Fitness for purpose: a means of comparing qualifications

A report to Sir Ron Dearing
to be considered as part of
his review of 16–19 education

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to Sir Ron Dearing.
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Fitness for purpose as a means of comparing qualifications: Project Remit

Project remit
The project was set up to develop and apply a method of analysing different qualifications. The method is to be effective for analysing all qualifications.

The key feature of this project is that it compares the qualifications in terms of their fitness for the purpose of enabling progression into employment or further or higher education for those who achieve them.

Through a system of analysis and coding of the detail of the subject domain and qualifications within the subject domain it will be possible to make comparisons of:

i. the extent to which qualifications meet the level required by users;
ii. the extent to which qualifications fulfil the breadth required by users;
iii. the extent to which the assessment objectives provide information about the range of achievement
iv. the degree of overlap between different qualifications (effectively identifying an empirical core);
v. the distinctive features of each qualification.

The analyses in this report cover outcomes for i-iii above, in terms of advanced science qualifications. Data has been gathered and collated which will allow conclusions to be drawn in terms of iv and v if required.

The methodology is to be developed in generic form so that it can be applied to different subjects, different qualifications, and different levels.

Research Questions
Can those who refer to qualifications when recruiting people for jobs or courses of study help to compare these qualifications?

If so:

What method can be used to make useful comparisons between qualifications?

Advanced qualifications in science subjects were the context for this comparative work. Therefore the more specific research question becomes:

To what extent do GCEs in science subjects and the Advanced Science GNVQ meet the needs of employers in science-based services and industries and tutors in science departments in higher education institutions?

More specifically:

What science knowledge, understanding and skills that employers and higher education tutors want?

Do employers and higher education tutors have the same requirements of advanced science qualifications?

Are science GCEs and the Advanced GNVQ providing the breadth of study that employers and higher education tutors want?

Are science GCEs and the Advanced GNVQ providing the depth of study that employers and higher education tutors want?

To what extent are the cores for science GCEs and the mandatory units of the Advanced GNVQ providing the essential core of science knowledge, understanding and skills that employers and higher education tutors want?
Executive summary

Background

The project was set up to develop and apply a method of analysing different qualifications. The method is to be effective for analysing all qualifications, particularly traditional and vocational qualifications. The methodology is to be developed in generic form so that it can be applied to different subjects, different qualifications, and different levels.

The key feature of this project is that it compares the qualifications in terms of their fitness for the purpose of enabling progression into employment or further or higher education for those who achieve them.

Outcomes

The fitness for purpose measure does provide a new way for comparing qualifications. It provides an independent judgement of the relative value of qualifications and components of qualifications, from the perspective of those who use them in recruitment.

The results of the pilot study provide a constructive perspective of both the GCE and the GNVQ. This can be contrasted with direct comparisons of alternative qualifications which may mislead because the comparison is usually made in terms of deficiencies of one qualification in relation to another.

The methodology allows for judgements to be made about the fitness for purpose of single qualifications. It is not essential for a comparison between qualifications to be made. This means that analyses can be carried out of different qualifications at different times.

Evidence from fitness for purpose analysis could support the development of qualification content. For example:

- If NCVQ/SCAA wanted to ensure that the core/mandatory components met the needs of users
- If an awarding body wanted to ensure that optional provision was valued by those who use the qualification in recruitment

Poor progression from one qualification to another is a serious problem. The fitness for purpose methodology can be applied ‘vertically’. Judgements can be made about how well a qualification builds on those at lower levels and prepares for those at higher levels.

If qualifications are to be developed to fit within a common structure, using common terminology, and to perhaps bring them into a single national framework, the fitness for purpose methodology should be applied at an early stage.

Investigation of the fitness for purpose of qualifications needs to be included in review/scrutiny programmes. This will provide a current view of what is valued by users of qualifications.

The Science qualifications

Employers and higher education tutors have more in common than they have differences in terms of their requirements of advanced qualifications.

It is clear that there are significant differences between the GCE and the GNVQ. The degree to which they meet user requirements is the same but the way they meet them is different. In summary, the GNVQ matches significantly more general skills components than GCE ‘A’ levels. In biology and chemistry the match of each qualification to user requirements is comparable. In physics qualifications the GCE has a higher match. Neither qualification provides the breadth required by users.

Communication (oral and written), comprehension, personal skills and team working were seen as a particularly strong requirement by employers and tutors in HE. They identified many different aspects of these skills as essential.

The mathematics components identified were identified as essential by a particularly high proportion of users in each domain.

Users wanted practical capability and application to dominate qualifications. They want students to do basic things well rather than study a wide range of topics or specialised topics in great depth. The science data produced in this project should be passed to awarding bodies and research teams.

Mike Coles, Institute of Education & Alison Matthews, NCVQ
Summary of methodology

The project employed a qualitative methodology, drawing on evidence gathered in meetings of small expert groups.

The stages of the project were as follows:

1. **Preparatory work:**
   a. Development of a systematic way of describing knowledge, skills and understanding to be applied consistently throughout the project.
   b. Definition and mapping of subject area to identify employer and higher education (HE) representatives.
   c. Piloting of framework and method.

2. **Development of qualitative coding frame** to be used through each stage of the project.

3. **Meetings of employer and HE representatives:** (users) to identify the range and level of knowledge and skills and understanding required in a qualification at advanced level.

4. **Validation and prioritisation** of knowledge, skills and understanding identified in meetings in previous stage.

5. **Selection of qualifications for analysis:** meetings with all awarding bodies for each qualification type (GCE and GNVQ Advanced). Selection of representative syllabus/specification, discussion of methodology for qualification scrutiny.

6. **Scrutiny of selected qualifications:** Review of the components of the qualifications concerned (including those which do not appear to be subject-specific). Carried out by subject experts including chief examiners and external verifiers of qualifications. These experts made judgements about the range and level of knowledge, skills and understanding demanded by the qualifications.

7. **Collation, consolidation and coding** of all the components identified in stages 3, 4 and 6.

8. **Interrogation of data:** analysis of components to answer research questions.
Why fitness for purpose needs to be measured

The usefulness of a qualification will be limited if those who use it to make judgements about the suitability of people applying for jobs and higher level study, do not find it indicative of aptitude and potential. It is therefore useful to measure a qualification’s fitness for purpose from time to time. Qualifications evolve and purposes (needs of users) change.

Where two or more different qualifications exist at a single national standard they are described as equivalent they may be designed to be different. To maintain confidence in national standards it is important to be able to demonstrate equivalence. Indeed measures of fitness for purpose will often lead to development of the qualification and improvements in equivalence.

Qualifications in a particular subject area will inevitably draw on a common base of knowledge and skill. The qualifications may be different in structure, approach (e.g. pure and applied) and assessment methodology. Where two types of qualification are available at a level some students will have clear preference for one, but many will see potential in sampling from both. Where this type of cross-qualification sampling is allowed, it is helpful to have a common system of describing the features of each qualification. This will help ensure that equivalence is maintained and students are more likely to choose appropriately.

The GCE A level and Advanced GNVQ

The GCE and GNVQ are designed to be distinctive, they are different in size, content, approach, assessment methodology and reporting scheme.

The structure of the two qualifications is also different. Traditional qualifications use a syllabus which states the course content for a subject area which is sampled in assessment, whereas GNVQs state the outcomes which students must meet in full to achieve their GNVQ.

The content of the GNVQ units are less specific than the ‘A’ level because they are designed to offer more choice of teaching and learning methods and context for the study to centres. Knowledge requirements are implicit in the GNVQ and in order to compare them with GCE assumptions must be made about the underpinning knowledge required to achieve the outcomes of the GNVQ.

Both qualifications have tests which are externally set and marked. These might offer some indication of knowledge expectations. However the tests have different purposes in each qualification. In the ‘A’ level they test depth of knowledge understanding and other cognitive skills. In the GNVQ they test knowledge through recall and some understanding, they are designed to confirm the student has covered the range of the unit rather than to test depth of knowledge - this is done through portfolio assessment.

The Core Skills of communication, application of number and information technology, are a central part of the GNVQ. If a student cannot demonstrate the standards they will not be awarded the qualification. There is no generic equivalent in the ‘A’ level and this also complicates drawing conclusions about comparability. In a similar way the generic skills of planning, information seeking and use, and evaluation are used to award merit and distinction in the GNVQ system. These skills are not specified explicitly in the GCE.

GNVQs were designed to provide an alternative to existing GCSE and GCE A level provision, at equivalent standards. Advanced GNVQs were to be equivalent to two GCE A levels. This statement of equivalence is very hard to examine in practice. Since the initial GNVQ specifications were available several projects¹ have compared GNVQs with GCE A levels to see how far this equivalence can be said to exist. Practice so far has centred on scrutiny and comparison of specifications and some examination of student work.

Fitness for purpose as a means of comparing qualifications:
Why fitness for purpose needs to be measured

As this discussion demonstrates, the difference between the qualifications in terms of both their structure and content, means that direct comparisons of one with the other cannot be comprehensive and may be misleading.

A new approach

In generating an alternative methodology to measure whether the qualifications are of equivalent standard it is necessary to move away from direct comparison of the qualifications. Instead they should each be analysed in terms of an external comparator, against which their performance can be measured. These results can then, if desirable, be compared.

The selection of the external comparator requires considerable care. It is essential that it be valid for both of the qualifications, that is, it must be equally appropriate in each case. The bases of equivalence of the qualifications were reviewed. The GCE and GNVQ are considered an appropriate way to prepare students for a common ‘next step’, or progression route, whether to work or further study. Consequently the preparedness of students reaching these destinations was considered a valid comparator for both qualifications.

The external comparator must also be fit for purpose and reflect the variety of possible progression routes for students. The comparator must provide information about the degree to which each qualification facilitates progression.

The method used in this project is based on a series of qualitative steps, providing a vast amount of detail. It is possible to use this detail to develop a series of profiles of qualifications - in terms of:
• the type of subject content
• general skills
• type of performance/achievement required.

These profiles of qualifications will allow comparisons to be made. They might reveal the extent of common content, significant content differences, the level of demand of each qualification, and, for any one particular user, how fit they are for their purposes.
Methodology in detail

The initial design of this project built on the work of the ‘Mechanics in Action’ project at Manchester University\(^2\), where researchers consulted with subject tutors in HE about mathematics requirements for entry onto their courses. They stated the mathematics - in terms of the skills and knowledge required as opposed to a broader statement of the grade of A level achievement. The content of A levels and GNVQs could then be analysed in terms of whether they demanded these skills and knowledge.

This project is far broader than the Manchester project and is designed to allow comparison of subject content, level of demand and assessment model. The project complements the NCVQ/SCAA comparability exercise which looks at examples of students’ work in addition to mapping one qualification with another.

The methodology hinges on the selection of representative users (see stage 1b, below) of the qualification, and the development of an approach that articulates the skills, knowledge and understanding they require. It also depends on the reliable mapping of skills, knowledge and understanding in qualifications.

Stage 1a: Development of a systematic way of describing knowledge, skills and understanding

The development of a framework for describing knowledge, skills and understanding in a consistent way was essential to the effectiveness of the methodology. The framework is used to structure:

- the requirements defined by employer and HE representatives in stage 3 of the project
- the information sent out in stage 4 (validation and prioritisation round)
- qualification content articulated in stage 6 in the scrutiny of selected qualifications
- the collation, consolidation and coding in stage 7

The framework also structures the data for all interrogation and analyses carried out in stage 8.

In considering the individual components of knowledge, skills and understanding which could be identified by user representatives and be contained in qualifications, it appeared that there were two main features that would be identified in each case.

First: the context or subject matter

For example: chemical reaction types

Although this is fairly easy to identify, it is essential that sufficient detail be given about the breadth and depth of coverage of the context so that meaningful comparisons can be drawn.

To try and ensure that this happened each component contained further detail. This detail describes clearly what is intended by the component term, and limits scope for different interpretation. For example one chemical reaction type was acid-base, and the component was

| Chemical reaction types: | Acid base: including and limited to neutralisation; indicators; salt formation; protonation; ionisation, buffers |

Second: the way in which the knowledge, skills or understanding were achieved.

For example would the student only need to recall information about Acid Base Chemical Reactions, or use understanding to solve problems, or would they also need to be able to carry out practical experiments in the area?

The term used for this was focus of performance, and in this case they required analysis (see below for definition).

To try and increase the consistency of decisions made about the focus of performance, it was decided to provide a single list of terms which could be used to describe the focus of performance, together with a definition of each term. All those involved in the project were required to use this common list of terms.

**Developing the focus**

A literature search was carried to identify existing taxonomies of learning strategies, both in traditional qualifications and in vocational qualifications which could be adapted for this project. This drew chiefly on the work of R M Gagné, BS Bloom, and Mitchell & Bartram.\(^3\) It was decided that the Bloomian model, which is well-known by many involved in education, should be used as the basis for the development of the ‘focus’ definitions. However, it needed to be modified in several ways:

- incorporation of a ‘skills’ component to recognise vocational or applied achievement (included in both the Gagné and Mitchell & Bartram work).
- collapsing of sub-categories of the Bloomian model into six distinctive types. Users felt that this made distinctions between types of knowledge and understanding clearer and it provided more consistency in the use of the broader categories.

The foci identified for use throughout the project, and their accompanying guidance, were as follows:

**Recall**
- recall of terminology such as chemical formulae;
- recall of facts such as examples of strong and weak acids;
- recall of criteria such as those for laboratory safety, or for the presentation of a project report;
- recall of ways of doing things such as how to use a tare in making a weighing or the way in which data should be input to a spreadsheet.

**Practical capability**
- science-specific capabilities such as using a pH meter;
- more general capabilities such as the ability to work in a team. These may range from simple operations to techniques or crafts which require considerable knowledge and understanding. Capabilities are mostly composite and involve problem solving, interpersonal skills, literacy, numeracy and computer skills.

**Interpretation**
- transformation of information, such as translation of the verbal statement of a chemical reaction into its symbolic form;
- giving a précis of a report in an oral presentation.

**Application**
- using principles or concepts in particular situations, such as using an equation in a calculation.

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Mitchel, L & Bartram, D, (1994) The place of knowledge and understanding in the development of National Vocational Qualifications and Scottish Vocational Qualifications in *Competence & Assessment* 10, 1-47

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Analysis
• the ability to see the connections and interactions between events, and the ability to recognise the organisation and structure of a system such as an electrochemical cell;
• distinguishing between facts from hypotheses in a report.

Synthesis
• bringing together understanding from different situations and the creation of abstract relationships which are used to explain or illustrate deeper understanding, such as:
  - drawing together the literature around a subject to develop hypotheses;
  - drawing conclusions which lead to new understanding.

Evaluation
• making judgements based on criteria which have been developed for the purpose. Such as the evaluation of the efficiency of a multi-step production process.

In summary, each component of knowledge, skills or understanding listed as a part of this project was to be described in the following format:

<table>
<thead>
<tr>
<th>Component context</th>
<th>Detail</th>
<th>Focus of performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical reaction types</td>
<td>Acid-base (limited to neutralisation; indicators; salt formation; protonation; ionisation, buffers)</td>
<td>analysis</td>
</tr>
</tbody>
</table>

1b: Definition and mapping of subject area (to identify user representatives)
The identification of representatives to carry out the work in stages three & four of the project was crucial. To ensure that the data they provide was valid, they were selected because they could speak confidently for their discipline or subject area from a firm base of current experience.

Representatives were chosen who were employed in either a significant employment or academic domain which recruits from advanced level science students. Representatives had to be familiar with the recruitment of these students, and have expectations of coverage of knowledge areas and skills acquisition through advanced level learning programmes. Almost all were scientists and expert in a particular area of science.

There are many ways of describing the scientific employment and HE. Boundaries are often vague and arbitrarily determined. Important considerations are such things as occupational indices (e.g. SIC, SOC, TOC coding), economic indicators (e.g. employment figures, GNP generators), academic scientific disciplines, and Higher Education provision (e.g. range of courses, course population statistics).

The criteria for selection of domains for the project were as follows:

i) They span the main areas of science.

ii) They cover the main economic and employment domains - many students with advanced qualifications will be recruited annually.

iii) They are HE areas which produces large numbers of graduates to main employment areas.

iv) There should be a maximum of eight domains, for reasons of manageability.

v) It is possible to identify key personnel who are likely to be representative of their area of employment or HE.
Looking at numbers employed and the largest recruitment HE courses it was possible to produce a composite list of domains. This list contained a number of duplicated or overlapping areas and was rationalised into a smaller number of primary domains, each of which was subdivided into a further set of constituent secondary domains. It was expected that groupings within a primary domain would have similar perspectives on recruitment needs. Moreover, it was expected that each primary domain would have distinct requirements.

These domains were subject to consultation with both employer and higher education contacts and the following table provided the basis for identification of representatives who became involved in this project.

<table>
<thead>
<tr>
<th>Primary domains</th>
<th>Secondary domains</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical production</td>
<td>pharmaceutical</td>
</tr>
<tr>
<td></td>
<td>bulk chemicals</td>
</tr>
<tr>
<td></td>
<td>biotechnology</td>
</tr>
<tr>
<td></td>
<td>chemical engineering</td>
</tr>
<tr>
<td>Engineering</td>
<td>mechanical</td>
</tr>
<tr>
<td></td>
<td>electrical</td>
</tr>
<tr>
<td></td>
<td>electronic</td>
</tr>
<tr>
<td></td>
<td>civil</td>
</tr>
<tr>
<td></td>
<td>transport</td>
</tr>
<tr>
<td>Public analysis</td>
<td>health and safety</td>
</tr>
<tr>
<td></td>
<td>quality control</td>
</tr>
<tr>
<td></td>
<td>environmental monitoring</td>
</tr>
<tr>
<td></td>
<td>forensic</td>
</tr>
<tr>
<td>Food production</td>
<td>agriculture</td>
</tr>
<tr>
<td></td>
<td>processing</td>
</tr>
<tr>
<td>Healthcare</td>
<td>medicine</td>
</tr>
<tr>
<td></td>
<td>occupations supportive to medicine</td>
</tr>
<tr>
<td></td>
<td>psychology</td>
</tr>
<tr>
<td>Materials extraction and processing</td>
<td>geology</td>
</tr>
<tr>
<td></td>
<td>oil refining</td>
</tr>
<tr>
<td></td>
<td>forestry</td>
</tr>
</tbody>
</table>

Working with the Royal Society and the Science, Technology & Maths Council and its associate members, key representatives for each of these areas were identified, reflecting the interests of both employment and HE.⁴

1c: Piloting of framework and method
Initial piloting work was carried out with research scientists in each of the key scientific disciplines - Biology, Chemistry, and Physics.

The pilot meetings were designed to find out whether the framework was viable. Each scientist was asked to describe their work, working closely with one of the project directors, using the framework to structure their description. The piloting confirmed that the framework did seem to function well as a way of ordering information. It was necessary, however, to alter the proposed methodology for the user meetings at this stage.

The pilot meetings had required close collaboration between the scientist and the project director. It appeared that quite detailed dialogue was needed to ensure that consistent information was given. It had been planned that the user meetings should be quite large, and that users would be asked to make decisions independently. Following the piloting this did not seem feasible, and

⁴a list of representative organisations is included in the ‘Acknowledgements’ section, individual representatives are included in the coding table at Appendix A.

