Science Higher Education in 2015 and beyond
Response from the Royal Society of Chemistry to the Royal Society

Response to section A. The nature of the benefits of to a student that accrue from studying an STM subject at HE level, whatever their future occupation.

Evidence from the PriceWaterhouseCoopers report 'The Economic Benefits of Higher Education Qualifications' (commissioned by the RSC and IoP), indicates the excellent financial rewards of completing a chemistry or physics degree. Over a working lifetime, the average graduate will earn around 23% (£129,000) more than his/her equivalent with two or more A Levels; however, chemistry and physics graduates earn around 30% (£185,000 - £190,000) more during their working lifetimes than A Level holders. The figure of 30% compares with between 13 and 16% for graduates in subjects including psychology, linguistics, English and history. While all graduate earnings show a steady increase in the early career years, a marked difference is observed in the mid-career years, with particular growth being associated with chemistry and physics compared with other subjects.

While studying for a chemistry degree, students develop a wide range of transferable skills in addition to their specialist scientific knowledge. These include communication skills, analytical skills, time management, numeracy, team-working and creativity. Such skills are very desirable to future both chemistry-using and non-chemistry-using employers.

Response to section B. The demand for STM graduates from the economy and wider society, and how it is changing.

A recent internal study at the RSC found demand for chemistry graduates by the main recruiters of UK graduate and doctorate chemists has remained steady throughout the period 1995-2002. This is despite mergers, recruitment freezes and total first degree graduate numbers falling over that period. Based on current information, this steady recruitment is predicted to continue over the next 5 years with little change in the skills base. The RSC is continuing this study into other UK recruiters of chemists, the findings of which will be used to provide information to UK universities in seeking to meet this demand.

With approximately 50% of first degree and doctoral graduates being employed in a sector and/or job closely related to chemistry, and often drawing on their general scientific background, it is crucial to maintain and increase the numbers of students graduating in chemistry from UK universities.

All this comes at a time when chemistry has never been so important, demand for chemistry graduates from non-vocational sectors is increasing and chemistry is becoming increasingly multidisciplinary and thus underpinning many other areas of UK industry.

Response for section C. The quantity of those graduating at all levels of the higher education system, and the quality, depth and breadth of their educational and training experiences.

The RSC is charged with establishing, upholding and advancing the standard of qualification, competence and conduct of those who practise chemistry as a profession. Such persons are characterised by the award of the Chartered Chemist (CChem) designation. The RSC ensures that the quality of chemistry higher

education in the UK addresses the professional need by accrediting degree courses for satisfying the academic requirements for CChem. The RSC accreditation standard is set at the full professional level (Masters, 2nd cycle Bologna).

The RSC recognises the continually evolving needs of the profession and its accreditation criteria are permissive to allow innovation in teaching. For this reason, there is no prescribed syllabus or specification for accredited degrees. Instead RSC accreditation criteria emphasise the necessity for students to apply their knowledge and solve unfamiliar chemical problems both in terms of breadth of study at a threshold level of competence and depth of study. RSC accreditation also requires course providers to address practical-based skills, varied assessment strategies, transferable skills and student development within a research context.

Accreditation criteria are reviewed periodically through RSC governance in order to ensure they continue to address contemporary professional practice and are fit for purpose (we are currently conducting a review). Such reviews are inclusive of both academic and industrial communities.

PhD level education has recently been reviewed by an international team on behalf of the EPSRC. A central finding of the review was that the educational aspects of programmes need to be developed to create not just the next generation of researchers, but also of research leaders – the latter requiring a more thorough scientific grounding beyond their immediate research topic.

Also see response to Section D.

Response to D. The length of time HE studies should take, and how that time should be broken down (with reference to the Bologna proposals to standardise the structure of HE across Europe).

The UK is a signatory to the Bologna agreement and will be chairing the 2007 unilateral meeting. However, the UK government has largely ignored the changes currently in place in continental universities, to the growing disadvantage of UK HE.

The three cycle system proposed by the Bologna Process offers a number of educational advantages and the 3+2+3 approach would not lengthen the current overall study time to PhD of eight years (commonly four years of MSci followed by four years of PhD) in England.

