The Physics Experience of Chemistry Students Part II

Background

Changes to the key stage 4 curriculum have dictated the redevelopment of GCSE Science specifications by all awarding bodies for first teaching in schools from September 2006.

Introduction

We are accustomed to dealing with the mathematical deficiencies of our students, but may have paid little attention to similar problems with physics. The majority of students have not studied physics beyond GCSE level and it is appropriate to consider the consequences of this. Most of these are obvious, but like all such conclusions, it is useful to gather them together to focus attention.

- Many students in the past have taken GCSE double science. The implication is that they have studied biology, chemistry and physics (three subjects) in the space allocated to two subjects. This has now been replaced from 2006 by Science A plus Additional Science A.
- Students who do not continue with physics beyond GCSE will have had a gap of at least two years before entering university. There will have been no reinforcement of this knowledge and they are likely to have forgotten most of what they learned before.

The basic GCSE syllabus itself is minimalist and, even when a more 'in-depth' study has been undertaken, lecturers will notice the increased emphasis on the societal impact of science. This has of necessity been introduced at the cost of more traditional material. The skills of both pre- and post- 2006 students *should not* be markedly different since the *formal* syllabuses are in principle very similar, but many school teachers believe that the academic rigour has been diluted. These views are held with respect to the whole science syllabus.

The requirements

A typical chemistry course will need background to the following items during the first two years:

Electromagnetic spectrum: gamma rays to radio waves (wavelength and frequency)

Quantization: black-body radiation and UV catastrophe; photoelectric effect; existence of atomic spectra.

Waves and particles: idea of Compton effect; diffraction of light; de Broglie; existence of quantum mechanics.

Atomic structure: spectrum of H atom; ideas behind H atom description in quantum mechanics.

Kinetic and potential energy. Pressure and force.

Laws of motion. Inertia and moments.

It would be prudent to assume that this background does not exist and it would be wise to assume that even the simplest equations (e.g. KE = ½mv^2) have been forgotten.

The syllabuses

There are several examination boards serving the UK and they differ from each other in their offerings at GCSE level. Those seeking exact details should consult the relevant publications[1-8]. The most popular, in terms of examination entries, is the 'Assessment and Qualifications Alliance (AQA), whilst many teachers regard the Oxford and Cambridge RSA Examinations body (OCR) as providing a more traditional syllabus. The 'Baccalaureate' is not covered in this document.

The redevelopment of GCSE Science specifications by all awarding bodies has been necessitated for first teaching from September 2006 following the publication in 2002 of the DfES '14–19: opportunity and excellence' policy document[9]. This resulted in changes to the key stage 4 National Curriculum for England, producing a new programme of study (published autumn 2004), and the consequent rewriting of the GCSE Criteria for Science. Another relevant change is a requirement to provide work-related learning for all students. These modifications have together dictated the redevelopment of GCSE Science specifications by all awarding bodies from September 2006 and minor revisions are still taking place. The main points are as follows.

- Importance is attached to the knowledge, skills and understanding of how science works in the world at large, as well as in the laboratory (referred to as the procedural content in the specification).
- This is set in the context of knowing and understanding a body of scientific facts (referred to as the substantive content). In the programme of study, procedural and substantive content are given equal emphasis.
- There is a new single award GCSE Science incorporating all of the content in the programme of study.

- There is a new single award GCSE Additional Science, which together with GCSE Science allows progression to post-16 science courses.
- Alternative progression routes are available in the form of single award separate sciences (GCSE Biology, GCSE Chemistry and GCSE Physics), and an applied science route leading to a new single award GCSE Additional Applied Science.

There are six basic courses although some boards have produced additional items such as Double Science or schemes with identical course content but with different methods of assessment. The underlying principles behind each course are as follows.

GCSE Science A which emphasises scientific literacy – the knowledge and understanding which candidates need to engage, as informed citizens, with science-based issues.

GCSE Additional Science A which is a concept-led course developed to meet the needs of candidates seeking a deeper understanding of basic scientific ideas. It is often regarded as providing (with GCSE Science A above) the nearest equivalent to the previous GCSE Science: Double Award and a pre-requisite for 'A' level.

GCSE Additional Applied Science A which meets the needs of candidates who wish to develop their scientific understanding through authentic, work related contexts. It is suitable for students who want to learn more about vocational contexts which are relevant to the modern world.

GCSE Biology A	Each of which provides an opportunity for further developing an
***GCSE Chemistry* A**	understanding of science explanations, how science works and the study of elements of applied science, with particular
***GCSE Physics* A**	relevance to professional scientists. Often regarded as the best preparation for the relevant 'A' level.