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plans for the user meetings were changed so that there were a large number of expert facilitators working with the ‘users’ to ensure consistency of interpretation (see stage three, below).

Stage 2: Development of qualitative coding frame
At this stage a coding frame was developed to describe the project. The project depended on an enormous amount of data being brought together and compared, and careful structuring of it was essential. QSR NUDIST\(^5\) was used to help interrogate the data. Unique codes were allocated to:
- focus of performance
- qualification references
- user and claimer participants
- selection criteria of claimers.

Codes referencing claimers and users describe:
- whether the individual is an employer or HE representative,
- the broad scientific discipline they are drawn from (biology, chemistry or physics)
- what sector of the scientific domain they represent.

A full coding list is included at Appendix A.

Stage 3: Meetings of employer and HE representatives (Users)
user representatives (n=46) identified in stage 1b were contacted and invited to one of a series of one-day meetings. More participants were briefed by telephone in advance about the project aims and how they could contribute. Prior to meetings all representatives had briefing papers sent to them explaining the proposed methodology and background to the project. There was a meeting of representative for each of the six primary domains.

Following the piloting work it was decided to brief a number of expert consultants on the project methodology and the description framework. These people were to act as facilitators in the small group format which was adopted for the user representative meetings.

Each user representative meeting had the same format: a brief introduction and description of the project from the project managers, information on the structure of the day, and a substantial time allowed for questions about the work. The rest of the day was spent in small groups (between 2-3) of user representatives, working with facilitators. Each small group was made up of representatives from both employment and HE, but separate notes were taken about requirements, when they differed.

Those facilitating the groups were also provided with a ‘prompt’ list of possible content headings for reference. Although this was sometimes useful in helping facilitators to prompt representatives, occasionally it was shared with representatives and a tendency for it to become prescriptive in these cases was noted.

The data gathered from all the meetings was brought together for collation into a single list. There was an enormous amount of data from each meeting - over 2000 separate components were identified, each with detailed description and focus of performance. The information was then divided into a series of groupings:
- Biology
- Chemistry
- General skills
- Mathematics
- Physics
- Scientific method and techniques

Each component referenced all the users who had identified it through the use of a series of unique codes (see stage 4 above).

\(^5\)NUDIST - Non-numerical Unstructured Data Indexing Searching and Theorising. Supports processes of indexing, searching and theorising qualitative data

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Stage 4: Validation and prioritisation
The claiming round provided users with a chance to check components identified so far (so providing a validation stage for the project), and an opportunity to prioritise the data.

Claimers (returns n=66) were made up of the original user groups plus additional representatives from each of the sectors. Claimers were asked whether they would prefer to carry out their work collectively at a meeting or individually by post. All claimers elected for postal consultation.

The information gathered in stage 3 formed the basis of the claiming round of the project. References to people or domains were removed from the components and a series of forms created (one for each of the groupings shown in stage 3 above), a sample page of the General skills form is included at Appendix B together with a copy of the letter sent to claimers. The letter also includes the definitions of focus of performance (see stage 1a, above).

Claimers were asked to identify the components they felt were required for the areas they represented. Claimers were posed the question:

‘what knowledge, skills and understanding would you like to see in students recruited to your company or your course with an advanced science qualification (A level sciences or Advanced science GNVQ)?

and asked to indicate whether each component was:

Essential and current or,
Essential and covered or,
Required and current or,
Required and covered

Where 'Essential' means that it is crucially important in their area, 'Required' means they would like to see the component in qualifications, 'Covered' means the student will have met the component at some time in their course and 'Current' means that the knowledge and/or skill is something that the student should still be able to demonstrate.

Asking the respondents to prioritise, or code, the components that they chose was designed to have a two-fold effect. Firstly, it provided valuable information about the relative importance of components to claimers, and secondly, it encouraged a thoughtful response rather than mechanistic ticking.

Claimers were also asked to identify any areas of knowledge, skills or understanding which they did not feel were covered by the component lists sent to them. In practice claimers did not nominate new components.

The responses from claimers were generally completed as requested (n=66). The most common problems were where claimers had indicated that a component was either essential or required, but had failed to indicate whether they wanted it to be current or covered. In these cases when the forms were coded 'covered' was included. If claimers had indicated both alternatives (e.g. essential and required) the higher priority was coded.

Stage 5: Selection of qualifications for analysis
Two initial meetings were held, one for all GCE awarding bodies and one for all GNVQ awarding bodies. The meetings focused on selection of an exemplar qualification for the project.

At the GCE meeting each awarding body was represented by an officer with responsibility for Science A levels. The project was described in some detail by the project directors and the awarding bodies were given the opportunity to raise and discuss the methodology for qualification scrutiny.

Concerns raised about the project included:
Fitness for purpose as a means of comparing qualifications: Methodology in Detail

- the project focused on progression from A level only and ignored progression from GCSE;
- the project focused on the needs of employment and HE only, not of educators and students.

Issues raised about scrutiny of A levels included:
- difficulty of matching knowledge or subject with focus of performance. The same scientific content can be examined at different levels every year;
- concern that scrutiny would be carried out by people unfamiliar with the awards;
- core content was common to all but would not give a good representation of coverage by students.

The scrutiny issues are addressed in section 8 (below).

The awarding bodies felt that, in general, syllabuses were fairly similar to each other, with major differences between optional and non-optional, and modular and linear syllabuses. Representatives recommended that three separate GCE syllabuses be selected in preference to the combined science A levels, because the latter have low candidature. They also advised that the syllabuses selected should be linear and have as much non-optional content as possible. Four of the GCE awarding bodies had syllabuses which fitted this description and representatives advised that the project should select for the project the one with the highest candidature.

Following this advice, the syllabuses which were selected for the project were from the Northern Examinations and Assessment Board (NEAB):
- Biology (Advanced) - End-of-course 4161 (including optional module 6 - Microorganisms and Biotechnology);
- Chemistry (Advanced) - End-of-Course 4171 (including optional modules 4, 5, and 6 - Further Physical Chemistry, Further Inorganic Chemistry, and Further Organic Chemistry);
- Physics (Advanced) - End-of-Course 4181 (including optional module 7 - Medical Physics).

At the GNVQ meeting each awarding body was represented by their officer with responsibility for Science GNVQ. The project was described in some detail by the project directors and the awarding bodies given the opportunity to raise and discuss the methodology for qualification scrutiny. The GNVQ awarding bodies raised no issues about the scrutiny process. They recommended that the GNVQ selected for the project should be that with the highest candidature.

Following this advice, the GNVQ which was selected for the project used BTEC Advanced Science optional units. These were:
- units 9, 14, 15, 16 (for a biology-based GNVQ);
- units 9, 10, 11, 16 (for a chemistry-based GNVQ);
- units 9, 11, 12, 13 (for a physics-based GNVQ).

Stage 6: Scrutiny of selected qualifications:
Following nomination by the awarding bodies of syllabuses for the project, a scrutiny group was convened. This was composed of representatives from NEAB and BTEC, together with representatives from the Royal Society of Chemistry, Institute of Biology, Institute of Physics, Chemical Industries Association, Association of British Pharmaceutical Industries, SCAA, and two external verifiers of GNVQ Science. Those representing the science professional bodies were familiar with both GNVQ and GCE structure and content.

The meeting focused on agreeing a series of issues as the basis for scrutiny of the qualifications, these were as follows:
- students are prepared so that they can answer questions on the whole of the GCE syllabus - no sampling of the syllabus is required;
- student's performance on the sections of the syllabus selected for a particular examination in written papers (GCE) is taken to be typical of their performance if other sections were chosen for another examination;
Fitness for purpose as a means of comparing qualifications: Methodology in Detail

- chief examiners for GCE syllabuses should identify the generalisable characteristics of student performance at grade E and grade A in the GCE;
- external verifiers for the GNVQ should identify the generalisable characteristics of student performance at pass and distinction in the GNVQ;
- it is possible to identify a set of skills which GCE students develop over the whole course, but which are not stated in the qualification (e.g. the ability to transfer knowledge);
- external verifiers should draw on their experience of implementation of GNVQ in order to identify the knowledge which GNVQ students require in order to achieve the outcomes stated in the qualification;
- external verifiers should draw on their experience of implementation of GNVQ in order to identify the depth of understanding which GNVQ students reach.

It was agreed that scrutiny of the GCE qualifications should be carried out by the Chief Examiner or a Principal Examiner for each subject, and validated by another Principal Examiner. The GNVQ scrutiny was to be carried out by a BTEC external examiner for the subject, and validated by a second external verifier. Initial work was carried out together with staff from the Science professional bodies.

The scrutineers made a series of judgements at particular grades and levels. They considered the range and level of knowledge, skills and understanding demanded by the qualifications, and, using the definitions of focus of performance developed for the project (stage 1a, above) presented their judgements in the same format as the data generated in the user meetings (stage 3, above).

<table>
<thead>
<tr>
<th>Component context</th>
<th>Detail</th>
<th>Focus of performance</th>
</tr>
</thead>
</table>

**Stage 7: Collation, consolidation and coding of data**

The two large sets of data (from user/claimer and scrutiny stages) were presented in the common format described above. It was necessary to make a series of decisions so that appropriate matches could be made between the user-generated data and the scrutiny data to produce a set of common components.

Where there was a mis-match at the level of aggregation, the larger component would be split and only the match would be coded to both the qualification and the user.

Where the mis-match was at the level of focus of performance there was an automatic ‘no match’ decision made.

When the focus of performance required by users and claimers was at a lower level than that contained within the qualifications it was decided not to make a match. Although this may lead to some findings which seem surprising - for example that certain basic components are marked as not present in the qualifications - it was felt important that this difference was shown since a finding that the qualifications contain material at too high a level is equally valid as a finding that content is either missing completely or is not at a sufficiently high level.

There was some evidence of inconsistency in the use of the focus of performance between the user/claimers and the scrutineers, this may have been a result of insufficient training in the application of the method of describing components.

The final data set, composed of components identified by users/claimers and components identified by scrutineers - both matching and specific - were then coded and entered onto the NUDIST database for analysis.

**Stage 8: Interrogation of data**

A series of analyses were then carried out to answer the research questions posed (see section above). The information generated is discussed in the 'Outcomes: fitness for purpose of advanced qualifications' section below.

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Limitations of Project

In the 'Fitness for Purpose' project, the effectiveness of the methodology in providing a basis for comparing qualifications was under investigation. Science qualifications provided the context for the work. Therefore, it would be inadvisable to draw too firm conclusions from the findings relating to the content and assessment of the science curriculum.

Qualifications are not just for users; they are primarily for the student. The student may take a science qualification but may have no intention of following a career in science. Both the GCE and the GNVQ are general qualifications and make a contribution to the broader education of the student. Many of the features of a broader qualification may have no immediate pay off for the student or users of the qualifications. However, progression is a very important consideration. Progression is very often dependent upon success in earlier qualifications. The views of HE and employers, effectively the gatekeepers, should bear heavily on the design of the qualification.

Another important aim of a qualification is to enable progression from an earlier stage - for example GCSE or Intermediate GNVQ. This project does not consider this role.

The user and 'claimer' identifiers used in this project were a carefully chosen sample of 68 people. These people, although immensely experienced and identified by their peers as likely to give a representative view from their sector, cannot be seen as representative of the field of science as a whole. The sample size would need to be significantly increased to provide comprehensive coverage.

It was decided not to look at students' work (e.g. question papers and assignments) because this varies from student to student and from year to year, and would have required a much longer time-scale. The project also chose not to generalise across different teaching approaches, but to compare the successful outcome of the teaching - the achievement of the qualification. To compensate for the range of achievement we asked scrutineers to make a general statement about the characteristics of GCE and GNVQ students. It was felt that a more reliable indicator of content and demand was the experience of chief examiners and external verifiers whose work centres on setting and marking papers and making judgements about standards.

The chief examiners and external verifiers were linked to specific qualifications (NEAB GCE and BTEC Advanced GNVQ). While these are the best people, in terms of their knowledge of qualification content and coverage, they are, by definition, very small in number. However, the qualifications compared in the project are both new. Whilst the GCE built on the previous syllabus which was well-established, in the case of the GNVQ both the content, and the qualification itself, are new. Therefore judgements made about content and coverage may have been more consistent if those scrutinising the qualifications had longer and deeper experience of the qualifications. Steps were taken to validate their decisions, using principal examiners and alternative external verifiers.

As a limited pilot, the project focused on a single exemplar GCE and GNVQ (identified on the advice of subject officers of all awarding bodies). Clearly, a single qualification at GCE or GNVQ cannot be representative of the whole. The project was, however, able to analyse core content for GCE and mandatory and core skills units of the GNVQ. These are generalisable to all advanced Science qualifications.

Equally, the generalised statements about A grade and E grade performance at GCE, and, to a lesser extent, Pass and Distinction at GNVQ, are not valid at the level of any individual student.

The framework developed for describing knowledge, skills and understanding was new to those who were required to use it (users' /claimers, and those scrutinising the qualifications), and there was some evidence that they would have benefited from more time to familiarise themselves with the framework which may have resulted in more consistent judgements. Later in the project when components were compared slight differences in perception of focus of performance led to

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problematic mis-matches. Unless there was a perfect match there was no match at all, and there are no 'grey' areas. This means that the number of matches were possibly fewer than expected.

During user meetings, facilitators were provided with a 'prompt' list of possible subject areas for their own reference. They were asked to use this list to prompt responses should 'users' be unable to articulate the components they considered important. In practice, when users had sufficient time to consider their needs this was rendered redundant. In fact, in later meetings users often brought with them well considered written responses from themselves and their colleagues (An example of the type of information brought along to meetings is included at Appendix C). On the few occasions that the prompt list was used there was some evidence that users relied on the list instead of thinking independently about the needs of their domain.

The project was set up to measure how quickly the 'Fitness for purpose' judgements could be made. Original estimates ranged between eight and twelve weeks. The project has been completed within twelve weeks, but a significant lead-in time (12 weeks) was necessary to identify and contact 'users'. Further projects of this type should make allowances for this lead-in time and be scheduled over six-nine months. As a pilot project our remit was necessarily diverse, future projects with more tightly focused remit may be able to make time savings.
Outcomes: Methodology

What method can be used to make useful comparisons between qualifications?

The fitness for purpose measure does provide a new dimension for comparing qualifications. It complements the NCVQ/SCAA comparability exercise, where the most important comparison is students' work in each qualification. In addition to providing a mapping of qualifications, the fitness for purpose comparison provides an independent judgement of the relative value of the components of qualifications. The relative value is indicated by the extent to which they meet the needs expressed by users.

The fitness for purpose project has provided an effective way of comparing alternative provision. The results of the pilot study (discussed below in more detail) do indicate the alternative strengths of each qualification. This provides a constructive perspective of both of the qualifications. This can be contrasted with information drawn from direct comparisons of alternative qualifications which may mislead because the comparison is usually made in terms of one or other of the qualifications. For example the comparison is either how far an Advanced GNVQ meets the aims of a GCE A level, or vice versa.

The methodology allows for judgements to be made about the fitness for purpose of single qualifications. It is not essential for a comparison between qualifications to be made. This means that analyses can be carried out independently over time.

Evidence from fitness for purpose analysis could support the development of qualification content. For example:
- If NCVQ or SCAA wanted to ensure that the core/mandatory components met the needs of users
- If an awarding body wanted to ensure that optional provision was well-targeted in terms of progression

The work carried out in this project, in the pilot area of science, indicates strong support for this recommendation from awarding bodies.

Poor progression from one qualification from another is a serious problem. Common frameworks, Y models, modular systems, and higher staying-on rates all require that this problem is addressed. The fitness for purpose methodology can be applied "vertically". Judgements can be made about the suitability of progression from and to each level of qualification.

Evidence from fitness for purpose analysis could support decisions about the provision of alternative qualifications. For example, if in an area there was little demand for practical applications it may indicate that a vocational qualification in this area would not have a significant uptake.

This was limited pilot exercise which did not set out to take into account broader needs than those of users of qualifications. Some of those involved in the project expressed concern that this rather functional approach may have neglected more general capabilities, in the pilot exercise these fears did not appear to be borne out, see Appendix D. However, to address this issues, future exercises could include teachers to provide this perspective.

In this pilot a relatively narrow view of student progression from advanced science qualifications was envisaged, with 'users' limited to those working in science-based employment or higher-education. Students with science qualifications do, of course, often move into a broader range of careers. If the fitness for purpose analysis was carried out across a wider range of potential jobs and HE provision, fitness for purpose could identify more diverse progression routes.

A more detailed critique of the fitness for purpose methodology is contained in the table which follows. This contains a breakdown of each feature of the methodology with judgements about their effectiveness and how they might be changed if this process was to be repeated.
<table>
<thead>
<tr>
<th>Feature of method</th>
<th>Success</th>
<th>Changes in future</th>
</tr>
</thead>
<tbody>
<tr>
<td>Framework (component)</td>
<td>Quite useful organiser - broad structuring</td>
<td>None</td>
</tr>
</tbody>
</table>
| Framework (detail) | Level of detail varied too much between groups | - Need to be more consistent about the type and level of detail required, clearer guidance to be provided. Inclusion of examples would be useful.  
- Detail intended to limit as well as amplify content.  
- No definitive answer on amount of detail possible, limited trialling should be carried out in each new domain. |
| Framework (focus) | Moderate success - some variation in interpretation. | More time would have led to more secure judgements - descriptors need to be more fully conceptualised by users, those scrutinising the qualifications. |
| Mapping user area - employer | Successful | None necessary - should always be rigorous. |
| Mapping user area - HE | Successful | None necessary - should always be rigorous. |
| Domains | Successful - six domains seemed to allow sufficient differentiation | Dependent on subject area. Domains may be more or less diverse. |
| Piloting/validation of framework | Limited in pilot study. Validation that did take place was very useful in informing subsequent work | Vital stage to be included in all future work. Each domain should have some pilot work. |
| User meetings | All effective. All users involved equally, ample evidence generated | - Prompt sheets should not be seen by users  
- Time should be given between initial briefing and meeting for users to gather information  
- 3-4 hours sufficient  
- Small groups (4) of users per expert facilitator  
- Mixed groups of employers/HE required  
- Evidence should be collected and validated during meeting |
| Time scale | Sufficient project time | Longer lead-in required. Project relies on co-operation with industry and HE goodwill must be maintained - time scale pressures are unhelpful. |
| Claiming round | Generally effective, postal system probably introduced some variation in interpretation. Some indication that claimers tended to tick unreflectively, despite use of prioritising system (e.g. essential, required) | - Claiming grid effective  
- Guidance on completion needs some refining to make prioritising system clearer  
- More people likely to contribute if time scale reasonable. |
| Scrutiny - process | Confused at times because methodology under development | • All participants to be identified in advance  
• Participants must always include chief & principal examiners, and senior external verifiers  
• Training sessions required  
• Validation of judgements vital |
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</thead>
<tbody>
<tr>
<td>Selection of qualifications</td>
<td>Unproblematic</td>
<td>Size of candidate entry key factor</td>
</tr>
<tr>
<td>Costs</td>
<td>£40,000 allocated - £5,000 spent - no officer costs incurred in this pilot, no users or claimers paid</td>
<td>Future projects would be unable to rely on unlimited goodwill. Users were happy to contribute to the Dearing review, this would not be an on-going factor.</td>
</tr>
</tbody>
</table>
| Who should carry out? | Project directors referred to project as ‘Dearing owned’, all meetings held at Royal Society, correspondence used Royal Society stationery - to stress independence of project | • Essential for manager to be independent of qualifications. Participants will only cooperate if they feel they are making a difference.  
• Joint NCVQ/SCAA operation would be effective, as would an independent commission from say, a university |
Outcomes:
Fitness for Purpose of Advanced Science Qualifications

The method developed in this pilot study has provided some interesting insights into the fitness for purpose of GNVQ and GCE Advanced level science qualifications. A series of analyses have been carried out which provide data which can be used to answer the following research questions.