There is a growing body of opinion in the chemistry community that there is insufficient differentiation between BSc (Hons) and MChem/MSci. Employers who recruit internationally are increasingly commenting that UK MChem/MSci graduates have an insufficient opportunity to develop the understanding and practical competencies acquired by their continental counterparts during their Masters programmes.

With increasing participation rates in HE, a three year programme for the Bachelors phase would enable a wide range of offerings. For the future professional, a two year programme for Masters, either continuing in science or in a different field (e.g. management) would be a better model educationally, giving time for in-depth studies and a major project. This would lead to professional level employment or a PhD programme. Other advantages for student mobility and for the competitiveness of UK HE would also accrue.

Response to section E. The current discipline boundaries, and whether a general science first degree option could be appropriate.

There are currently numerous HE courses on offer that combine two or more of the sciences. 'Chemistry with…' (e.g. chemistry with environmental science and chemistry with bioscience) and 'chemistry and…' (e.g. chemistry and molecular physics, chemistry and nanomaterials science) degrees are offered at many UK universities. Students who undertake 'chemistry with…' courses generally spend about two thirds of their time studying chemistry and the remainder studying another subject, while 'chemistry and…' courses tend to involve students spending 50% of their time studying chemistry and 50% studying another subject.

An interdisciplinary science ('i-science') course has also been developed and is currently available at the University of Leicester. This is the first degree course of its kind in the UK and integrates all the sciences with the teaching of real-world problem solving skills at the university level.

Degrees such as the i-science course provide students with a sound basis in the knowledge and skills required for careers in a range of sectors. These include science communication, teaching and non-chemistry-using sectors that value the transferable skills that students develop whilst studying for a science degree, for example strong numerical and analytical skills may be valued in financial roles.

In the interests of improving the accessibility of UK HE science degrees, a range of options should be available for students to choose from. This diversity is key to meeting not only the needs of the students, but those of employers as well.

The *Chemistry for our Future* (CFOF) programme will explore curriculum development. Strand 3.2 of the project will look at 'Chemistry for all – alternative approaches to chemistry curricula' and will aim to develop a forward looking model for 21st century chemistry courses, enhance the scientific literacy of the general population, increase the skill base available to high tech industries and foster widening participation through producing a chemical science degree with appeal to a broader range of young people. The objectives are to:

- build new chemical science programmes based on successful modern approaches to teaching, including context-based and problem-based learning (these are likely to include interdisciplinary elements),
- attract, engage, and motivate students by emphasising career and vocational issues, and linking this to courses that emphasise interdisciplinarity and generic skills.
- Effect a sea change in the teaching of higher education chemistry, through dissemination of successful new methods of teaching and learning.

A wide range of course content and of teaching and learning approaches should be available to prospective students. However, there are two consequences:

i) The progress of science is often interdisciplinary. Many of the challenges in both academe and industry are tackled by multidisciplinary teams. However, each member of such a team has expertise in his/her core discipline, allied to an ability to interact with colleagues from other disciplines. Employers very much prefer to recruit graduates with competence in a core scientific discipline rather than a generalist.

ii) With a wide range of options in HE, prospective students need much better careers advice than is currently available. HE, professional bodies, employers and the careers services all have roles to play in this.

Response to section F. The changes to the skills, knowledge and experience of those entering the HE system and how the HE system can accommodate these changes.

A Level (or equivalent) mathematics is no longer an entry requirement for most chemistry degree courses in UK universities. This means that many students entering onto HE chemistry courses are under-equipped to cope with the level of mathematics associated with chemical science degrees. The RSC is currently collecting data on the extent of this problem.

Maths support classes have been introduced on some chemistry courses to help students get up to speed with the mathematical knowledge required. The RSC is also looking into ways of supporting HE chemistry on this issue.

