must be a clear mechanism for continuous student feedback on actual workload and the use of this feedback to correct the structure of programmes where necessary.

Modules and Mobility

Mobility must be an important feature of EUROMASTER® qualifications. It should be possible throughout the course, but particularly at the Thesis level, where use can be made of existing research cooperation with external partners.

Mobility will be restricted unnecessarily if institutions define a high proportion of course modules as being "non-transferable", i.e. they must be taken at the home institution.

Modules or course units should be fully described as detailed on p.28 of the ECTS Users Guide (http://ec.europa.eu/education/lifelong-learning-policy/doc/ects/guide_en.pdf). Thus the following information is necessary for each course unit:

- Course unit title
- Course unit code
- Type of course unit
- Level of course unit
- Year of study (if applicable)
- Semester/trimester when the course is delivered
- Number of ECTS credits allocated (workload based)
- Name(s) of lecturer(s)
- Learning outcomes of the course unit
- Prerequisites
- Course contents
- Recommended or required reading
- Planned learning activities and teaching methods
- Assessment methods and criteria
- Language of instruction

Compensation

The Chemical technology EUROMASTER® does not recommend compensation (in which failed modules/course units are considered to be "passed" because of an overall grade average).

Recognition of Credits Gained Abroad

The EUROMASTER® is concerned with mobility and recognition. Thus EUROMASTER® institutions must guarantee automatic recognition of credits gained at foreign host institutions if they have been obtained according to the terms of a learning agreement. The EUROMASTER® institution must comply with the standard ECTS procedures:

- Learning agreements must be concluded with students going abroad before their departure and corrected if necessary during the stay at the host institution
- Because the learning agreement is a contract, it must be signed by someone in the EUROMASTER® institution who is responsible for recognition as well as by the student and a responsible representative of the host institution
- Credits gained which are listed in the learning agreement must be recognised automatically and should be referred to or listed in the Diploma Supplement issued to the graduate. Alternatively, the Transcript of Records issued by the host institution can be appended to the Diploma Supplement.
- Grade transfer, if it occurs, must be carried out on the basis of ECTS rankings. If the foreign host institution does not use ECTS rankings, a procedure for grade transfer must be used which does not result in “downgrading” of the grades awarded by the host institution

Methods of Teaching and Learning

A wide variety of learning and teaching approaches is to be recommended. The element of research involved in a EUROMASTER® course will, as stated above, be considerable.

Lectures should be supported by multimedia teaching techniques wherever possible and also by problem-solving classes. These offer an ideal platform for teaching in smaller groups, and institutions are advised to consider the introduction of tutor/mentor systems as a standard feature of Master programmes, where the student will need guidance on his or her study programme because of the initially unexpected degree of freedom in choosing modules/course units.

Assessment procedures and performance criteria

The assessment must be designed to cover the defined learning outcomes.

a) Coursework

The assessment of student performance must involve as many procedures as possible, such as:

- Written examinations
- Oral examinations
- Laboratory and individual projects reports
- Excursion and professional practice reports
- Problem-solving exercises
- Oral presentations
- Preparation and displays of posters reporting thesis or other work.

Since EUROMASTER® programmes are credit-based, assessment should be carried out with examinations at the end of each term or semester. It should be noted that the use of ECTS does not automatically preclude the use of "comprehensive examinations" at the end of the degree course; if these are used they must however also be included in the credit distribution process and carry appropriate credits!

Examination questions should be problem-based as far as possible; though essay-type questions may be appropriate in some cases, questions involving the reproduction of material learned more or less by heart should be avoided as far as possible.

Members of the teaching staff should aim for a consistent and transparent policy on assessment.

b) The Thesis

To ensure comparability of standards throughout institutions operating the programme, a significant part of the assessment should be 'competence based'. Different levels of performance clearly need to be defined, and this can be facilitated through a series of statements which describe student skills, attitude and behaviour during the Master Thesis. Attainment levels achieved by particular students can then be judged and compared. For example, keys to a successful Master Thesis are the intellectual and scientific input of the student, the comprehension of the project, organisation and planning besides a well-written report.

The following two statements might encapsulate the range of abilities expected of students under the heading of Intellectual and scientific input: 'The student demonstrated an enquiring mind and an ability to innovate by controlling the direction of the project' and 'The student provided a technical rather than an intellectual contribution to the project'. Such statements can be equated to a mark or grading. Use of such grading tools allows us to move beyond the sometimes subjective assessment of a written document which only reports on the outcome and background to a project. Used in conjunction with a report, student log book, oral presentation and poster, such a range of assessments can provide a very accurate picture of student ability.

Grading

While the national grading systems will be used initially, it seems necessary to aim for the establishment of a recognised pan-European grading system.

The Diploma Supplement

All chemical technology EUROMASTERs® must be provided with a European Diploma Supplement (as described under http://ec.europa.eu/education/lifelong-learning-policy/doc/ds/ds_en.pdf or on p.57 of the ECTS Users Guide) in English and if required in the language of the degree-awarding institution.

Quality Assurance

The chemical technology EUROMASTER® designation will be a quality label and must involve national chemical societies and their pan-European counterpart (the European Association for Chemical and Molecular Sciences (EuCheMS)) as well as wider European chemistry organisations such as CEFIC and AllChemE. It will thus involve the formation of one of the first trans-national European quality assurance networks in the European Higher Education Area.

Appendix I

Generic competences as defined in the EUROBACHELOR® framework

- The capacity to apply knowledge in practice, in particular problem-solving competences, relating to both qualitative and quantitative information.
- Numeracy and calculation skills, including such aspects as error analysis, order-of-magnitude estimations, and correct use of units.
- Information-management competences, in relation to primary and secondary information sources, including information retrieval through on-line computer searches.
- Ability to analyse material and synthesise concepts.
- The capacity to adapt to new situations and to make decisions.
- Information-technology skills such as word-processing and spreadsheet use, data-logging and storage, subject-related use of the Internet.
- Skills in planning and time management.
- Interpersonal skills, relating to the ability to interact with other people and to engage in team-working.
- Communication competences, covering both written and oral communication, in one of the major European languages (English, German, Italian, French, Spanish) as well as in the language of the home country.
- Study competences needed for continuing professional development. These will include in particular the ability to work autonomously.
- Ethical commitment.

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