What science knowledge, understanding and skills that employers and higher education tutors want?

The components which were claimed by at least one representative of each domain were identified. This provides the broadest picture of the requirements of employers and higher education tutors.

The detailed requirements of employers and higher education tutors are included in Appendix D.

The main areas identified by users in all domains are:

**Biology**
- anatomy
- biological materials
- biological structure
- ecology
- flowering
- food supply
- genetics
- growth and medium for growth
- human physiology
- microbiology
- osmosis
- plant nutrition
- social biology

**Chemistry**
- analytical chemistry
- atomic structure and bonding
- biochemistry
- catalysts
- chemical names
- chemical properties
- chemical reactions
- environmental conservation
- extraction of materials
- physical chemistry
- quantitative chemistry
- solubility
- structures

**Physics**
- control
- dynamics
- electricity
- electronics
- electrostatics
- energy transfer
- fields
- fluid flow
- forces and motion
- kinetic theory
- light
- light and sound
- materials
- mechanics
- network theory
- physical properties
- physics of measurement
- properties of matter
- quantum mechanics
- radioactivity
- structure and dynamics
- thermodynamics
- waves
### Fitness for purpose as a means of comparing qualifications:

**Outcomes: Fitness for Purpose of Advanced Science Qualifications**

<table>
<thead>
<tr>
<th>scientific method and practice</th>
<th>general skills</th>
<th>mathematics and numeracy</th>
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</thead>
<tbody>
<tr>
<td>fieldwork</td>
<td>comprehension</td>
<td>accuracy and precision</td>
</tr>
<tr>
<td>measurements and observations</td>
<td>cultural awareness</td>
<td>algebra</td>
</tr>
<tr>
<td>science in society</td>
<td>data skills</td>
<td>calculus</td>
</tr>
<tr>
<td>scientific method techniques</td>
<td>economic awareness</td>
<td>geometry</td>
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<td></td>
<td>environment</td>
<td>interpretation of relationships</td>
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<td></td>
<td>ethics</td>
<td>logarithms</td>
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<td>evaluation</td>
<td>matrices</td>
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<td>geology</td>
<td>modelling</td>
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<td></td>
<td>health &amp; safety</td>
<td>numeracy</td>
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<td></td>
<td>history of science</td>
<td>presentation of relationships</td>
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<td></td>
<td>information handling</td>
<td>statistics</td>
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<td></td>
<td>information technology</td>
<td>units</td>
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<td></td>
<td>language (foreign)</td>
<td>vectors</td>
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<td></td>
<td>oral communication</td>
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<td></td>
<td>personal skills</td>
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<td>philosophy of science</td>
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<td>planning</td>
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<td></td>
<td>problem solving</td>
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<tr>
<td></td>
<td>social skills</td>
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<td></td>
<td>social, economic and environmental issues, standards</td>
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<td></td>
<td>surveying</td>
<td></td>
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<tr>
<td></td>
<td>team working</td>
<td></td>
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<tr>
<td></td>
<td>written communication</td>
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</tbody>
</table>

**Additional requirements of representatives of the different domains**

The representatives of the chemical production domain also identified such components as metabolic pathways, redox processes, resistance to infection and disease, knowledge of branches of biological sciences as important.

The representatives of the public analysis domain also identified such components as metabolic pathways, resistance to infection and disease, classification and taxonomy, hygiene as important. They also laid extra emphasis on cell biology and genetics, commercial production of food and plant biology generally, embryology and knowledge of organ systems.

The components identified by the representatives of the engineering domain were also identified by representatives of other domains. The only distinctive features of the engineering domain at this level of discrimination were aspects of radio frequency transmission, components and devices and production and detection of polarised light.

The representatives of the materials extraction and processing domain also identified components which treated chemical equilibria more deeply. They also included a requirement for the study of pH buffers and the structures of solid materials.

The representatives of the healthcare domain also identified such components as metabolic pathways, redox process (especially that involved in plant biology), applications of biology, medical use of radioactivity, treatment of disease, food science, ecology, and nutrition of plants and animals. Biotechnology and micro propagation techniques also featured amongst requirements. Healthcare representatives also required a deeper study of some aspects of chemistry notably the chemistry of organic compounds and chemical equilibria.

The representatives of the food production domain identified additional components which were similar to those for healthcare. They also identified aspects of animal health, and food science for particular emphasis.

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An essential core for employers and tutors in higher education
When a more restrictive analysis is carried out - identifying those components identified as essential across all domains, by employers and tutors in higher education - the list of components identified is much reduced. The emphasis falls firmly on generic skills and, to a much lesser extent, physics. No biological or chemical areas are identified. (see Appendix E).

<table>
<thead>
<tr>
<th>physics</th>
<th>scientific method and practice</th>
<th>general skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>electricity</td>
<td>basic laboratory skills</td>
<td>comprehension</td>
</tr>
<tr>
<td>energy transfers in different</td>
<td>fieldwork</td>
<td>creativity</td>
</tr>
<tr>
<td>systems</td>
<td>judging reliability of data</td>
<td>evaluation</td>
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<tr>
<td>mechanics</td>
<td>making measurements and</td>
<td>health and safety awareness</td>
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<td></td>
<td>observations</td>
<td>human impact on the</td>
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<td></td>
<td>scientific method</td>
<td>environment</td>
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<td>information handling</td>
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<td>IT skills</td>
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<td></td>
<td></td>
<td>oral communication</td>
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<td></td>
<td></td>
<td>personal skills - inc.</td>
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<td></td>
<td></td>
<td>independent working,</td>
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<td>time management,</td>
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<td>team working</td>
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<td>written communication</td>
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</table>

mathematics and numeracy
algebra
calculus
geometry
logarithms
numeracy statistics
trigonometry

Communication (oral and written), comprehension, personal skills and team working were seen as a particularly strong requirements by employers and tutors in HE. They identified many different aspects of these skills as essential.

The mathematics components identified were identified as essential by a particularly high proportion of users in each domain.

With the selection of components as common to every domain, it would be expected that only generic skills would be identified. All science subject components would be expected to be identified as essential by users in some, but not all domains. The identification of a core of generic skills did not arise as a result of these skills being the only common components across widely differing domains. Users from all domains were keen to see such skills in recruits and rated them as essential.

The analysis of this essential core produces two significant findings:

i) that only a limited range of physics components (and none for biology or chemistry) are seen as essential by representatives of all user domains;

ii) developing a students' capability in a wide range of generic skills (including mathematics skills) is regarded as very desirable features of courses leading to advanced science qualifications by representatives of all domains.
Do employers and higher education tutors have the same requirements of advanced qualifications?

Employers and higher education tutors have more in common than they have differences in terms of their requirements of advanced qualifications. The number of components common to employers and higher education tutors (Appendix E) is about twice the number of components specific to employers (Appendix F) and about twice the number of components specific to tutors in higher education (Appendix G).

Chart A: shows the requirement for foci of performance for employers and for HE

Not surprisingly the common components are mostly those relating to generic skills. Some physics components are also common to employers and higher education tutors. The only clear difference between the set of components specific to employers and that specific to higher education tutors is in terms of the focus of performance. Higher education tutors require higher
level skills such as analysis more often. On the other hand employers require significantly more recall.

There are some differences in the content of the lists of components which are specific to the two types of users. In addition to the components identified in common, higher education users require:

- additional personal skills
- additional skills in algebra
- more chemistry
- significantly more physics

Employer users require:
- additional practical techniques

There is a discernible feel for more application of science to the set of additional components which are specific to tutors in higher education, for example, industrial applications. (See appendices F and G.)
Are science 'A' levels and the Advanced GNVQ providing the breadth of study that employers and higher education tutors want?

The components identified by employers and higher education tutors were matched against those that were identified by those scrutinising the qualifications as included in GCE science 'A' levels and Advanced Science GNVQ. Appendix H includes these common components.

The total number of distinct components identified by employer and tutors in higher education was 1164. Many of these are distinct in terms of level rather than content. Perhaps 800 of these will reflect distinct content areas. A match of 235 components with both GCE and GNVQ qualifications represents about a third of the requirements of employers and tutors in higher education. Any pure science GCE or GNVQ slanted towards a pure science through choice of optional units, will significantly reduce commonality.

When the components which are identified by employers and tutors in higher education and are inspected in terms of their overlap with qualifications, it is clear that there are significant differences between the GCE and the GNVQ. The degree of overlap for each qualification is similar in size, but the areas covered are substantially different.

This means that when any one qualification is compared to the requirements of employers and tutors in higher education the level of match is lower still. Approximately 80% of components matched to advanced qualifications are only matched to one of them.

In summary, the GNVQ matches significantly more general skills components than GCE 'A' levels. In biology and chemistry the match of each qualification to user requirements is comparable. In physics qualifications the GCE has a higher match. Neither qualification provides the breadth required by users.

The detailed match of each qualification against the components identified by users is provided in Appendix I (for the GCE) and J (for the GNVQ).
Are science 'A' levels and the Advanced GNVQ providing the depth of study that employers and higher education tutors want?

In the framework developed to describe components of knowledge, skills and understanding (see methodology section, stage 1a above), each component is described both in terms of its content and in terms of the focus of performance. The latter gives an indication of the depth of treatment required. It also gives an indication of how the knowledge, understanding and skills might be demonstrated. A categorisation\(^6\) of foci of performance was developed at the start of the project, and applied consistently throughout. The broad foci are:

- Practical capability
- Recall
- Interpretation
- Application
- Analysis
- Synthesis
- Evaluation

A series of analyses were carried out on the final data. The chart on the following page (Chart B) shows the occurrence of each category for:

1. Users (called claimers)
2. GCE
3. GNVQ

Practical capability: was significant for users. It was also a significant focus for the GNVQ. However, it was much less significant in the GCE. There are several reasons why there may be fewer practical components identified in the GCE:

- practical requirements in the GNVQ are integrated, whereas in the GCE they are a separate component, left to teachers to apply, they may be more difficult to identify
- the core skills and grading within GNVQ yield a high number of practical capability components. The number of these non-science specific components may be significant.

However, there does appear to be a significantly higher number of practical components in the GNVQ which comes near to the requirements of users. It further suggests that practical activity should play a more prominent part in the GCE if the needs of users are to be met.

Recall: occurrences in this category were fairly similar in each case, with the users falling between below GCE and above GNVQ.

Interpretation: in this category users required more than were provided by either the GCE or the GNVQ, with the GNVQ showing the least occurrences, about one third of those required by users.

Application: featured strongly in both qualifications, and matched that required by users. The GNVQ showed the highest level of occurrences and the GCE the least.

Analysis: users required little analysis, both GNVQ and GCE contained significantly more. GNVQ about twice as required by users, and GCE over three times as much.

Synthesis: users required little synthesis, both qualifications delivered significantly more, with little difference between them.

Evaluation: users required little evaluation. Both qualifications delivered significantly more than required, with the GCE providing about six times as much as users required, and the GNVQ about twice as much.

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\(^6\)A full description of their development and application is given in the methodology section, stage 1, above.
Chart B: For each category, the occurrence is expressed as a percentage of: the total number of occurrences of foci listed as essential by users; and the total number of occurrences of foci listed in the scrutiny of GCE and GNVQ.

In summary, users wanted practical capability and application to dominate qualifications, and appeared to be far less interested in developing more complex skills. This seems to correlate well with views expressed during the user meetings where the ability to do fundamental things well was stressed as preferable to covering a wider and deeper range of topics.7

The GCE appears to focus more strongly on the higher level skills than the GNVQ, with significantly higher occurrences in the evaluation and analysis categories, it also shows significantly higher occurrences in recall.

In general, the GNVQ matches user requirements more closely than the GCE.

7see ‘Outcomes - some general points’ for discussion
Differential performance

One of the problems with making judgements about the breadth and depth of the GCE and GNVQ is that some students will simply have achieved a minimal pass, while others will have excelled. The project was designed to be sensitive to the differences in performance between candidates.

When the scrutineers were briefed, it was agreed that they should assume coverage of the syllabus and specifications for all candidates. However, they were also asked to provide information about the types of performance which were characteristic of A and E grade students in the GCE, and Distinction and Pass students in the GNVQ. The scrutineers, who were very experienced examiners/verifiers\(^8\) were confident in their decisions, which were validated by equally experienced personnel.

The differential between students in the GCE was often expressed as deeper treatment, by A grade students, of common content. In the GNVQ the differential tended to be in more advanced development of generic skills.

A consequence would be that A grade and Distinction students were demonstrating enhanced E grade and Pass level performance, rather than covering different material.

Analyses in this area concentrated on the differences in the focus of performance between students achieving different grades.

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\(^8\)see methodology section, stage 8, above for more detail

Mike Coles, Institute of Education & Alison Matthews, NCVQ
Chart C: shows how scrutineers view E grade and A grade performance in GCE in terms of their focus of performance. The information is shown in terms of the percentage incidence of each focus.

Whilst the chart shows an increase in the occurrence of practical capability, this is likely to be the result of components which reference the same content for practical component already covered albeit at a different level. It is unlikely that A grade students do significantly more practical work than E grade.

The higher level foci show significant enhancement for A grade students, with occurrences for analysis, synthesis and evaluation appearing to triple. Clearly, this seems in line with the stated aim of the GCE.
Chart D shows how scrutineers view Pass grade and Distinction grade performance in GNVQ in terms of their focus of performance. The information is shown in terms of the percentage incidence of each focus.

In the case of the GNVQ there is, again, an increase in the occurrences of practical capability. Again, some of this increase is likely to be the result of components which reference the same content for practical component, already covered albeit at a different level. It is unlikely that Distinction grade students do significantly more practical work than Pass grade students. However, the level of practical in the GNVQ is already double that of the GCE (see Chart B, above), and much of the enhancement at Distinction grade shown in the chart can be attributed to new components derived from generic skills, chiefly related to grading.

As with the GCE, the higher level foci show significant enhancement for high performing students, with occurrences for analysis, synthesis and evaluation enhanced.
Fitness for purpose as a means of comparing qualifications:
Outcomes: Fitness for Purpose of Advanced Science Qualifications

To what extent are the cores for science ‘A’ levels and the mandatory units of the Advanced GNVQ providing the essential core of science knowledge, understanding and skills that employers and higher education tutors want?

The methodology allows for the identification of components as core/mandatory or non core/optional. This means the analyses carried out for the full qualification can be applied to core or mandatory units only.

Appendix K shows all components which are common to all domains, regarded as essential and in the GCE cores for biology, chemistry and physics.

The main areas of science identified as common to user requirements as essential and in the GCE ‘A’ level cores are:

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<thead>
<tr>
<th>biology</th>
<th>chemistry</th>
<th>physics</th>
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<tr>
<td>biological materials</td>
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<td>dynamics</td>
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<td></td>
<td></td>
<td>light and sound</td>
</tr>
<tr>
<td></td>
<td></td>
<td>mechanics</td>
</tr>
<tr>
<td></td>
<td></td>
<td>network theory</td>
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<td>scientific method and practice</td>
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<td>general skills</td>
<td>physics of measurement</td>
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<tr>
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<td>comprehension</td>
<td>radioactivity</td>
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<tr>
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<td>evaluation</td>
<td>structure and dynamics</td>
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<tr>
<td></td>
<td>interpretation of relationships</td>
<td></td>
</tr>
<tr>
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<td></td>
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<tr>
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<tr>
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<td>planning</td>
<td></td>
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<tr>
<td></td>
<td>written communication</td>
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</table>

Appendix L shows all components which are common to all domains, regarded as essential and in the mandatory units, core skills units and grading criteria for the Advanced Science GNVQ.

The main areas of science identified as common to user requirements as essential and in the Advanced Science GNVQ mandatory content are:
Fitness for purpose as a means of comparing qualifications:
Outcomes: Fitness for Purpose of Advanced Science Qualifications

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<thead>
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<tr>
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<td>and practice</td>
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</tr>
<tr>
<td></td>
<td>trigonometry</td>
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</table>

Close inspection of the data shows that the GCE contains more components relating to scientific method, electricity and light and sound. On the other hand, the GNVQ has significantly greater emphasis on generic skills including information technology, oral and written communication, personal skills, team working and scientific techniques.

When cross-referencing the content of the GCE core and GNVQ mandatory units with the components required by users, overlap is small and tends either to involve fairly low level basic science, or fundamental generic skills, with some focus on review and method. The full list of common components - between GCE core, GNVQ mandatory, and user requirements - is given in Appendix M.

To what extent do 'A' levels in science subjects and the Advanced Science GNVQ meet the needs of employers and tutors in science departments in higher education institutions?

A review of all the analyses carried out for this project reveals a low match between the stated requirements of employers and tutors in higher education. As has been said, above, some mismatches may have occurred because of subtle differences in interpretation between users and those who scrutinised the qualifications. However, this will not account for all of the difference.

One of the major contributory factors does appear to be the tendency for employers and higher education tutors to emphasise knowledge, skills and understanding at a more basic level than the GCE or GNVQ appears to provide.
The GCE and the GNVQ appeared to meet different requirements of employers and HE, as described above. However, neither appeared to be more 'fit for purpose' than the other.

The levels of non-scientific skills required by employers and higher education tutors were extremely significant, and neither qualification matched the levels required. However, the GNVQ did contain far higher levels than the GCE.
Outcomes: general points

Priorities

The Fitness for purpose project has been designed so that all types of knowledge, skills and understanding which are identified as requirements by those working in HE or employment are treated equally. No weighting is ascribed to any of them. However, during the process of generating the full list of requirements with representatives from science-based HE and employment fields there was a significant coincidence in the order in which certain aspects of achievement were raised and the emphasis which was placed on them. This section is independent of the final analyses for the project, and the information it contains is supplementary and descriptive.

An interesting aspect of each meeting was that when asked what was needed in a recruit to their area, both employers and HE Tutors immediately focused on what was lacking in the skills, knowledge and understanding of their current recruits. In almost all instances the more general abilities were mentioned first, before any science content.

The following list of points is in order of frequency with which abilities were mentioned - the most frequently mentioned is first.

Numeracy: when early discussion focused on mathematical ability it was numeracy which was stressed as the most essential. In almost all groups from all sectors the importance of a feel for numbers was stressed as crucial and often felt to be lacking in current recruits.