Over the past few years there is much anecdotal evidence, in particular from students, that practical work in secondary schools is not very inspiring. The RSC-commissioned report 'Laboratories, resources and budgets' indicates that around 65% school laboratories have been found to be in an unsafe, unsatisfactory or uninspiring condition. This is likely to have a negative effect on students' experiences of science at school and raises concerns that some school students may be turned off studying science further. The formulaic nature of the assessment of practical work at GCSE and A Level is a constraint on lessons.

Another frequently cited reason for the downturn in exciting practical work is the misconception that many of the more adventurous experiments are now banned, which in many cases is untrue. The RSC-commissioned report 'Surely that's banned?' highlights the extent of some of these misunderstandings and has been widely distributed to relevant parties in an attempt to raise awareness of this issue.

Outreach initiatives which allow school students access to good quality university science laboratories can help overcome the problem of poor laboratory facilities in schools. Such projects are already being conducted, for example as part of the *Chemistry: The Next Generation* pilot. Better use of existing university laboratory facilities will also be explored as part of the *Chemistry for our Future* programme.

Key educational interfaces will be explored in detail as part of the *Chemistry for our Future* programme, in an attempt to smooth the transition from school to university for students. This will be done through a Fellowship programme; Academic Fellows will spend time in schools and Teacher Fellows will spend time in universities. It is hoped that this will improve understanding of both school and HE curricula between institutions.

It should be noted that the GCSE science criteria has been reviewed and that new specifications for GCSE science will operate from 2006. The A Level criteria for science is currently under review, including practical work.

Section G.

No response.

Response to section H. The increasing number of students who choose to study later in their lives, and/or part-time, and/or have geographic limitations on where they can study.

With the increasing rate of participation in HE by school leavers, it may be the case that fewer students will be engaging with HE for the first time as mature students (contrary to what is stated above). Also, with increasing participation, widespread convenient access and part-time opportunities need to be provided. The latter have largely disappeared in chemistry.

Section I.

No response.

Response to section J. The impact, on the UK, of international flows of students and STM professionals.

At undergraduate level the average percentage of non-UK domiciled students in science (physical science, biological science, mathematical science and computer science) is 6. Chemistry sits at the average.

The core science subjects would benefit from an influx of non-EU foreign students not least because of the income they bring with them. The RSC has noted before that to meet commitments to increase the percentage of GDP spent on science more scientifically skilled people are needed and one source of such people is overseas, either as students or already qualified.

At postgraduate level around a third of students are non-UK. In fact this proportion is greater at 'stand alone' Masters level than at doctorate level. Chemistry again lies very close to the average figure. Such a high percentage indicates that people abroad value a UK research training. As noted above the UK needs trained people, not only to provide a flow of people through university science departments but also to enrich the economy. The RSC would urge a pragmatic approach to foreign postgraduates upon completion of their courses. In fields where the UK may be experiencing shortages of skilled people, consideration should be given to granting these highly skilled graduates work permits. In doing this, care must be taken not to denude third world countries of skilled personnel.

See Appendix 2 for data on postgraduates from the HESA student dataset 2004/2005.

Additional Comment

Please see the Annex to this response.

The RSC has considerable internal expertise in the handling of data, especially data purchased form HESA. In fact the RSC holds large HESA datasets in databases in which these data can be manipulated easily. The RSC would be happy to share knowledge and to work with the Royal Society on aspects of this study.

Section K.

No response.

Section L. The nature of employment of chemists.

As referred to in Section B, the demand for chemistry graduates from non-vocational sectors is increasing. This is a consequence of the huge diversity of skills learnt and training received whilst undertaking a chemistry degree. These skills stretch from creativity, through organic synthesis, to problem solving and analytical thinking. As these skills are core to much of UK industry, chemistry graduates are now being sought by a growing number of sectors thus increasing the employability of a chemistry graduate.

It is crucial for the UK universities to meet the needs and demands of UK industry and would therefore like the Royal Society to reflect this within the study and working group membership.