AQA Physics Syllabus

It is clearly not possible to give details of all the relevant syllabuses but here is a very condensed summary of the Physics sections taken from publications relating to the most popular examinations board. It is really necessary to read the whole documents to get the intimate details. In particular, the earlier sections relating to the philosophy underlying the changed content is revealing.

Science A

Each science subject is divided into two areas to be examined plus a common practical test. Note that, specifically for the Physics papers, all necessary equations will be provided although candidates may have to identify the units. The structure of the assessment is as follows.

- Physics 1a. Matching/multiple choice questions. Objective test 12.5% 30 minutes.
- Physics 1b. Matching/multiple choice questions. Objective test 12.5% 30 minutes.
- Science Centre-Assessed Unit based on normal class practical work. 25%.

  (The unit comprises an Investigative Skills Assignment, which is normal class practical work followed by an externally set, internally assessed test taking 45 minutes, and a Practical Skills Assessment which is a holistic practical skills assessment).

There are four equivalent written papers in Biology and Chemistry (4 x 12.5%) contributing the remaining marks.

The broad summary of the contents of the two papers is as follows with the equations that need to be understood (not recalled).

Physics 1a Energy and Electricity

How is heat (thermal energy) transferred and what factors affect the rate at which heat is transferred?

What is meant by the efficient use of energy?

Why are electrical devices so useful?

How should we generate the electricity we need?

efficiency = useful energy transferred / total energy supplied

energy transferred = power × time

Physics 1b Radiation and the Universe

What are the uses and hazards of the waves that form the electromagnetic spectrum?

What are the uses and dangers of emissions from radioactive substances?

What do we know about the origins of the Universe and how it continues to change?

wave speed = frequency × wavelength

Additional Science A

There is one written paper per science subject. Each takes 45 minutes and contributes 25% of the marks. The remaining 25% comprises the practical component with the same structure as for Science A above. The Physics written paper has the following content.

Physics 2

How can we describe the way things move?

How do we make things speed up or slow down?

What happens to the movement energy when things speed up or slow down?

What is momentum?

acceleration = change in velocity / time taken for change

weight = mass × gravitational field strength

resultant force = mass × acceleration

work done = force applied × distance moved in direction of force

kinetic energy = ½ × mass × speed^2

momentum = mass × velocity

force = change in momentum / time taken for the change

What is static electricity, how can it be used and what is the connection between static electricity and electric currents?

What does the current through an electrical current depend on?

What is mains electricity and how can it be used safely?

Why do we need to know the power of electrical appliances?

What happens to radioactive substances when they decay?

potential difference = current × resistance

power = energy transformed / time

power = current × potential difference

energy transformed = potential difference × charge

charge = current × time

What are nuclear fission and nuclear fusion?

Physics A

This comprises Physics 1 (or Physics 1A and 1B), Physics 2, Physics 3 and the practical paper. Each contributes 25% to the total mark.

Physics 3

How do forces have a turning effect?

What keeps bodies moving in a circle?

What provides the centripetal force for planets and satellites?

moment = force x perpendicular distance from the line of action of the force to the axis of rotation

What do mirrors and lenses do to light?

magnification = image height / object height

What is sound?

What is ultrasound and how can it be used?

How can electricity be used to make things move?

How do generators work?

How do transformers work?

p.d. across primary / p.d. across secondary =number of turns on primary / number of turns on secondary

What is the life history of stars?

Conclusion

It is not possible to cover all the syllabuses from all the examination boards in this briefing paper and University teachers should examine the relevant documents below and determine for themselves what instructional action needs to be taken. It is clear that the new syllabuses are employing a different approach and philosophy which mandates responses from us in the University sector. The introduction of a strong procedural content plus a broadening of the subject matter must result in significant changes to students' background.

The current situation as far as the needs of University Chemistry teachers are concerned until the post-2006 cohort filter through is not so very different in terms of *formal* syllabus content and basing the requirements on the new syllabuses would seem to be an appropriate starting point. The list of 'essential equations' currently operating is as follows:

speed = distance / time taken

force = mass × acceleration

acceleration = change in velocity / time taken

density = mass / volume

work done = force × distance moved in direction of force

energy transferred = work done

kinetic energy = ½ × mass × speed^2

change in potential energy = mass × gravitational field strength × change in height

weight = mass × gravitational field strength

pressure = force / area

moment = force × perpendicular distance from pivot

charge = current × time

voltage = current × resistance

electrical power = voltage × current

wave speed = frequency × wavelength

The relationship between the voltage across the coils in a transformer and the number of turns in them.

Briefing papers are designed to provide a condensed discussion on issues and topics related to teaching and learning in the physical sciences. Each guide focuses on a particular aspect of higher education and is written by an academic experienced in that field.

References

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