Even areas which drew recruits with GCE A level Mathematics as a course or employment requirement noted that their current recruits, although adept at using computers and calculators to solve mathematical problems, were unable to tell when errors had been made. Further, some HE tutors noted that students with high grade science GCEs were sometimes weak in their knowledge of mathematics and its application.

A lack of feeling for orders of magnitude was repeatedly cited with students unable to estimate a rough answer. Respondents also felt that students failed to appreciate the need for accuracy. A commonly-noted tendency was for students to always give answers to the level of accuracy provided by the calculator they were using (e.g. always to six figures), rather than to the appropriate level of accuracy required for the context they were working in.

When groups were asked to give more detail on mathematical content they required this was often limited to a fairly low level - arithmetic, algebra and statistics at a basic level were commonly stated. A familiar message was that what was needed was basic knowledge which was properly understood. That students should know what they are doing, rather than just be able to do it.

Communication/personal skills: both employers and HE tutors felt that current recruits were not entering with a sufficiently high level of basic written and oral communication skills. They noted that basic grammatical errors were common and that students seemed to have no feeling for the correct use of language, or familiarity with writing different types of communication.

Both employers and HE felt that communication skills and teamwork were crucial, with employers appearing to rate them at least as highly as scientific knowledge and skills.

IT: although there was a feeling that IT skills were important, neither HE or employers stressed software-specific skills. There seemed to be a consensus that it was important that the students should have a basic familiarity from which they could build specific skills. Confidence in using IT was stressed as important, and there seemed to be a feeling that students would have acquired basic word-processing etc.

Scientific background: the clear theme here was that both employers and HE representatives felt that it was essential for students to have done the fundamentals thoroughly, rather than to have
Fitness for purpose as a means of comparing qualifications:
Outcomes: General Points

studied broader or deeper. There was a feeling that students were coming through advanced programmes of study without having a command of these basics. HE tutors in particular stressed that they felt that it was their role to take the students levels of understanding higher, but that the foundation that they needed to build on was lacking currently.

Further analyses

It would be possible to draw some comparisons about the extent to which science ‘A’ levels and the Advanced GNVQ provide the same breadth and depth of study using the components generated in the scrutiny stage of this project. However, since this does not provide any measure of ‘fitness for purpose’ we have not undertaken any analysis of qualifications independently of user requirements in this report. We will be happy to provide the data for the current NCVQ/SCAA comparability work for Science qualifications, if this is felt to be appropriate.

Commitment to the Dearing Review

There was a clear feeling of goodwill toward the project’s aims, and those of the Dearing Review more generally. The selection of users and claimers was relatively straightforward, with many representatives making special efforts to attend meetings at short notice and at a difficult time of year. Many consulted with colleagues prior to meetings, and some also provided written evidence. 9

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9An example of the type of information brought along to meetings is included at Appendix C

Mike Coles, Institute of Education & Alison Matthews, NCVQ
Recommendations

The project was not set up to offer recommendations to the Dearing Review, its prime purpose was to test the methodology. However, issues have arisen which are worthy of including as recommendations to the review team.

If qualifications are to be developed to fit within a common structure, using common terminology, and to perhaps bring them into a single national framework, the fitness for purpose methodology should be applied at an early stage.

Investigation of the fitness for purpose of qualifications needs to be included in review/scrutiny programmes. This will provide a valuable updating in terms of what is valued by users of qualifications.

More could be done to express GCEs in outcome terms - to increase comparability between qualifications and make them more transparent to other users.

Whilst the focus of the research was on methodology the scientific data yielded is of particular interest to all awarding bodies and should be passed to them as quickly as possible. Similarly, teams working on the ‘Y’ model, and the NCVQ/SCAA comparability work in Science should also be given access to this data.

The project has gathered a considerable amount of data from university tutors. Research teams investigating progression from advanced qualifications should have access to the scientific data from this project.
Fitness for purpose: a means of comparing qualifications

A report to Sir Ron Dearing
to be considered as part of
his review of 16–19 education

Appendices

Mike Coles  NCVQ Fellow
University of London Institute of Education

Alison Matthews  Lead Officer – Evaluation and Methodology
NCVQ

15 December 1995
## Appendices

### Appendix A

### Coding

#### Identifiers:

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<td>Head of Department - Quality</td>
<td>REME Training &amp; Development Team</td>
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### Fitness for purpose as a means of comparing qualifications: Appendices

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| 224 | engineering | Emp | physicist | Geoff Deakin | Group Training Manager | Hinxworth Engineering Ltd |
| 225 | materials extraction | HE | physicist | Professor Steve Sparks | Professor of Volcanology | University of Bristol |
| 226 | materials extraction | HE | physicist | Lynn Gabrielson | Admissions Tutor, Materials Science & Technology | Brunel University |
| 227 | materials extraction | HE | physicist | Peter Hymans | Head of Department of Minerals Engineering | Doncaster College |
| 228 | materials extraction | Emp | - | Dr David Barnes | Process Development Manager | English China Clay International (Europe) |
| 229 | materials extraction | Emp | chemist | Mark Farrar | Fibre Research Manager | St Regis Paper Company Ltd |
| 230 | healthcare | HE | biologist | Professor Chris Duncan | Admissions Tutor for Biology | University of Liverpool |
| 231 | healthcare | HE | chemist | Dr Keith Elliott | Senior Lecturer in Biochemistry | University of Manchester |
| 232 | healthcare | HE | biologist | Dr Pat Judd | Senior Lecturer in Nutrition and Dietetics | Kings College London |
| 233 | healthcare | HE | biologist | Alan White | Senior Lecturer - Pre-Registration Nursing | Leeds Metropolitan University |
| 234 | healthcare | HE | biologist | Jane Lockwood | Senior Lecturer School of Physiotherapy | University of Nottingham |
| 235 | healthcare | Emp | biologist | Gareth Morgan | Biomedical Science Coordinator | NESCOT |
| 236 | healthcare | HE | biologist | Dr Ian Todd | Senior Lecturer - Division of Immunology | University of Nottingham Medical School |
| 237 | healthcare | HE | biologist | Ian Grigor | Senior Tutor in Biomedical Sciences | Leeds College of Health |
| 238 | healthcare | HE | biologist | Mr Chris J. Grigor | Course Manager for Dental Technology | Lambeth College |
| 239 | food production | HE | biologist | Professor Tom Sanders | Head of Department of Nutrition & Dietetics | Kings College London |
| 240 | food production | HE | biologist | Dr John Alliston | Dean of Agriculture | Royal Agricultural College |
| 241 | food production | HE | - | Mr Richard Hinman | Academic Director | Writtle College |
| 242 | food production | Emp | - | John Nullis | Chairman of Employment & Education | National Farmers’ Union |
| 243 | food production | Emp | - | Ben Brough | Associate Tutor | Agriculture Training Board |
| 244 | food production | Emp | biologist | Mr Chris White Moncrieff | Operations Manager | Westend Nursery Van Heiningen Bros. |
| 245 | food production | Emp | - | Johanna Hignett | Group Nutrition & Sensory Manager | Nestlé UK Ltd |
| 246 | food production | Emp | - | Mrs J Kershaw | HR Training Manager/Logistics | Bass Brewers Ltd |

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Mike Coles, Institute of Education & Alison Matthews, NCVQ 42
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Mike Coles, Institute of Education & Alison Matthews, NCVQ
### Status:

The status code on the tree has the following titles - these relate directly to the final digit in 'claimers' codes:

1 = Essential & Current  
2 = Essential & Covered  
3 = Required & Current  
4 = Required & Covered

### Component level:

Component level coding is at the lowest common aggregation - i.e. where there is common agreement about the component, its associated detail and the focus of performance. Where there is any difference (including less or more detail) the components are not the same and are treated separately.
Focus of performance:
These should be coded (additionally) so that the types of performance can be searched. This can be done using two digit identifier:

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Letter to all claimers

2 November 1995

Dear «sal»

Fitness for purpose project - Dearing 16-19 Review

Thank you for your help with this project, we have now analysed all information generated at the round of meetings with employer and higher education representatives. The list which is attached contains all the components which have been identified as those which could be included in an advanced science qualification. This list has been generated by analysing all the information from all of these meetings to generate a single, consolidated list which eliminates repetition. To facilitate the next stage of this project some of the components are very small.

We have grouped the components under the headings of:
- general skills (including communication, IT, personal skills)
- mathematics
- scientific method and practice (including laboratory techniques, methods of analysis)
- biology
- chemistry
- physics

Not all components fit easily into any one section this means you will need to examine all the material to make sure that nothing is overlooked - for example, Earth science is in the general skills section and radioactivity is in the physics section.

No restrictions were imposed when this list was generated. Please would you help us to prioritise the components by considering the question:

'what knowledge, skills and understanding would you like to see in students recruited to your company or your course with an advanced science qualification (A level sciences or Advanced Science GNVQ)'.

Reading the component lists

You have been sent a full set of all the components from all of the meetings, consequently many of the components in the list will not be important to you, we simply want you to select those which are important, and to prioritise them.

You will notice that many of the components in the list seem very similar, in fact each is unique. We suggest you examine the components in the following way:

1. look at the 'component' column on the left for a broad guide to the topic covered;
2. check the 'detail' column in the middle for more information about the scope and depth of coverage; if you think this is important to you:
3. look at the third column 'focus of performance' which shows how the students will have covered this. For example will they simply have recall of it, or will they have carried out practical work in the area?

Completing the form:

We would like you to select those components that you require by ticking the box marked "required" on the right hand side of the list.
If you feel that particular components of the ones you select are crucially important we would like
you to indicate this by ticking the box marked 'essential'.

You will notice that there are two further boxes:

If you feel that it is sufficient that the student has covered the component at some point in
their course but does not necessarily have current skills or knowledge of it tick the box
marked 'covered'.

If you feel that it is important that the student should come with current skills and/or knowledge in
relation to the component (i.e.: that they are still able to demonstrate this knowledge and/or skill
after finishing their course), tick the box marked 'current'.

Please annotate or add to the lists if there are components missing which you require.

Listed below, as a reference for you, and to increase the level of consistency of all responses, are
the definitions that we have used for the types of knowledge and skill included in the 'Focus of
performance' column.

Recall examples include:
• recall of terminology such as chemical formulae
• recall of facts such as examples of strong and weak acids
• recall of criteria such as those for laboratory safety, or for the presentation of a project
  report;
• recall of ways of doing things such as how to use a tare in making a weighing or the way
  in which data should be input to a spreadsheet

Practical capability may range from simple operations to techniques or crafts which require
considerable knowledge and understanding. Capabilities are mostly composite and involve
problem solving, interpersonal skills, literacy, numeracy and computer skills.

Interpretation means transformation of information, such as translation of the verbal statement of
a chemical reaction into its symbolic form, or giving a précis of a report in an oral presentation.

Application means using principles or concepts in particular situations. Examples will include:
- using an equation in a calculation
- using theoretical knowledge of a cell to identify components in an observed cell.

Analysis means the ability to see the connections and interactions between events, and the ability
to recognise the organisation and structure of a system. Examples will include:
- distinguishing between facts from hypotheses in a report
- recognition of unstated assumption in a plan
- drawing conclusions based on a graph line.

Synthesis means bringing together understanding from different situations and the creation of
abstract relationships which are used to explain or illustrate deeper understanding. Examples will
include:
- drawing together the literature around a subject to develop hypotheses
- drawing conclusions which lead to new understanding

Evaluation means making judgements based on criteria which have been developed for the
purpose. An example of this would be the evaluation of the efficiency of a multi-step production
process.

Please make sure that your name, organisation, contact address and subject discipline are
included at the top of the forms and that you return them to us by 13 November 1995, using the
enclosed pre-paid reply label.

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If you feel that any of your colleagues could make a useful contribution to this project, we would welcome a response from them. We have included a further copy of the list for this purpose, please make further copies if necessary.

If you have any queries, please contact Bridie Duffy at NCVQ (tel 0171 728 1941, fax 0171 916 4985). Thank you for your help, we hope to be able to provide information about the project findings early in the New Year.

Yours sincerely

Mike Coles & Alison Matthews
'Fitness for Purpose Project' Dearing 16 - 19 Review
General skills claiming form

About you: to help us identify you, and the area you represent, please can you give us the following information

Name: ___________________________  Discipline: __________________________________________________________

Department & organisation: ____________________________________________________________

Contact address: ________________________________________________________________

<table>
<thead>
<tr>
<th>Component</th>
<th>detail</th>
<th>focus of performance</th>
<th>required</th>
<th>essential</th>
<th>covered</th>
<th>current</th>
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<tbody>
<tr>
<td>awareness of work</td>
<td>business skills (supply and demand, quality assurance, quality control, packaging/advertising, market forces, costing, budget planning, management styles)</td>
<td>recall</td>
<td></td>
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<tr>
<td>awareness of work</td>
<td>careers guidance</td>
<td>application</td>
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<td>awareness of work</td>
<td>work experience</td>
<td>practical</td>
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<tr>
<td>comprehension</td>
<td>checking validity of information</td>
<td>application</td>
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<tr>
<td>comprehension</td>
<td>integrate knowledge from different sources</td>
<td>practice</td>
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<td>comprehension</td>
<td>note taking</td>
<td>application</td>
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<td>evaluation</td>
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<td>application</td>
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<td>application</td>
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<td>application</td>
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<td>application</td>
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<tr>
<td>comprehension</td>
<td>using information sources - literature</td>
<td>application</td>
<td></td>
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</tbody>
</table>

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Appendix C

Comments from The University of Nottingham Medical School

This response has been compiled by Dr. I. Todd (Div. of Immunology), in consultation with Dr. M. Anderson (Div. of Pathology), Prof. S. Gardiner (Dept. Physiology & Pharmacology), Dr. P. Garrud (Div. of Behavioural Sciences), Prof. D. Greenwood (Div. of Microbiology), Dr. B. Middleton (Dept. of Biochemistry), Dr. N. Thomas (Dept. of Human Morphology), Dr. J. Van Tam (Dept. of Public Health Medicine & Epidemiology).

These comments relate to the education of undergraduate medical students. This is a very broad course, covering disciplines as diverse as Biochemistry, Anatomy, Behavioural Science and Public Health Medicine. The comments are given in three sections: general issues which highlight both similarities and differences between disciplines; examples of specific background knowledge which facilitate the teaching of particular subjects; skills which students require for effective learning and which apply to the course as a whole.

General Issues.

The areas which generally give rise to concern are those of competence in very basic skills, particularly numeracy and grammar, and advanced skills of acquiring, using and applying information. Recall of specific facts is less of a concern and little is assumed in terms of subject-specific information.

For many medicine-related disciplines, a basic understanding is required of the structure and functions of molecules, cells, systems of the body and organisms, and how these inter-relate. However, in view of the differences between disciplines, it is not surprising that there are differences in the preferred background for each. For example, a background in structure/functional aspects of biology is advantageous for Biochemistry, but in evolutionary biology for Behavioural Sciences. By contrast, for some aspects of Physiology, a background in physics, chemistry and mathematics is more desirable than biology.

There are dangers associated with introducing some material into the curriculum at a stage prior to higher education. These could include students being 'switched-off' to more advanced consideration of the subject at a later stage, and some aspects of the subject being taught in an incorrect or over-simplified manner.

Examples of background knowledge

General background components common to Biochemistry, Physiology, Immunology, Microbiology, Pathology:

- molecular forces of attraction and repulsion
- general structure of proteins: primary, secondary and tertiary structural features
- the nature of mammalian genes: exons, introns and gene regulation
- gene expression: transcription and translation
- general structure of cells and their components
- cell differentiation and division
- general structure of tissues and organs, and their relationship to the blood circulation

Required modes of performance: recall, application and synthesis

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Components specific to Immunology:
- the body’s requirements for protection from microbes
- the body’s physical and chemical barriers against infection
- the role of white blood cells and their circulation
- the principles of vaccination
- the concept of inflammation

Required modes of performance: mainly recall, some analysis

Components specific to Cardiovascular System:
- concept of heart/pump and blood vessels
- blood circulates and has a transport function (e.g. concept that blood carries oxygen, but not necessarily how)
- elementary fluid mechanics (flow, velocity, resistance)
- chemistry - molarity, acid-base

Components for Behavioural Science include:

Evolution and natural selection
- analysis in relation to function
- systems theory: social structures, family functions
- individual differences: temperament, complementarity between experience and make-up

Components for Public Health Medicine include:

Medicine and society
- social role of doctors
- keeping society healthy
- political and financial aspects of healthcare
Skills for effective learning

Basic skills

- numeracy (e.g. dilutions, percentages, ratios)
- spelling and grammar

Study skills

- facility in accurately memorising terminology and facts
- inter-relate knowledge presented in different ways (e.g. lectures, practicals, reading)
- cope with different qualities and styles of teaching
- distinguish essential from exemplary information
- effective note-taking from information presented

Practical skills

- computer skills (e.g. keyboard use, data retrieval)
- use of microscopes

Conceptual skills

- ability to appreciate fairly complex molecular and cellular concepts and relate these to their broader biological significance
- transform raw data into graphs, etc.
- interpret data (e.g. from graphs) and draw conclusions
- integrate information from disparate sources
- questioning attitude: why are things done the way they are? why is a particular piece of knowledge useful?

Research skills

- research and retrieve information: use resources, communicate findings
- evaluate limitations of data available
- how to generate and test hypotheses
- cope with the ‘unknown’
Communication skills

- Organise material for presentation, either written or orally
- Present information in accordance with requirements (eg. for different types of examination questions)
- Effective oral expression and involvement in discussions
- Ability to communicate with individuals with similar and different backgrounds

Personal skills

- Appreciate personal strengths and weaknesses and organise private study accordingly
- Ability to exercise self-discipline
- Ability to cope with sustained stress
Appendix D

Report: all sectors intersect - claimers/identifiers - specified by one or more claimer

BIOLOGY

Anatomy
name and location of organs, application

Biological materials
cellular structure, basic concepts of nucleus; mitochondria; cell wall structure, recall
structure of cell, cell membranes, difference between plant and animal cell, lipid base,
osmosis, application

cell biology, DNA - what it does, how proteins are made, what they are, how they differ,
how different products are developed in different conditions, application

photosynthesis - energy transfer and redox processes involved (the light reaction and light
independent reactions), analysis

photosynthesis - energy transfer and redox processes involved (the light reaction and light
independent reactions), application

Biological structure
behaviour hierarchy: organisms (bacteria, mammals, plants), recall
biochemical hierarchy: molecules (amino acids, sugars, proteins, nucleotides), organelles
(nucleus, mitochondria, Golgi, endoplasmic reticulum, ribosomes, chloroplasts), cells -
membrane, variety of shape differentiation, recall

physiological hierarchy: tissues - composition, differentiation, organs - (heart, kidney, liver,
brain, skin, skeletal, blood, muscle, lung), systems (gastro intestinal, cardio vascular,
endocrine, immune), recall

physiology: tissue composition, differentiation; organs - (heart, kidney, liver, brain, skin,
skeletal, blood, muscle, lung), systems (gastro intestinal, cardio vascular, endocrine,
immune), practical, interpretation

Ecology
populations, ecosystems, energy transfers, nutrient cycles, water cycles, application

Flowering
pollination, fertilisation, development of seed, methods, natural (insect, wind, other vectors),
application

Food supply
global issues, population v. food supply, developing economies, natural resources, religions,
aid, recall

Genetics
life-cycles - sexual, asexual, hermaphrodite, application, analysis

natural selection/artificial selection, application, analysis

variation, biodiversity and evolution, application, analysis

Growth
development and reproduction, appreciate number of cycles: growth/maturatiageing,
puberty, menstrual cycle, circadian cycle, application

Growth medium
soil composition, application

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10 Total number of text units retrieved = 456
Retrievals in 4 out of 5 documents, = 80%.
The documents with retrievals have a total of 1164 text units, so text units retrieved in these documents =
39%.
All documents have a total of 2163 text units, so text units found in these documents = 21%.