Appendix 1 - supporting documents

The economic benefits of higher education qualifications - http://www.rsc.org/Education/Policy/EconomicBenefitsofHE.asp

Chemistry at the Centre: an international assessment of university research in chemistry in the UK - http://www.epsrc.ac.uk/ResearchFunding/Programmes/Chemistry/ReviewsAndConsultations/ChemistryInternationalReview.htm

Surely that's banned? – http://www.rsc.org/Education/Policy/SurelyThatsBanned.asp

Laboratories, resources and budgets – http://www.rsc.org/Education/Policy/Laboratories2004.asp

Study of the costs of chemistry departments in UK universities - http://www.rsc.org/ScienceAndTechnology/Policy/CostsOfChemistryDepartments.asp

Appendix 2 - Data from the HESA student dataset 2004/2005

Postgraduate Subject	Overseas Domicile		UK Domicile		Grand Total
Broadly-based programmes within physical sciences	1	100%	0	0%	1
Broadly-based programmes within mathematical sciences	19	76%	6	24%	25
Artificial intelligence	76	71%	31	29%	107
Others in computing sciences	42	59%	29	41%	71
Operational research	263	54%	226	46%	489
Computer science	6462	48%	7080	52%	13542
Genetics	313	43%	415	57%	728
Others in mathematical & computing sciences	85	40%	126	60%	211
Statistics	524	40%	777	60%	1301
Botany	136	38%	221	62%	357
Software engineering	635	38%	1057	62%	1692
Zoology	156	38%	260	63%	416
Materials science	76	37%	129	63%	205
Forensic & archaeological science	344	35%	647	65%	991
Microbiology	545	34%	1049	66%	1594
Information systems	2240	34%	4375	66%	6615
Chemistry	1722	31%	3775	69%	5497
Mathematics	1013	31%	2235	69%	3248
Molecular biology, biophysics & biochemistry	746	31%	1666	69%	2412
Physical & terrestrial geographical & environmental sciences	1517	31%	3424	69%	4941
Physics	1005	29%	2460	71%	3465
Biology	1281	28%	3242	72%	4523
Ocean sciences	96	27%	255	73%	351
Geology	370	27%	996	73%	1366
Others in biological sciences	484	23%	1605	77%	2089
Astronomy	68	21%	259	79%	327
Sports science	221	16%	1170	84%	1391
Psychology	1635	15%	9150	85%	10785
Others in physical sciences	79	9%	754	91%	833
Broadly-based programmes within biological sciences	3	4%	81	96%	84
Grand Total	22157	32%	47500	68%	69657

Undergraduate Subject	Overseas Domicile		UK Domicile		Grand Total
Materials science	26	38%	43	62%	69
Others in mathematical sciences	1	25%	3	75%	4
Operational research	76	21%	279	79%	355
Artificial intelligence	57	15%	322	85%	379
Genetics	242	15%	1402	85%	1644
Microbiology	269	12%	1979	88%	2248
Molecular biology, biophysics & biochemistry	747	12%	5666	88%	6413

Software engineering	482	10%	4190	90%	4672
Computer science	6447	10%	58783	90%	65230
Mathematics	1317	8%	15174	92%	16491
Statistics	122	8%	1412	92%	1534
Information systems	1776	6%	27072	94%	28848
Physics	502	6%	7748	94%	8250
Biology	1009	6%	16446	94%	17455
Chemistry	644	6%	10587	94%	11231
Broadly-based programmes within mathematical sciences	19	5%	328	95%	347
Broadly-based programmes within physical sciences	34	5%	600	95%	634
Ocean sciences	32	5%	568	95%	600
Physical & terrestrial geographical & environmental sciences	682	5%	14248	95%	14930
Astronomy	63	5%	1327	95%	1390
Psychology	2006	4%	44269	96%	46275
Forensic & archaeological science	113	4%	2518	96%	2631
Zoology	124	4%	3205	96%	3329
Geology	183	3%	5160	97%	5343
Others in physical sciences	51	3%	1468	97%	1519
Broadly-based programmes within biological sciences	9	3%	330	97%	339
Botany	10	3%	384	97%	394
Sports science	361	2%	17198	98%	17559
Others in biological sciences	239	2%	11986	98%	12225
Others in computing sciences	11	2%	678	98%	689
Others in mathematical & computing sciences	18	2%	1140	98%	1158
Grand Total	17672	6%	256513	94%	274185