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Human physiology,
- brain/nervous system, \textit{application, synthesis}
- structure and functions of: reproductive system, \textit{application, synthesis}
- structure and functions of: digestive system, \textit{application, synthesis}
- structure and functions of: respiratory system, cardiovascular system, \textit{application, synthesis}

Microbiology
- commensal bacteria and pathogens, role of bacteria in disease,
- applications using bacteria eg fermentation, \textit{application, practical}
- role of microorganisms in food production, effects on food including benefits, growth of microbes, disease-causing bacteria, \textit{analysis, practical}

Osmosis
- mechanism, \textit{application}

Plant nutrition
- nitrates, nitrogen cycle/carbon cycle, food chain-use of agricultural chemicals, why used and effect on food, \textit{analysis, practical}

Social biology.
- water purification, sewage disposal, housing issues, pollution, spread of infection, \textit{interpretation}
- public health, general awareness, social structure, health services, prevention rather than cure, environmental and genetic influence in health, \textit{interpretation}

CHEMISTRY

Analytical Chemistry
- water quality testing, neutralisation, universal indicators, pH, titration, chromatography, precipitation methods, \textit{practical, recall}
- chemical tests for cations/anions, \textit{practical, interpretation}
- analytical chemistry, absorption spectroscopy, \textit{application}

Biochemistry
- molecule types (proteins, carbohydrates, lipids and their combinations), \textit{interpretation}

Catalysts
- properties of catalysts, \textit{recall, practical}
- catalysis, \textit{practical, application}
- catalysts, \textit{application, analysts}
- lowering of energy barrier; bringing reactants together, \textit{interpretation}

Solubility
- solubility - solvent/solute interactions, \textit{practical, application}
- product, hydrophilic/hydrophobic, \textit{recall}

Chemical names.
- common elements and compounds, \textit{recall}
- elements, periodic table, \textit{recall, practical}

Physical chemistry
- Particle size, colloidal behaviour, particle charge, packing, \textit{practical, application}
- first order reaction kinetics, \textit{recall, practical}
- kinetics, order, collision theory, rate constants, \textit{practical, application}
- behaviour at interfaces eg dispersion, flocculation, coagulation, \textit{recall, practical}
- osmosis, diffusion, \textit{recall, practical}
- states of matter, \textit{recall}
- colligative Properties, vapour pressure lowering, osmosis, \textit{analysis}
rates of reaction, recall
change of phase (latent heat and vapour pressure), expansion of solids and liquids, analysis
Chemical properties
trends in properties, periodic table - including reactivity and bonding, interpretation
control of degradation, limiting corrosion, biological change, application
oxidation/reduction, recall, practical
pH, recall, practical
exothermic/endothermic, recall
concept of equilibrium, recall
acids, bases, pH, titration, use of indicators, recall, Practical
organic chemistry, recall, practical,
inorganic chemistry, practical, application
Atomic structure and bonding
atomic structure, recall
bonding, recall
atomic structure, interpretation
properties of atoms, molecules ions, recall
bonding - including intermolecular bonding dipole-dipole interaction and hydrogen bonds, application
Chemical reactions
reaction types, recall, practical
oxidation and reduction, addition of oxygen and hydrogen, addition and removal of electrons
from metals, practical, application, analysis
chemical equations - balancing, interpretation
polymer reactions, recall, practical
oxidation/reduction, application, practical
endothermic/exothermic, Dehydration/reduction, application, practical
addition/elimination, substitution, hydrolysis, application, practical,
hydrolysis, oxidation, recall
acid-base (neutralisation; indicators; salt formation; protonation; ionisation, buffers), analysis
Environmental conservation,
human impact on environment, issues (industrial production and conservation, structure of
the atmosphere, acid rain, ozone depletion, recycling, waste management), interpretation
Extraction of materials
continuity of supply, environmental issues, preparing raw material, application
Quantitative chemistry
concentrations, recall, practical
Avogadro constant, mole, concentrations, application
Avogadro constant, mole, concentrations, aqueous solutions, titrations, analysis,
energetics, enthalpy changes, entropy, free energy, practical, application
Structures
shapes of molecules, application
isomers and asymmetry, interpretation
states of matter, application
shapes of molecules, recall
atomic orbitals, shapes of orbitals, analysis

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GENERAL SKILLS
Economic awareness
manufacturing processes, costs of input, efficiency/effectiveness, quality assurance systems, competition, interpretation
business skills (supply and demand, quality assurance, quality control, packaging/advertising, market forces, costing, budget planning, management styles), recall, careers guidance, application
work experience, practical

Comprehension
checking validity of information, application, practical
integrate knowledge from different sources, practical, application, synthesis
note taking, application, practical
reading complex texts, evaluation
reading fluently, application, practical
selecting relevant sources, application, practical,
selection/abstraction of information, application, practical
understanding information, application, practical
using information sources - literature, application, practical

Cultural awareness
respond to various cultures - w/in UK, EU and globally, understanding of cultures and implications for work, application

Data Skills
nature of biological record, nature of chemical record: - origin - how processed - form of output required, population data, monitoring & detecting changes through data, fieldwork, analysis, evaluation

Environment
human impact, - a sense of responsibility, appreciate consequences, sustainability, value natural capital, interpretation
control, climate (rainfall, temp), micro climate (computer, light, transmission, humidity, CO2, irrigation), analysis,
conservation, how human activity affects the environment, issues relating to industrial production and conservation, structure of the atmosphere, acid rain, ozone depletion, recycling (benefits, non-benefits), waste management, interpretation, analysis
ecological issues, recall
applied to scientific application eg: regulations, estimation of cost/benefits, application

Ethics
applied to scientific applications, recall

Evaluation
ability to make recommendations, advantages and disadvantages, ability to work out important aspects, ability to discuss science, design/use of controls - understanding of role of controls, analysis, evaluation, synthesis
recognition of validity of answers, critical analysis of results - review of results, analysis, evaluation, synthesis

Geology
climate, recall

Health & Safety,
awareness of legislation (HASAWA/COSHH), recall
risk assessment, hazards/ideas that all situations have risks/safe lab practice, application
first aid - including resuscitation, application, practical

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History of science
major milestones in the progress of science, eg Descartian dualism, discovery of germs,
DNA, work of Pasteur, Fleming. Development of cell theory, impact of immunisation.
recall
Information handling
evaluate from data gathered and draw conclusions, evaluation, practical
Information Technology,
CAD/CAM, practical, application
capability of www/e-mail, recall
e-mail, practical, application
computer literacy, application, practical
control applications of IT - interfaces, recall
data collection and storage, practical
data transfer, recall
database, application, practical
generating graphs/data displays, practical, application
information retrieval - multi-media/CD-ROM, practical, application
keyboard skills, application, practical
networks, recall
operating systems, application, practical
potential and limitations of IT, recall
simple programming, application, practical
spreadsheets, application, practical
video conferencing, practical, recall
word processing, application, practical
Language (Foreign)
standard working knowledge (cet fluency), reading/speaking / listening, some cultural
awareness, practical, application
Oral communication
accuracy, application, practical
adaptation to audience level, interpretation, practical
clarity of expression, practical, application,
communicate ideas, application, practical
communicate information, application, practical
communicate problems & issues, application, practical
confidence, application, practical
debatting/discussion skills, application, practical
fluency - command of language, practical, application
physical factors affecting communication: body
language, eye contact, application, practical
presentation - one-to-one, application, practical
presentation to group, practical, application
presentation to non-experts, practical, application
presentation to peers, practical, application
presentation to seniors/tutors, practical, application
questioning, application, practical
respond to questions, application, practical
summarise information, application, practical
take advice from others, application, practical
use of audio-visual aids, application, practical
use of telephone, application, practical
Personal skills
adaptability/flexibility, practical
appreciate own strengths and weaknesses (self-criticism), practical
confidentiality, practical
cope with stress, practical
creativity, practical
lateral thought, practical
independent working, practical
integrity - rigour, practical
living independently, practical
personal hygiene-awareness of other people's needs, practical
personal organisation, practical
questioning attitude, practical
self-discipline, practical
sense of responsibility, practical
think on feet, practical
common sense, practical
listening skills, engaging, practical
motivation, practical
enquiring mind, practical
ambition, practical
enthusiasm, practical
time-management skills, setting priorities, meeting deadlines, managing own learning,
setting project goals, application, practical
initiative, independent action, solve problems, be pro-active, take responsibility for actions,
application
Philosophy of science
basic awareness: nature of science, why we trust it, how go about it, recall
Planning
considering all options, evaluation of opportunities, application, practical
modifying (review and revision of plan), application, practical
aims - clarity of purpose, application, practical
prioritising tasks, target setting, application, practical
Problem solving
systematic approach to problems, practical, analysis
Social skills
as required in every day business (letters of thanks, appropriate approach for help,
punctuality), practical, application
Social/economic/environmental issues,
applied to scientific applications eg: public health, air & water quality, application
impact of industry on society and the environment, application
Standards
BS5750 (ISO9000), critical path, analysis, TQM, recall

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Surveying
interpretation of maps - ordnance survey, geological, remote sensing images, practical, interpretation
surveying, techniques, practical, application

Team working
accepting guidance/feedback, application, practical
appreciate benefits of team, application, practical
appreciation of alternative perspectives, application, practical,
appreciation of different roles in team, application, practical
appreciation of strengths and weaknesses of team members, application, practical
brainstorming, application, practical
communication, application, practical
co-operative working - with others in team, application, practical
deadlines, application, practical
diplomacy, application, practical
flexibility/adaptability, application, practical
leadership, application, practical
negotiation, application, practical
overview of task, application, practical
project/task planning, application, practical
providing feedback to others, application, practical,
shared commitment, application, practical
team building, application, practical
understanding personal targets, application, practical
understanding team targets, application, practical
work independently, application, practical
work to agreed criteria, application, practical
work with new and different people, application, practical

Written communication
clarity of expression, application, practical
precising, application, practical
accuracy, application, practical
breadth of vocabulary, application, practical
essay writing, application, practical
fluency of expression (taken to be distinct from clarity), application, practical
forms of written communication, recall
grammar, application, practical
handwriting skills, practical
layout of documents, application, practical
match writing to audience (level/expertise), application, practical,
present information in required form, application, practical
presentation of graphs, tables & charts, images, application, practical
punctuation, sentence & paragraph construction, application, practical
spelling, application, practical
structure and write reports, application, practical
summarise, application, practical

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using scientific nomenclature, application, practical
write using discussion format, application, practical

Accuracy and precision
error, application

Algebra
change - first order, exponential, application
forms of equations, recall
fractional indices, application
functions, application
indices - multiplication, division, power and roots, application
solving equations - up to quadratics, application
solving simultaneous equations, application
substitute, rearrange formulae, application
symbols (e.g. < >), application

Calculus
differentiation and integration, application
differentiation and integration of trigonometric functions, application
first and second order differential equations, application
maxima and minima, application

Geometry
co-ordinates - Cartesian and polar, application
hyperbolic function, application
spatial, three dimensional concepts (areas & volumes), application

Presentation of relationships
graphs/charts/tables, application

Interpretation of relationships
graphs/charts/tables, application

Logarithms
bases, scales, powers, application
graphical form, application

Matrices
forms, manipulation, application

Modelling
form and solve equations, synthesis

Numeracy
add, subtract, multiply, divide, percentages, ratios, application
mental arithmetic, application
order of magnitude - estimation/approximation, application
order of magnitude, recall
use of calculator, application
operators, inequalities, manipulation, application
probability, addition, multiplication, application

Statistics
bias, application
distributions - mean, median, mode, application
measures of significance of results, application
permutations, application
populations and samples, application
regression, application
series, binomial theorem, notation, application
standard deviation, application
variance, application
Trigonometry
sine, cosine, tangent, similar triangles, application
Units
SI, transform quantities, recall
Vectors
addition, subtraction - two/ three dimensions, application

**SCIENTIFIC METHOD AND PRACTICE**

Fieldwork
sampling (including limitation), practical
observation and recording, practical

Measurements and observations
familiarity with basic laboratory equipment, practical
chemical analysis - qualitative, practical
information from instruments - spectrometers, recall
information from instruments - chromatographs, recall
information from instruments - electrophoresis, recall,
estimating errors, analysis
reading instruments (vernier, meters), practical,
range of instruments, selecting for purpose, analysis
use of units, recall
design principles of instrumentation, recall
reliability of data, analysis,
chemical analysis - quantitative, practical
chemical analysis - titration, practical measurements and observations, chemical analysis of
ions, cations, group separation, practical
collecting samples, practical

NI3, BOD, COD, suspended solids, gas emission (CO2, CH4), dissolved solids, practical
pH, practical
refractometer, practical

**Science in society**
options about social issues - based on evidence, analysis

**Scientific method**
ability to follow instructions (standard procedures), practical
accurate observation, practical
make and test hypotheses, practical, analysis,
observation, hypotheses, controls, measurements, conclusions, evaluation, practical,
analysis
controls on variables, analysis
presentation of results, practical
logical approach, application, analysis
drawing valid conclusions, analysis
evaluation of process, evaluation

Techniques
chromatography (paper, column, thin layer), practical
mass spectrometry, application
IR, UV, AA, GC, HPLC, Electron microscope, MS, NMR, Electrophoresis, elemental analysis, recall
UV visible, practical
preparing substances, practical
preparing reagents, practical
purification, practical
safe practice (hygiene), practical
radiography, practical
microscopy - types of microscope, practical
microscopy, practical
weighing, practical
evaluation of results, evaluation
 calibration of instruments, practical
spectroscopy - principles, interpretation, application

PHYSICS
Control
components of an automatic feedback system, monitoring and safety, application, practical

Dynamics
simple harmonic motion, application
simple harmonic motion, analysis
uniform motion and uniform accelerated motion, analysis, practical
pressure, pressure measurement, practical, application

Electronics,
electronic components, interpretation
digital circuits for computation, electronic measurement, application
transmission and reception of radio, application
optic fibres, lasers, practical
optic fibres, lasers, application
diode rectifier, transistor, logic gates - AND, OR, NOT, practical, application
negative feedback and control system theory, Electronic control circuits, Remote sensing,
fibre optics technology, interpretation, practical
fibre optics technology, recall
negative feedback and control system theory, Electronic control circuits, Remote sensing,
semi-conductors, recall

semiconductor properties, components of electronic data transfer devices and their functions,
Features of electronic data transmission, Analogue techniques, application, practical
components - diode, transistor, application
how connect into circuits, Simple circuits, Test and build circuits, application, practical
basic semiconductor theory, Diode and transistor - how they work, Basic operational
amplifier (as a black box), interpretation, application, practical

Electricity

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nature of electric current, nature of potential difference, Ohm’s law and power, interpretation, application
generator motors, interpretation
safety - domestic and industrial, interpretation terminology, circuits and electronic devices, recall
transducers - LDR, thermistor, strain gauge, application
Lenz Laws, concept of static charge electric fields as different shaped objects, Applications as sensors, application, practical
voltage, current, resistance, recall / practical
ohm’s law and power, application
internal resistance, interpretation, practical
capacitance, charge, interpretation
capacitance, charge, practical
alternating/direct current, AC theory (three phase), interpretation, practical,
Kirchoff’s law, Energy stored, interpretation, practical
force on a moving charge, motion of charged particles in a magnetic field, application
force on a current-carrying conductor, application
photovoltaic effects, practical, interpretation, application
Coulomb’s Law, electric field, energy transfer in electric circuits, principles of electrical measurements (standards, ammeters, voltmeters, potentiometer, bridge circuits), B and Flux, magnetic moment, practical, interpretation, application
Electrostatics
charge, dipole, analysis
Energy Transfer
second law of Thermodynamics, superheating, analysis, practical
heat capacity, analysis, practical
temperature scales, Absolute zero, analysis, practical
radiation, conduction, convection, Internal energy, analysis, practical
conductivity, interpretation
conductivity, specific latent heat, analysis, practical
energy sources, energy changes, energy conservation and budgets, recall
electromagnetic radiation, recall
work and power, Conservation of energy, application
alternative energy sources, Microwave generators, controlling rate of energy transfer in applications, application
thermal transfer - detection, black body, interpretation
electromagnetic radiation, application
energy changes during change of state, application
microwave generators, synthesis
fundamentals of energy balance, interpretation
radiation, conduction, convection, interpretation
energy transfer, convection, diffusion, convection, recall
measurement of conductivity, analysis, practical
processes and their effects, interpretation
calculate energy changes during change of state, application
Fields
electric and magnetic, recall

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magnetic, application
gravitational, magnetic, application, practical
gravitational, magnetic, recall
magnetic effect of a current, Force on/in a field, application
Fluid Flow
Fluid flow, pressure drop, determining Reynold’s Number, laminar and turbulent flow, Particle behaviour, including small particle settling, terminal velocity, bubble formation, drag, buoyancy, awareness
mass flow through tubes - poissule equation, Solids liquids gases, viscosity, specific gravity, calculate F12, application
fluid flow measurement, orifice plates, V-slots -, practical, application f
fluid flow - its measurement and control in industrial, medical, construction contexts including turbine flow meter, venturi meter, thermal flow meter, anemometers, orifice plates, v-slots, vortex meter, interpretation
Forces and motion
forces and balances (including Newton’s Laws), Moments of inertia, Linear & angular velocity, calculate F12
Kinetic theory,
matter - non-ideality, interpretation
Light
the eye, application
spectrum - infra red, interpretation
photography - use of camera, application
Light and sound
properties, interpretation
diffraction, application
phase difference and superposition optical instruments - operation of telescope, practical, application
progressive and stationary waves, different media of waves, polarisation, speed, practical, application
reflection, refraction, wavelength and frequency, analysis
interference, practical, application
optics, recall
nature of sound and light, Ultrasound measurements and applications, interpretation, application
structure of the ear, interpretation, application
laws of reflection and refraction, structure of cameras, wave theory related to refraction, Sound systems and other ‘sound’ machines, interpretation, application
principles of geometrical optics (laws of reflection and refraction), recall, practical
polarisation (production and detection of polarised light), general background to microscopes, focusing of lens, recall, practical
Materials
assess the materials in an existing product or select materials for a given application in terms of potential or extent of modification, analysis
structures of about 1,um or larger, structural features, shape, grains, spherulite, crystalinity, relate micro structure to properties, phase diagrams as predictors of micro structure., practical - observation
grain size, dislocation, interpretation, analysis,
properties related to bonding, application, practical
solubility/miscibility/viscosity, interpretation
metallurgy, awareness
Hooke’s Law, application
stress, strain, Young Modulus, Relate behaviour of material to its structure, Ductile and brittle behaviour, application
crystalline, amorphous, polymeric, composite, application, practical
crystalline, amorphous, polymeric, composite, recall
elastic, plastic, application, practical
elastic, plastic, recall
tensile & bulk properties (stress & strain), recall
tensile & bulk properties (stress & strain), application, practical
alloying, heat treatment, chemical treatment, application
criteria for use, recall
criteria for use, analysis, practical
bending and conduction, practical
Mechanics
momentum, application, practical
pressure, optics (curved lenses etc), application, practical
levers, forces, application, practical
friction, analysis
forces and moments including uniformly distributed load, resolving forces/moments, moments of inertia, forces in frames, application, practical, problem solving (analysis)
Newton’s laws, Conservation of momentum, Collisions, Motion in circle, Energy P.E./K.E. conservation, Work and power, Moment of force, Force as a vector, Pressure - Boyle’s/Charles law, practical
work and power, application
Newton’s laws, Conservation of momentum, Collisions, Energy P.E./K.E. conservation, Force as a vector, Pressure - Boyle’s/Charles law, application
motion in circle, application
moment of force, application
pressure of measurement, Boyle’s law, interpretation
vacuums, interpretation
Network theory,
resistivity - inductance, capacitance, resonance, application
Physical properties
Young modulus, application, practical
density, practical, analysis
physical quantities - units of measurement, application, practical
scalar and vector quantities, interpretation
Physics of measurement
radiation, Inverse square laws, Simple hydrometers for density measurement, Specific gravity, recall,
Properties of matter
basic level, interpretation
Quantum Mechanics, quantum effects., Wave - particle duality as a notion., interpretation
Radioactivity
decay, half life, application

Mike Coles, Institute of Education & Alison Matthews, NCVQ
Fitness for purpose as a means of comparing qualifications: Appendices

range of natural sources, half-life, alpha, beta and gamma radiation, recall

Structure and dynamics,
force, laws of motion, recall
force including gravity, laws of motion, analysis
force including gravity, laws of motion, torque, angular acceleration, hydraulics, practical
torque, angular acceleration, application
force including gravity, laws of motion, hydraulics, application
torque, angular acceleration, pressure, pressure measurement, analysis, practical

viscosity, interpretation, practical
motion, equilibrium and rigid bodies, application,
centre of gravity, application, practical, problem solving (analysis)
principle of superposition (standing waves, interference, beats, diffraction), practical, application
wave motion (reflection, refraction, dispersion, polarisation, sinusoidal travelling waves), practical, interpretation, application
angular motion, rotational dynamics (rotational kinematics, moment of inertia, energy of rotation, conservation of angular momentum), fluids at rest (density and pressure, Archimedes' principle), Doppler effect (frequency change, red shift and broadening of spectral lines), practical, interpretation, application

Thermodynamics
temperature scales and range of devices for measuring it, isothermal and adiabatic processes, concept of temperature gradient, first law of thermodynamics, analysis, practical
basic level, qualitative approach, interpretation

Waves,
frequency, harmonics, EM spectrum, Infra red, ultra violet, X rays, Gamma rays (including safety aspects), recall
fundamental nature of sound and light, relationship between frequency, wavelength and velocity, refraction, reflection, angle of incidence, angle of reflection, phase changes due to change in density of transmitting medium, calculation/application (simple calculation)
Appendix E

Report: Essential components from all sectors identified by employers and HE

General skills
comprehension, checking validity of information, application, practical
comprehension, integrate knowledge from different sources, practical, application, synthesis
comprehension, note taking, application, practical
comprehension, reading complex texts, evaluation
comprehension, reading fluently, application, practical
comprehension, understanding information, application, practical
Environment - Human Impact, Instil a sense of responsibility + Appreciate consequences + Sustainability + Value natural capital, interpretation
Evaluation, ability to make recommendations + advantages and disadvantages + ability to work out important aspects + ability to discuss science + design/use of controls - understanding of role of controls, analysis, evaluation, synthesis
Evaluation, recognition of validity of answers + critical analysis of results - review of results, analysis, evaluation, synthesis
Health & Safety, Awareness of legislation (HASAWA/COSHH), recall
Information handling, extrapolate from data gathered and draw conclusions, evaluation, practical
Initiative, independent action + solve problems + be proactive + take responsibility for actions, application
IT, computer literacy, application, practical
IT, data collection and storage, practical
IT, generating graphs/data displays, practical, application
IT, word processing, application, practical
Motivation, requiring mind + ambition + enthusiasm, practical
oral communication, accuracy, application, practical
oral communication, communicate ideas, application, practical
oral communication, communicate information, application, practical
oral communication, communicate problems & issues, application, practical
oral communication, presentation - one-to-one, application, practical
oral communication, presentation to non-experts, practical, application
oral communication, presentation to peers, practical, application
oral communication, presentation to seniors/tutors, practical, application
oral communication, questioning, application, practical
oral communication, summarise information, application, practical
oral communication, take advice from others, application, practical
oral communication, use of telephone, application, practical
Personal skills, adaptability/flexibility, practical
Personal skills, appreciate own strengths and weaknesses (self-criticism), practical
Personal skills, confidentiality, practical

11 Total number of text units retrieved = 148
Retrievals in 2 out of 5 documents, = 40%.
The documents with retrievals have a total of 803 text units, so text units retrieved in these documents = 18%.
All documents have a total of 2163 text units, so text units found in these documents = 6.8%.
Personal skills, creativity + lateral thought, practical
Personal skills, independent working, practical
Personal skills, integrity - rigour, practical
Personal skills, Personal hygiene-awareness of other people's needs, practical
Personal skills, personal organisation, practical
Personal skills, questioning attitude, practical
Personal skills, self-discipline, practical
Personal skills, sense of responsibility, practical
Personal skills, common sense, practical
Planning, Considering all options + Evaluation of opportunities, application, practical
Planning, Modifying (review and revision of plan), application, practical
Planning, aims - clarity of purpose, application, practical
Planning, prioritising tasks + target setting, application, practical
Problem solving, systematic approach to problems, practical, analysis
Social etiquette, Social skills required in everyday business (letters of thanks, appropriate approach for help, punctuality), practical, application
Team working, accepting guidance/feedback, application, practical
Team working, appreciate benefits of team, application, practical
Team working, appreciation of alternative perspectives, application, practical
Team working, appreciation of different roles in team, application, practical
Team working, appreciation of strengths and weaknesses of team members, application, practical
Team working, communication, application, practical
Team working, co-operative working - with others in team, application, practical
Team working, deadlines, application, practical
Team working, diplomacy, application, practical
Team working, shared commitment, application, practical
Team working, team building, application, practical
Team working, understanding personal targets, application, practical
Team working, understanding team targets, application, practical
Team working, work independently, application, practical
Team working, work to agreed criteria, application, practical
Team working, work with new and different people, application, practical,
Time-management skills, Setting priorities + Meeting deadlines + Managing own learning + setting project goals, application, practical
Written communication, clarity of expression, application, practical
Written communication, accuracy, application, practical
Written communication, grammar, application, practical,
Written communication, layout of documents, application, practical
Written communication, present information in required form, application, practical
Written communication, presentation of graphs, tables & charts, images, application, practical
Written communication, punctuation + sentence & paragraph construction, application, practical
Written communication, spelling, application, practical
Written communication, structure and write reports, application, practical
Written communication, summarise, application, practical
Written communication, using scientific nomenclature, application, practical

Mike Coles, Institute of Education & Alison Matthews, NCVQ
Accuracy and precision, error, application
Algebra, change - first order, exponential, application
Algebra, forms of equations, recall
Algebra, fractional indices, application
Algebra, functions, application
Algebra, indices - multiplication, division, power and roots, application
Algebra, solving equations - up to quadratics, application
Algebra, solving simultaneous equations, application
Algebra, substitute, rearrange formulae, application
Algebra, symbols (e.g. < >), application
calculus, maxima and minima, application
Geometry, co-ordinates - Cartesian and polar, application
Geometry, spatial, three dimensional concepts (areas & volumes), application
interpretation of relationships, graphs/charts/tables, application
logarithms, bases, scales, powers, application
logarithms, graphical form, application
Numeracy, add, subtract, multiply, divide + percentages + ratios, application
Numeracy, mental arithmetic, application
Numeracy, order of magnitude - estimation/approximation, application
Numeracy, order of magnitude, recall
Numeracy, use of calculator, application
operators, inequalities, manipulation, application
presentation of relationships, graphs/charts/tables, application
probability, addition, multiplication, application
statistics, distributions - mean, median, mode, application
statistics, measures of significance of results, application
statistics, populations and samples, application
statistics, regression, application
statistics, standard deviation, application
statistics, variance, application
trigonometry, sine, cosine, tangent, similar triangles, application
units, SI, transform quantities, recall
vectors, addition, subtraction - two/three dimensions, application
fieldwork, observation and recording, practical
manual skills, familiarity with basic laboratory equipment, practical
measurements and observations, accuracy, recall
measurements and observations, estimating errors, analysis
measurements and observations, reading instruments (vernier, meters), practical
measurements and observations, use of units, recall
measurements and observations, reliability of data, analysis
scientific method, ability to follow instructions (standard procedures), practical
scientific method, make and test hypotheses, practical, analysis
scientific method, observation, hypotheses, controls, measurements, conclusions, evaluation, practical, analysis
scientific method, presentation of results, practical
scientific method, logical approach, application, aanalysis

Mike Coles, Institute of Education & Alison Matthews, NCVQ 70
scientific method, drawing valid conclusions, analysis
scientific method, evaluation of process, evaluation
techniques, evaluation of results, evaluation
techniques, calibration of instruments, practical
physics
Electricity, nature of electric current + nature of potential difference + Ohm’s law and power, interpretation, application
Electricity, Electrical safety - domestic and industrial, interpretation
electricity, voltage, current, resistance, recall/practical
electricity, ohm’s law and power, application
Energy Transfer, Temperature scales + Absolute zero, analysis, practical
Energy Transfer, conductivity + specific latent heat, analysis, practical
Energy transfer, energy sources + energy changes + energy conservation and budgets, recall
Energy transfer, electromagnetic radiation, recall
Energy transfer, Work and power + Conservation of energy, application
Energy transfer, Electromagnetic radiation, application
Energy transfer, Energy changes during change of state, application
energy transfer, convection, diffusion, conduction, recall
fields, electric and magnetic, recall
Forces and motion, forces and balances (including Newton’s Laws) + Moments of inertia +
Linear & angular velocity, calculate, application (simple calculation)
Mechanics, forces and moments including uniformly distributed load + resolving
forces/moments + moments of inertia + forces in frames, application, practical, problem
solving (analysis),
Mechanics, Newton’s laws + Conservation of momentum + Collisions + Motion in circle +
Energy P.E./K.E. conservation + Work and power + Moment of force + Force as a vector +
Pressure - Boyles/Charles law, practical
Mechanics, Work and power, application
Mechanics, Newton’s laws + Conservation of momentum + Collisions + Energy P.E./K.E.
conservation + Force as a vector + Pressure - Boyles/Charles law, application
Mechanics, Motion in circle, application
Mechanics, Moment of force, application
physical properties, density, practical, analysis
physical properties, physical quantities - units of measurement, application, practical
physical quantities, scalar and vector quantities, interpretation
physics measurement, Radiation, Inverse square laws + Simple hydrometers for density
measurement + Specific gravity, Recall
Appendix F

Report: Essential to Employers, but not to Higher Education Tutors

Biology
Biological materials, Energy transfer + redox processes + enzymes (nature and function, receptor sites) + movement through cell membranes, recall
Biological materials, proteins, fats, carbohydrates, vitamins (structure/function), recall
Biological Materials, nucleic acids, recall
biological materials, Structure of eukaryote cell components, prokaryote cell structure, recall
biological structure, Physiology: Tissue composition, differentiation; Organs - (heart, kidney, liver, brain, skin, skeleton, blood, muscle, lung), practical, interpretation
biological structure, Physiology: Tissues - composition, differentiation; Systems (gastro intestinal, cardiovascular, endocrine, immune), practical, interpretation

Cell biology, differentiation, application
Cell Biology, DNA - what it does + how proteins are made, what they are, how they differ + How different products are developed in different conditions, application
Cellular structure, Basic concepts of nucleus; mitochondria; cell wall structure, Recall
Ecology, Species diversity + Succession + Species & their interaction with surroundings and other species + Population dynamics, application
Evaluating Wildlife on a Site, Evaluation criteria and environmental legislation, interpretation
Genetics, RNA as a template for protein synthesis; + restriction enzymes + DNA use in genetic fingerprinting + concept of vectors and cloning, application
Genetics, Human Genome, application
Microbiology, commensal bacteria and pathogens + role of bacteria in disease + applications of bacteria eg fermentation, application, practical
Microbiology, colony counts, recall
Organ systems, structure and function, recall,
Organisms, Biosynthesis + Microbiology + pharmacology/toxicology/neurology - awareness of what these branches of science are, recall

chemistry
ATP, energy rich phosphate bond, application, practical
Chemical names, common, recall
Equilibria, dynamic equilibrium + Equilibrium constant Kc, recall
Grignard reagents, addition to ketones, recall
Hormones, structures and functions, interpretation, Isomerism, optical, interpretation
Organic chemistry, alphatics v aromatics, application
Reacting masses, determination, application
Electrophilic, nucleophilic, free radical, interpretation
Structure of materials, shapes of molecules, recall
Surface chemistry, hydrophilic, hydrophobic + why things bond + applications in industry - emulsion technology, application, evaluation
Vitamins, Simple structures and functions, recall

general

\[^{12}\]Total number of text units retrieved = 68
Retrievals in 4 out of 5 documents, = 80%.
The documents with retrievals have a total of 1164 text units, so text units retrieved in these documents = 5.8%. All documents have a total of 2163 text units, so text units found in these documents = 3.1%.

Mike Coles, Institute of Education & Alison Matthews, NCVQ
Data Skills, Nature of biological record, Nature of chemical record: - origin - how processed - form of output required + Population data + Monitoring & detecting changes through data, practical, analysis, evaluation

Economic awareness, manufacturing processes + costs of input + efficiency/effectiveness + quality assurance systems + competition, interpretation

Environment - Human Impact, Instil a sense of responsibility + Appreciate consequences + Sustainability + Value natural capital, interpretation

Initiative, independent action + solve problems + be pro-active + take responsibility for actions, application

IT, CAD/CAM, practical, application.

Graphic designing, practical, application

IT, operating systems, application, practical

Oral communication, communicate problems & issues, application, practical

Oral communication, summarise information, application, practical,

Planning, Considering all options + Evaluation of opportunities, application, practical

Surveying, demographic (provision of services, waste management), interpretation

Surveying, techniques, practical, application

Team working, work to agreed criteria, application, practical

Terminology, circuits and electronic devices, recall

Numeracy, order of magnitude, recall

Measurements and observations, accuracy, recall,

Measurements and observations, NH3, BOD, COD, suspended solids, gas emission (CO2, CH4), dissolved solids, practical

Measurements and observations, refractometer, practical

Science in society, opinions about social issues - based on evidence, analysis F04,

Techniques, mass spectrometry, application,

Techniques, electrophoresis - amino acids and proteins, practical

Techniques, evaluation of results, evaluation

Techniques, spectroscopy - principles, interpretation, application

physics

Electronics, digital circuits for computation + electronic measurement, application

Electronics, transmission and reception of radio, application

Electricity, ohm’s law and power, application

Energy Transfer, second law of Thermodynamics + superheating, analysis, practical

Energy transfer, calculate energy changes during change of state, application

Materials, crystalline, amorphous, polymeric, composite, recall

Materials, elastic, plastic, recall

Materials, alloying, heat treatment, chemical treatment, recall

Materials, criteria for use, recall

Network theory, resistivity - inductance, capacitance, resonance, application

Passive and active components at radio frequency, passive LCR networks at RF with lumped and distributed components + electronic devices to work at RF in transmission and reception functions, application

Physical properties, Young modulus, basic awareness/recall

Structure and dynamics, force + laws of motion, recall

Structures and dynamics, Viscosity, interpretation, practical

Structures and dynamics, fluid flow measurement, orifice plates, V-slots - practical, application
Appendix G

Report: Essential to Higher Education tutors, but not to Employers

Biology

Applications of biology, nutrition + medical use of radioactivity + hygiene + microbiology + treatment of disease and trauma, application

Biological materials, maia ways that materials pass through cell membranes, analysis

Biological materials, structure of eukaryote cell components, prokaryote cell structure, analysis

Biological materials, structure of cell + cell membranes: + importance + semi-permeable membrane + difference between plant and animal cell + lipid base + osmosis, application

Biological structure, Behaviour hierarchy: Organisms (bacteria, mammals, plants), Recall

Biological structure, Physiological hierarchy: a - Tissues - composition, differentiation, b - Organs - (heart, kidney, liver, brain, skin, skeleta, blood, muscle, lung), c - systems (gastro intestinal, cardio vascular, endocrine, immune), Recall

Commercial production, selective breeding and the factors involved in the selection of organisms, application

Ecology, populations + ecosystems + energy transfer³, s + nutrient cycles + water cycles, application

Homeostasis, Aware of composite elements which are regulated, temperature, gases, pH, electrolytes + Temperature control mechanisms + Fluid level control + Waste removal + Cellular respiration + negative feedback, Analysis

Metabolic pathways, production of energy from foodstuffs + transfer of energy (glycolysis, TCA cycle, cytochromes and electrons, formation of ATP, photosynthesis + energy transformation, analysis

Organ systems, catabolic processes, application, synthesis

Plant biology, processing of energy by biological systems, analysis

Plant biology, transport systems, analysis

Public Health, General awareness + social structure + health services + example public health company + prevention rather than cure + environmental and genetic influence in health, interpretation

Resistance to infection, infective agents limited to bacteria and virus + Passive (skin) and active (white blood cells) + resistance including the basic way active agents work; (binding and destroying) + Vaccination, interpretation

Social Biology, Health programmes + Population, interpretation

Chemistry

Analytical chemistry, chemical tests for cations/anions, practical, interpretation

Analytical chemistry, absorption spectroscopy, application

Carbohydrates, Carbohydrates and lipids in terms of: chemical linkages + storage + structural, application

Chemicals, catalysts, application, analysis

Chemistry, inorganic chemistry, practical, application

Colligative Properties, vapour pressure lowering + osmosis, analysis

Colour chemistry, preparation and purification of pigments, dyestuffs, application

Energetics, factors which influence feasibility (entropy), analysis

¹³Total number of text units retrieved = 73
Retrievals in 4 out of 5 documents, = 80%.
The documents with retrievals have a total of 1164 text units, so text units retrieved in these documents = 63%. All documents have a total of 2163 text units, so text units found in these documents = 3.4%.

Mike Coles, Institute of Education & Alison Matthews, NCVQ
environmental conservation, human impact on environment + issues (industrial production and conservation + structure of the atmosphere, acid rain, ozone depletion + recycling, waste management), interpretation
Extraction of materials, continuity of supply + environmental issues + preparing raw material, application
lipids, Carbohydrates and lipids in terms of: chemical linkages, storage, structural, application reactions, Control of reactions + exothermic/endothermic + Redox + Polymerisation, analysis
solid structures, giant ionic + macro molecular + molecular, interpretation
structure of materials, expansion of solids and liquids + orbitals, atomic, shapes of orbitals + change of phase (latent heat and vapour pressure), analysis
general
Awareness of work, careers guidance, application
comprehension, integrate knowledge from different sources, practice, application, synthesis
Geology, Mining technology - + mining techniques: surface, underground + drilling techniques + deposit types: laminar, massive, recall
IT, simple programming, application, practice
oral communication, questioning, application, practice
Personal skills, cope with stress, practice
Personal skills, self-discipline, practice
Personal skills, think on feet, practice
Philosophy of science, basic awareness: nature of science + why we trust it + how go about it, recall
Algebra, change - first order, exponential, application
Algebra, fractional indices, application
Algebra, solving simultaneous equations, application
calculus, differentiation and integration of trigonometric functions, application
operators, inequalities, manipulation, application
statistics, permutations, application
measurements and observations, information from instruments - electrophoresis, recall
physics
Dynamics, simple harmonic motion, application
electricity, force on a moving charge + motion of charged particles in a magnetic field, application
electricity, force on a current-carrying conductor, application
electricity, photoelectric effect, practical, interpretation, application
electricity, Coulomb's Law + electric field + energy transfer in electric circuits + principles of electrical measurements (standards, ammeters, voltmeters, potentiometer, bridge circuits) + B and Flux + magnetic moment, practical, interpretation, application
electronics, fibre optics technology, recall
electronics, Negative feedback and control system theory + Electronic control circuits + Remote sensing + semi-conductors, recall
electrostatics, charge, dipole, analysis
Energy transfer, Thermal transfer - detection, black body, interpretation
Energy transfer, microwave generators, synthesis
energy transfer, convection, diffusion, conduction, recall
fields, electric and magnetic, recall
fields, gravitational, magnetic, recall
Fitness for purpose as a means of comparing qualifications: Appendices

fluid flow, mass flow through tubes - poissule equation + Solids liquids gases, viscosity, specific gravity, calculate, application

Materials, properties related to bonding, application, practical
Materials, How materials are processed in industrial processes, recall

materials, metallurgy, awareness, 227

physical quantities, scalar and vector quantities, interpretation

physics measurement, Radiation, Inverse square laws + Simple hydrometers for density measurement + Specific gravity, Recall

Quantum Mechanics, quantum effects. + Wave - particle duality as a notion., interpretation

Sound and light, principles of geometrical optics (laws of reflection and refraction), recall, practical

Sound and light, polarisation (production and detection of polarised light) + general background to microscopes, focusing of lens, recall, practical

Structures and dynamics, motion, equilibrium and rigid bodies, application

structures and dynamics, principle of superposition (standing waves, interference, beats, diffraction), practical, application

structures and dynamics, wave motion (reflection, refraction, dispersion, polarisation, sinusoidal travelling waves), practical, interpretation, application

structures and dynamics, angular motion + rotational dynamics (rotational kinematics, moment of inertia, energy of rotation, conservation of angular momentum) + fluids at rest (density and pressure, Archimedes' principle) + Doppler effect (frequency change, red shift and broadening of spectral lines), practical, interpretation, application
Appendix H

Report: all sectors intersected - essential to all claimers/identifiers - common to GCE and GNVQ

BIOLOGY

Biological materials
- cellular structure, basic concepts of nucleus; mitochondria; cell wall structure, recall
- structure of cell, cell membranes, difference between plant and animal cell, lipid base, osmosis, application
- cell biology, DNA - what it does, how proteins are made, what they are, how they differ, how different products are developed in different conditions, application
- photosynthesis - energy transfer and redox processes involved (the light reaction and light independent reactions), analysis
- photosynthesis - energy transfer and redox processes involved (the light reaction and light independent reactions), application

Biological structure
- behaviour hierarchy: organisms (bacteria, mammals, plants), recall
- biochemical hierarchy: molecules (amino acids, sugars, proteins, nucleotides), organelles (nucleus, mitochondria, Golgi, endoplasmic reticulum, ribosomes, chloroplasts), cells - membrane, variety of shape differentiation, recall
- physiological hierarchy: tissues - composition, differentiation, organs - (heart, kidney, liver, brain, skin, skeletal, blood, muscle, lung), systems (gastrointestinal, cardiovascular, endocrine, immune), recall

Ecology
- populations, ecosystems, energy transfers, nutrient cycles, water cycles, application

Genetics
- life-cycles - sexual, asexual, hermaphrodite, application, analysis
- natural selection/artificial selection, application, analysis
- variation, biodiversity and evolution, application, analysis

Human physiology,
- brain/nervous system, application, synthesis
- structure and functions of: reproductive system, application, synthesis
- structure and functions of: digestive system, application, synthesis
- structure and functions of: respiratory system, cardiovascular system, application, synthesis

Osmosis,
- mechanism, application

CHEMISTRY

Catalysts
- properties of catalysts, recall, practical
- catalysis, practical, application
- catalysts, application, analysis
- lowering of energy barrier; bringing reactants together, interpretation

Solubility
- solubility - solvent/solute interactions, practical, application
- product, hydrophilic/hydrophobic, recall

Chemical names,
- elements, periodic table, recall, practical

Physical chemistry
- kinetics, order, collision theory, rate constants, practical, application
- states of matter, recall
- change of phase (latent heat and vapour pressure), expansion of solids and liquids, analysis

Mike Coles, Institute of Education & Alison Matthews, NCVQ
Chemical properties
- trends in properties, periodic table - including reactivity and bonding, interpretation
- control of degradation, limiting corrosion, biological change, application
- oxidation/reduction, recall, practical
- pH, recall, practical
- acids, bases, pH, titration, use of indicators, recall, Practical
- inorganic chemistry, practical, application

Atomic structure and bonding
- bonding, recall
- atomic structure, interpretation

Chemical reactions
- oxidation and reduction, addition of oxygen and hydrogen, addition and removal of electrons from metals, practical, application, analysis
- chemical equations - balancing, interpretation
- oxidation/reduction, application, practical
- endothermic/exothermic, Dehydration/reduction, application, practical
- addition/elimination, substitution, hydrolysis, application, practical
- acid-base (neutralisation; indicators; salt formation; protonation; ionisation, buffers), analysis

Environmental conservation,
- human impact on environment, issues (industrial production and conservation, structure of the atmosphere, acid rain, ozone depletion, recycling, waste management), interpretation

Quantitative chemistry
- Avogadro constant, mole, concentrations, application
- energetics, enthalpy changes, entropy, free energy, practical, application

Structures
- shapes of molecules, application
- isomers and asymmetry, interpretation

States of matter, application

GENERAL SKILLS

Comprehension
- checking validity of information, application, practical
- integrate knowledge from different sources, practical, application, synthesis
- note taking, application, practical
- selecting relevant sources, application, practical
- selection/abstraction of information, application, practical
- understanding information, application, practical
- using information sources - literature, application, practical

Environment
- conservation, how human activity affects the environment, issues relating to industrial production and conservation, structure of the atmosphere, acid rain, ozone depletion, recycling (benefits, non-benefits), waste management, interpretation, analysis

Ethics
- applied to scientific applications, recall

Evaluation
- ability to make recommendations, advantages and disadvantages, ability to work out important aspects, ability to discuss science, design/use of controls - understanding of role of controls, analysis, evaluation, synthesis

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Fitness for purpose as a means of comparing qualifications: Appendices

recognition of validity of answers, critical analysis of results - review of results, analysis, evaluation, synthesis

Health & Safety,
risk assessment, hazards/ideas that all situations have risks/safe lab practice, application

Information handling
extrapolate from data gathered and draw conclusions, evaluation, practical

Information Technology,
data collection and storage, practical
generating graphs/data displays, practical, application
operating systems, application, practical
word processing, application, practical

Oral communication
adapting to audience level, interpretation, practical
clarity of expression, practical, application
communicate ideas, application, practical
communicate information, application, practical
communicate problems & issues, application, practical
debating/discussion skills, application, practical
fluency - command of language, practical, application
presentation - one-to-one, application, practical
presentation to group, practical, application
presentation to non-experts, practical, application
presentation to peers, practical, application
presentation to seniors/tutors, practical, application
questioning, application, practical
summarise information, application, practical

Personal skills
appreciate own strengths and weaknesses (self-criticism), practical
lateral thought, practical
independent working, practical
integrity - rigour, practical
time-management skills, setting priorities, meeting deadlines, managing own learning, setting project goals, application, practical
initiative, independent action, solve problems, be pro active, take responsibility for actions, application
meeting deadlines, managing own learning application, practical

Planning
considering all options, evaluation of opportunities, application, practical
modifying (review and revision of plan), application, practical
aims - clarity of purpose, application, practical
prioritising tasks, target setting, application, practical

Problem solving
systematic approach to problems, practical, analysis

Social/economic/environmental issues,
applied to scientific applications eg: public health, air & water quality, application
impact of industry on society and the environment, application

Team working
accepting guidance/feedback, application, practical
appreciation of alternative perspectives, application, practical,
appreciation of different roles in team, application, practical
appreciation of strengths and weaknesses of team members, application, practical
coopervative working - with others in team, application, practical
diplomacy, application, practical
flexibility/adaptability, application, practical
providing feedback to others, application, practical,
work to agreed criteria, application, practical
work with new and different people, application, practical
Written communication
clarity of expression, application, practical
accuracy, application, practical
breadth of vocabulary, application, practical
essay writing, application, practical
fluency of expression (taken to be distinct from clarity), application, practical
forms of written communication, recall
grammar, application, practical
handwriting skills, practical
layout of documents, application, practical
present information in required form, application, practical
presentation of graphs, tables & charts, images, application, practical
punctuation, sentence & paragraph construction, application, practical
spelling, application, practical
structure and write reports, application, practical
using scientific nomenclature, application, practical,
write using discussion format, application, practical
Accuracy and precision
error, application
MATHEMATICS
Algebra
indices - multiplication, division, power and roots, application
solving equations - up to quadratics, application
solving simultaneous equations, application
substitute, rearrange formulae, application
Calculus
differentiation and integration, application
differentiation and integration of trigonometric functions, application
Geometry
c-oordinates - Cartesian and polar, application
hyperbolic function, application
spatial, three dimensional concepts (areas & volumes), application
Presentation of relationships
graphs/charts/tables, application
Interpretation of relationships
graphs/charts/table, application
Logarithms
bases, scales, powers, application

Matrices
forms, manipulation, application

Modelling
form and solve equations, synthesis

Numeracy
add, subtract, multiply, divide, percentages, ratios, application
order of magnitude - estimation/approximation, application
order of magnitude, recall

Statistics
measures of significance of results, application
regression, application
standard deviation, application
variance, application

Trigonometry
sine, cosine, tangent, similar triangles, application

Vectors
addition, subtraction - two/three dimensions, application

Scientific Method and Practice

Fieldwork
sampling (including limitation), practical

Measurements and observations
chemical analysis - qualitative, practical
information from instruments - spectrometers, recall
estimating errors, analysis
reading instruments (vernier, meters), practical
use of units, recall
reliability of data, analysis
chemical analysis - quantitative, practical
collecting samples, practical

pH, practical

Scientific method
ability to follow instructions (standard procedures), practical
accurate observation, practical
make and test hypotheses, practical, analysis
observation, hypotheses, controls, measurements, conclusions, evaluation, practical, analysis
controls on variables, analysis
presentation of results, practical
drawing valid conclusions, analysis
evaluation of process, evaluation

Techniques
chromatography (paper, column, thin layer), practical
IR, UV, AA, GC, HPLC, Electron microscope, MS, NMR, Electrophoresis, elemental analysis, recall
purification, practical
microscopy - types of microscope, practical
microscopy, practical
evaluation of results, evaluation
spectroscopy - principles, interpretation, application

PHYSICS
Control
components of an automatic feedback system, monitoring and safety, application, practical
Dynamics
simple harmonic motion, application
simple harmonic motion, analysis
uniform motion and uniform accelerated motion, analysis, practical
pressure, pressure measurement, practical, application
Electronics,
electronic components, interpretation
digital circuits for computation, electronic measurement, application
transmission and reception of radio, application
optic fibres, lasers, practical
optic fibres, lasers, application
diode rectifier, transistor, logic gates - AND, OR, NOT, practical, application
negative feedback and control system theory, Electronic control circuits, Remote sensing, fibre optics
technology, interpretation, practical
fibre optics technology, recall
negative feedback and control system theory, Electronic control circuits, Remote sensing, semi-conductors, recall
semiconductor properties, components of electronic data transfer devices and their functions, Features of electronic data transmission, Analogue techniques, application, practical
components - diode, transistor, application
how connect into circuits, Simple circuits, Test and build circuits, application, practical
basic semiconductor theory, Diode and transistor - how they work, Basic operational amplifier (as a black box), interpretation, application, practical

Electricity
nature of electric current, nature of potential difference, Ohm's law and power, interpretation, application
generator motors, interpretation
safety - domestic and industrial, interpretation terminology, circuits and electronic devices, recall
transducers - LDR, thermistor, strain gauge, application
Len's Laws, concept of static charge electric fields as different shaped objects, Applications as sensors, application, practical
voltage, current, resistance, recall, practical
Ohm's law and power, application
internal resistance, interpretation, practical
 capaci tance, charge, interpretation
 capaci tance, charge, practical
alternating/direct current, AC theory (three phase), interpretation, practical, Kirchoff's law, Energy stored, interpretation, practical
force on a moving charge, motion of charged particles in a magnetic field, application
force on a current-carrying conductor, application
photoelectric effect, practical, interpretation, application
Coulomb's Law, electric field, energy transfer in electric circuits, principles of electrical measurements (standards, ammeters, voltmeters, potentiometer, bridge circuits), B and Flux, magnetic moment, practical, interpretation, application

Electrostatics
charge, dipole, analysis

Energy Transfer
second law of Thermodynamics, superheating, analysis, practical
heat capacity, analysis, practical
temperature scales, Absolute zero, analysis, practical
radiation, conduction, convection, Internal energy, analysis, practical
conductivity, specific latent heat, analysis, practical
energy sources, energy changes, energy conservation and budgets, recall
electromagnetic radiation, recall
work and power, Conservation of energy, application
alternative energy sources, Microwave generators,
controlling rate of energy transfer in applications, application
thermal transfer - detection, black body, interpretation
electromagnetic radiation, application
energy changes during change of state, application
microwave generators, synthesis
fundamentals of energy balance, interpretation
radiation, conduction, convection, interpretation
energy transfer, convection, diffusion, conduction, recall
measurement of conductivity, analysis, practical
processes and their effects, interpretation
calculate energy changes during change of state, application

Fields
electric and magnetic, recall
magnetic, application

gravitational, magnetic, application, practical
gravitational, magnetic, recall
magnetic effect of a current, Force on/in a field, application

Fluid Flow
Fluid flow, pressure drop, determining Reynold's Number, laminar and turbulent flow, Particle behaviour, including small particle settling, terminal velocity, bubble formation, drag, buoyancy, awareness
mass flow through tubes - poissulle equation, Solids liquids gases, viscosity, specific gravity, calculate F12, application

Forces and motion
forces and balances (including Newton's Laws), Moments of inertia, Linear & angular velocity, calculate F12

Kinetic theory,
matter - non-ideality, interpretation

Light
the eye, application
spectrum - infra red, interpretation
photography - use of camera, application
Light and sound
Fitness for purpose as a means of comparing qualifications: Appendices

properties, interpretation
diffraction, application
phase difference and superposition optical instruments - operation of telescope, practical, application
progressive and stationary waves, different media of waves, polarisation, speed, practical, application
reflection, refraction, wavelength and frequency, analysis
interference, practical, application
optics, recall
nature of sound and light, Ultrasound measurements and applications, interpretation, application
structure of the ear, interpretation, application
laws of reflection and refraction, structure of cameras, wave theory related to refraction, Sound systems
and other 'sound' machines, interpretation, application
principles of geometrical optics, laws of reflection and refraction, recall, practical
polarisation, production and detection of polarised light, general background to microscopes, focusing of
lens, recall, practical
fundamental nature of sound and light, relationship between frequency, wavelength and velocity, refraction,
reflection, angle of incidence, angle of reflection, phase changes due to change in density of transmitting
medium, calculation, application

Materials
assess the materials in an existing product or select materials for a given application in terms of potential
or extent of modification, analysis
structures of about 1,um or larger, structural features, shape, grains, spherulite, crystallinity, relate micro
structure to properties, phase diagrams as predictors of micro structure, practical - observation
grain size, dislocation, interpretation, analysis,
properties related to bonding, application, practical
solubility/miscibility/viscosity, interpretation
metallurgy, awareness
Hooke's Law, application
stress, strain, Young Modulus, Relate behaviour of material to its structure, Ductile and brittle behaviour,
application
crystalline, amorphous, polymeric, composite, application, practical
crystalline, amorphous, polymeric, composite, recall
elastic, plastic, application, practical
elastic, plastic, recall
tensile & bulk properties (stress & strain), recall
tensile & bulk properties (stress & strain), application, practical
alloying, heat treatment, chemical treatment, application
criteria for use, recall
criteria for use, analysis, practical
bending and conduction, practical

Mechanics
momentum, application, practical
pressure, optics (curved lenses etc), application, practical
levers, forces, application, practical
friction, analysis
forces and moments including uniformly distributed load, resolving forces/moments, moments of inertia,
forces in frames, application, practical, problem solving (analysis)
Newton's laws, Conservation of momentum, Collisions, Motion in circle, Energy P.E./K.E. conservation,
Work and power, Moment of force, Force as a vector, Pressure - Boyles/Charles law, practical

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work and power, application
Newton's laws, Conservation of momentum, Collisions, Energy P.E./K.E. conservation, Force as a vector, Pressure - Boyle's/Charles law, application
motion in circle, application
moment of force, application
pressure of measurement, Boyle's law, interpretation
vacuums, interpretation
Network theory,
resistivity - inductance, capacitance, resonance, application
Physical properties
Young modulus, application, practical
density, practical, analysis
physical quantities - units of measurement, application, practical
scalar and vector quantities, interpretation
Physics of measurement
radiation, Inverse square laws, Simple hydrometers for density measurement, Specific gravity, recall
Properties of matter
basic level, interpretation
Quantum Mechanics, quantum effects, Wave - particle duality as a notion, interpretation
Radioactivity
decay, half life, application
range of natural sources, half-life, alpha, beta and gamma radiation, recall
Structure and dynamics,
force, laws of motion, recall
force including gravity, laws of motion, analysis
force including gravity, laws of motion, torque, angular acceleration, hydraulics, practical
torque, angular acceleration, application
force including gravity, laws of motion, hydraulics, application
torque, angular acceleration, pressure, pressure measurement, analysis, practical
fluid flow - its measurement and control in industrial, medical, construction contexts including turbine flow meter, venturi meter, thermal flow meter, anemometers, orifice plates, V-slots, vortex meter, interpretation
viscosity, interpretation, practical
motion, equilibrium and rigid bodies, application, centre of gravity, application, practical, problem solving (analysis)
fluid flow measurement, orifice plates, V-slots, practical, application
principle of superposition (standing waves, interference, beats, diffraction), practical, application
wave motion (reflection, refraction, dispersion, polarisation, sinusoidal travelling waves), practical, interpretation, application
angular motion, rotational dynamics (rotational kinematics, moment of inertia, energy of rotation, conservation of angular momentum), fluids at rest (density and pressure, Archimedes' principle), Doppler effect (frequency change, red shift and broadening of spectral lines), practical, interpretation, application
Thermodynamics
temperature scales and range of devices for measuring it, isothermal and adiabatic processes, concept of temperature gradient, first law of thermodynamics, analysis, practical
basic level, qualitative approach, interpretation
Waves
frequency, harmonics, EM spectrum, Infra red, ultra violet, X rays, Gamma rays (including safety aspects), recall

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Appendix I

Report: Components common to all sectors and matched by GCE only

Biology

Anatomy

Biological materials
structure of cell, cell membranes, difference between plant and animal cell, lipid base, osmosis, application

cell biology, DNA - what it does, how proteins are made, what they are, how they differ, how different products are developed in different conditions, application

photosynthesis - energy transfer and redox processes involved (the light reaction and light independent reactions), application

Biological structure

biochemical hierarchy: molecules (amino acids, sugars, proteins, nucleotides), organelles (nucleus, mitochondria, Golgi, endoplasmic reticulum, ribosomes, chloroplasts), cells - membrane, variety of shape differentiation, recall

physiology: tissue composition, differentiation; organs - (heart, kidney, liver, brain, skin, skeletal, blood, muscle, lung), systems (gastro intestinal, cardio vascular, endocrine, immune), practical, interpretation

Genetics

natural selection/artificial selection, application, analysis

variation, biodiversity and evolution, application, analysis

Human physiology

brain/nervous system, application, synthesis

structure and functions of: digestive system, application, synthesis

structure and functions of: respiratory system, cardiovascular system, application, synthesis

Osmosis,

mechanism, application

Chemistry

Catalysts

properties of catalysts, recall, practical

catalysis, practical, application

catalysts, application, analysis

lowering of energy barrier; bringing reactants together, interpretation

Chemical names

elements, periodic table, recall, practical

Physical chemistry

kinetics, order, collision theory, rate constants, practical, application

states of matter, recall

Chemical properties

trends in properties, periodic table - including reactivity and bonding, interpretation

acids, bases, pH, titration, use of indicators, recall, Practical

inorganic chemistry, practical, application

Atomic structure and bonding

model of Bohr atom, recall

atomic structure, interpretation

Chemical reactions

oxidation and reduction, addition of oxygen and hydrogen, addition and removal of electrons from metals, practical, application, analysis

chemical equations - balancing, interpretation
oxidation/reduction, application, practical
acid-base (neutralisation; indicators; salt formation; protonation; ionisation, buffers), analysis

Quantitative chemistry
Avogadro constant, mole, concentrations, aqueous solutions, titrations, analysis, energetics, enthalpy changes, entropy, free energy, practical, application

Structures
shapes of molecules, application
isomers and asymmetry, interpretation
states of matter, application
atomic orbitals, shapes of orbitals, analysis

GENERAL SKILLS
Economic awareness

Comprehension
integrate knowledge from different sources, practical, application, synthesis

Environment
conservation, how human activity affects the environment, issues relating to industrial production and conservation, structure of the atmosphere, acid rain, ozone depletion, recycling (benefits, non-benefits), waste management, interpretation, analysis

Evaluation
ability to make recommendations, advantages and disadvantages, ability to work out important aspects, ability to discuss science, design/use of controls - understanding of role of controls, analysis, evaluation, synthesis
recognition of validity of answers, critical analysis of results - review of results, analysis, evaluation, synthesis

Health & Safety
risk assessment, hazards/ideas that all situations have risks/safe lab practice, application

Oral communication
questioning, application, practical

Planning
modifying (review and revision of plan), application, practical
prioritising tasks, target setting, application, practical

Written communication
clarity of expression, application, practical
fluency of expression (taken to be distinct from clarity), application, practical
layout of documents, application, practical
present information in required form, application, practical
structure and write reports, application, practical
using scientific nomenclature, application, practical,

Algebra
indices - multiplication, division, power and roots, application

Presentation of relationships
graphs/charts/tables, application

Interpretation of relationships
graphs/charts/tables, application

Logarithms
bases, scales, powers, application

Modelling
form and solve equations, *synthesis*

**Statistics**
measures of significance of results, *application*
standard deviation, *application*

**Vectors**
addition, subtraction - two/three dimensions, *application*

**Scientific Method and Practice**
information from instruments - spectrometers, *recall*
use of units, *recall*
reliability of data, *analysis*
Scientific method
ability to follow instructions (standard procedures), *practical*
accurate observation, *practical*
make and test hypotheses, *practical, analysis*
observation, hypotheses, controls, measurements, conclusions, *evaluation, practical, analysis*
controls on variables, *analysis*
presentation of results, *practical*
drawing valid conclusions, *analysis*
evaluation of process, *evaluation*

**Techniques**
chromatography (paper, column, thin layer), *practical*
mass spectrometry, *application*
IR, UV, AA, GC, HPLC, Electron microscope, MS, NMR, Electrophoresis, elemental *analysis, recall*
microscopy, *practical*
evaluation of results, *evaluation*
spectroscopy - principles, *interpretation, application*

**Physics**

**Dynamics**
simple harmonic motion, *application*
simple harmonic motion, *analysis*
uniform motion and uniform accelerated motion, *analysis, practical*

**Electronics**
optic fibres, lasers, *application*
negative feedback and control system theory, Electronic control circuits, Remote sensing, fibre optics

**Electricity**
nature of electric current, nature of potential difference, Ohm’s law and power, *interpretation, application*
transducers - LDR, thermistor, strain gauge, *application*

ohm’s law and power, *application*
capacitance, charge, *interpretation*
alternating/direct current, AC theory (three phase), *interpretation, practical*
Kirchhoff’s law, Energy stored, *interpretation, practical*
force on a moving charge, motion of charged particles in a magnetic field, *application*
force on a current-carrying conductor, *application*
Energy Transfer
- temperature scales, Absolute zero, analysis, practical
- conductivity, interpretation
- electromagnetic radiation, recall
- work and power, Conservation of energy, application
- convection, diffusion, conduction, recall

Fields
- electric and magnetic, recall
- magnetic, application
- magnetic effect of a current, Force on/in a field, application

Fluid Flow
Forces and motion
- forces and balances (including Newton’s Laws), Moments of inertia, Linear & angular velocity, calculate F=ma

Kinetic theory
- matter - non-ideality, interpretation

Light
- the eye, application

Light and sound
- diffraction, application
- phase difference and superposition optical instruments - operation of telescope, practical, application
- progressive and stationary waves, different media of waves, polarisation, speed, practical, application
- interference, practical, application
- structure of the eye, interpretation, application
- laws of reflection and refraction, structure of cameras, wave theory related to refraction, Sound systems and other ‘sound’ machines, interpretation, application
- principles of geometrical optics (laws of reflection and refraction), recall, practical
- fundamental nature of sound and light, relationship between frequency, wavelength and velocity, refraction, reflection, angle of incidence, angle of reflection, phase changes due to change in density of transmitting medium, calculation/application (simple calculation)

Materials
- crystalline, amorphous, polymeric, composite, application, practical
- crystalline, amorphous, polymeric, composite, recall
- elastic, plastic, recall
- tensile & bulk properties (stress & strain), recall

Mechanics
- friction, analysis
- work and power, application
- motion in circle, application
- moment of force, application
- pressure of measurement, Boyle’s law, interpretation

Network theory
- resistivity - inductance, capacitance, resonance, application

Physical properties
- physical quantities - units of measurement, application, practical
- scalar and vector quantities, interpretation

Radioactivity
range of natural sources, half-life, alpha, beta and gamma radiation, recall

Structure and dynamics
force, laws of motion, recall
force including gravity, laws of motion, analysis
principle of superposition (standing waves, interference, beats, diffraction), practical, application
wave motion (reflection, refraction, dispersion, polarisation, sinusoidal travelling waves), practical, interpretation, application

Waves
frequency, harmonics, EM spectrum, Infra red, ultra violet, X rays, Gamma rays (including safety aspects), recall
Appendix J

Report: Components common to all sectors and matched by GNVQ only

BIOLOGY

Biological materials
- cellular structure, basic concepts of nucleus, mitochondria, cell wall structure, recall
- photosynthesis - energy transfer and redox processes involved (the light reaction and light independent reactions), analysis
- photosynthesis - energy transfer and redox processes involved (the light reaction and light independent reactions), application

Biological structure
- biochemical hierarchy: molecules (amino acids, sugars, proteins, nucleotides), organelles (nucleus, mitochondria, Golgi, endoplasmic reticulum, ribosomes, chloroplasts), cells - membrane, variety of shape differentiation, recall

Ecology
- populations, ecosystems, energy transfers, nutrient cycles, water cycles, application

Flowering

Genetics
- life-cycles - sexual, asexual, hermaphrodite, application, analysis
- natural selection/artificial selection, application, analysis

Human physiology
- brain/nervous system, application, synthesis
- structure and functions of: reproductive system, application, synthesis
- structure and functions of: digestive system, application, synthesis
- structure and functions of: respiratory system, cardiovascular system, application, synthesis

CHEMISTRY

Catalysts
- catalysis, practical, application

Physical chemistry
- kinetics, order, collision theory, rate constants, practical, application
- states of matter, recall

Chemical properties
- control of degradation, limiting corrosion, biological change, application
- oxidation/reduction, recall, practical
- acids, bases, pH, titration, use of indicators, recall, Practical
- inorganic chemistry, practical, application

Atomic structure and bonding
- bonding, recall

Chemical reactions
- oxidation and reduction, addition of oxygen and hydrogen, addition and removal of electrons from metals, practical, application, analysis
- chemical equations - balancing, interpretation
- endothermic/exothermic, Dehydration/reduction, application, practical
- addition/elimination, substitution, hydrolysis, application, practical

Environmental conservation
- human impact on environment, issues (industrial production and conservation, structure of the atmosphere, acid rain, ozone depletion, recycling, waste management), interpretation

Quantitative chemistry
Avogadro constant, mole, concentrations, application
energetics, enthalpy changes, entropy, free energy, practical, application

Structures
isomers and asymmetry, interpretation
states of matter, application
shapes of molecules, recall

GENERAL SKILLS
Comprehension
checking validity of information, application, practical
integrate knowledge from different sources, practical, application, synthesis
note taking, application, practical
selecting relevant sources, application, practical,
selection/abstraction of information, application, practical
understanding information, application, practical
using information sources - literature, application, practical

Environment
conservation, how human activity affects the environment, issues relating to industrial production and
conservation, structure of the atmosphere, acid rain, ozone depletion, recycling (benefits, non-benefits),
Waste management, interpretation, analysis

Ethics
applied to scientific applications, recall

Evaluation
ability to make recommendations, advantages and disadvantages, ability to work out important aspects,
ability to discuss science, design/use of controls - understanding of role of controls, analysis, evaluation, synthesis
recognition of validity of answers, critical analysis of results - review of results, analysis, evaluation, synthesis

Health & Safety
risk assessment, hazards/ideas that all situations have risks/safe lab practice, application

Information handling
extrapolate from data gathered and draw conclusions, evaluation, practical

Information Technology
data collection and storage, practical
data transfer, recall
generating graphs/data displays, practical, application
operating systems, application, practical
word processing, application, practical

Oral communication
adapting to audience level, interpretation, practical
clarity of expression, practical, application,
communicate ideas, application, practical
communicate information, application, practical
communicate problems & issues, application, practical
developing discussion skills, application, practical
fluency - command of language, practical, application
presentation - one-to-one, application, practical
presentation to group, practical, application

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Fitness for purpose as a means of comparing qualifications: Appendices

presentation to non-experts, practical, application
presentation to peers, practical, application
presentation to seniors/tutors, practical, application
summarise information, application, practical
Personal skills
appreciate own strengths and weaknesses (self-criticism), practical
creativity, practical
lateral thought, practical
independent working, practical
integrity - rigour, practical
motivation, practical
enquiring mind, practical
ambition, practical
enthusiasm, practical
time-management skills, setting priorities, meeting deadlines, managing own learning, setting project goals, application, practical
Planning
considering all options, evaluation of opportunities, application, practical
modifying (review and revision of plan), application, practical
aims - clarity of purpose, application, practical
prioritising tasks, target setting, application, practical
Problem solving
systematic approach to problems, practical, analysis
Social/economic/environmental issues
applied to scientific applications eg: public health, air & water quality, application
impact of industry on society and the environment, application
Team working
accepting guidance/feedback, application, practical
appreciation of alternative perspectives, application, practical,
appreciation of strengths and weaknesses of team members, application, practical
co-operative working - with others in team, application, practical
diplomacy, application, practical
flexibility/adaptability, application, practical
providing feedback to others, application, practical,
work to agreed criteria, application, practical
work with new and different people, application, practical
Written communication
clarity of expression, application, practical
accuracy, application, practical
breadth of vocabulary, application, practical
essay writing, application, practical
fluency of expression (taken to be distinct from clarity), application, practical
forms of written communication, recall
grammar, application, practical
handwriting skills, practical
layout of documents, application, practical
present information in required form, application, practical
presentation of graphs, tables & charts, images, application, practical
punctuation, sentence & paragraph construction, application, practical
spelling, application, practical
structure and write reports, application, practical
using scientific nomenclature, application, practical,
write using discussion format, application, practical

Accuracy and precision
error, application

Algebra
indices - multiplication, division, power and roots, application
solving equations - up to quadratics, application
solving simultaneous equations, application
substitute, rearrange formulae, application

Calculus
differentiation and integration, application
differentiation and integration of trigonometric functions, application

Presentation of relationships
graphs/charts/tables, application

Interpretation of relationships
graphs/charts/tables, application

Modelling
form and solve equations, synthesis

Numeracy
add, subtract, multiply, divide, percentages, ratios, application
order of magnitude - estimation/approximation, application
order of magnitude, recall

Statistics
measures of significance of results, application
regression, application
variance, application

Trigonometry
sine, cosine, tangent, similar triangles, application

SCIENTIFIC METHOD AND PRACTICE

Fieldwork
sampling (including limitation), practical
observation and recording, practical

Measurements and observations
chemical analysis - qualitative, practical
information from instruments - spectrometers, recall
estimating errors, analysis
reading instruments (vernier, meters), practical,
reliability of data, analysis,
chemical analysis - quantitative, practical
collecting samples, practical
pH, practical
Scientific method
accurate observation, practical
observation, hypotheses, controls, measurements, conclusions, evaluation, practical, analysis
presentation of results, practical
drawing valid conclusions, analysis
evaluation of process, evaluation
Techniques
chromatography (paper, column, thin layer), practical
mass spectrometry, application
preparing substances, practical
purification, practical
microscopy - types of microscope, practical
microscopy, practical
evaluation of results, evaluation
spectroscopy - principles, interpretation, application
PHYSICS
Control
components of an automatic feedback system, monitoring and safety, application, practical
Dynamics
simple harmonic motion, analysis
uniform motion and uniform accelerated motion, analysis, practical
Electronics
digital circuits for computation, electronic measurement, application
diode rectifier, transistor, logic gates - AND, OR, NOT, practical, application
negative feedback and control system theory, Electronic control circuits, Remote sensing, fibre optics
technology, interpretation, practical
semiconductor properties, components of electronic data transfer devices and their functions, Features of
electronic data transmission, analogue techniques, application, practical
components - diode, transistor, application
how connect into circuits, Simple circuits, Test and build circuits, application, practical
basic semiconductor theory, Diode and transistor - how they work, Basic operational amplifier (as a black
box), interpretation, application, practical
Electricity
nature of electric current, nature of potential difference, Ohm’s law and power, interpretation, application
alternating/direct current, AC theory (three phase), interpretation, practical
photoelectric effect, practical, interpretation, application
Energy Transfer
heat capacity, analysis, practical
work and power, Conservation of energy, application
alternative energy sources, Microwave generators, radiation, conduction, convection, interpretation
Fluid Flow
fluid flow - its measurement and control in industrial, medical, construction contexts including turbine flow
meter, venturi meter, thermal flow meter, anemometers, orifice plates, v-slots, vortex meter, interpretation
Forces and motion
forces and balances (including Newton’s Laws), Moments of inertia, Linear & angular velocity, calculate
F12
Kinetic Light
spectrum - infra red, interpretation
Light and sound
diffraction, application
Material
assess the materials in an existing product or select materials for a given, application in terms of potential or extent of modification, analysis
tensile & bulk properties (stress & strain), application, practical
alloying, heat treatment, chemical treatment, application
Mechanics
work and power, application
motion in circle, application
moment of force, application
Physical properties
Young modulus, application, practical
force including gravity, laws of motion, hydraulics, application
principle of superposition (standing waves, interference, beats, diffraction), practical, application
Waves
fundamental nature of sound and light, relationship between frequency, wavelength and velocity, refraction, reflection, angle of incidence, angle of reflection, phase changes due to change in density of transmitting medium, calculation/application (simple calculation)
Appendix K

Report: all sectors essential intersected with GCE core

BIOLOGY

Biological materials
structure of cell, cell membranes, difference between plant and animal cell, lipid base, osmosis, application
cell biology, DNA - what it does, how proteins are made, what they are, how they differ, how different products are developed in different conditions, application
photosynthesis - energy transfer and redox processes involved (the light reaction and light independent reactions), analysis

Biological structure
biochemical hierarchy; molecules (amino acids, sugars, proteins, nucleotides), organelles (nucleus, mitochondria, Golgi, endoplasmic reticulum, ribosomes, chloroplasts), cells - membrane, variety of shape differentiation, recall

Genetics
natural selection/artificial selection, application, analysis
variation, biodiversity and evolution, application, analysis
Osmosis
mechanism, application

CHEMISTRY

Chemical names
elements, periodic table, recall, practical

Physical chemistry
kinetics, order, collision theory, rate constants, practical, application
Atomic structure and bonding
atomic structure, recall
atomic structure, interpretation

Chemical reactions
chemical equations - balancing, interpretation

Quantitative chemistry
Avogadro constant, mole, concentrations, application

Structures
shapes of molecules, application
isomers and asymmetry, interpretation
states of matter, application
states of matter, recall
atomic orbitals, shapes of orbitals, analysis

GENERAL SKILLS

Comprehension
integrate knowledge from different sources, practical, application, synthesis

Evaluation
ability to make recommendations, advantages and disadvantages, ability to work out important aspects, ability to discuss science, design/use of controls - understanding of role of controls, analysis, evaluation, synthesis
recognition of validity of answers, critical analysis of results - review of results, analysis, evaluation, synthesis

Oral Communication
questioning, application, practical
Planning
modifying (review and revision of plan), application, practical
prioritising tasks, target setting, application, practical
Written communication
clarity of expression, application, practical
fluency of expression (taken to be distinct from clarity), application, practical
layout of documents, application, practical
present information in required form, application, practical
structure and write reports, application, practical
Presentation of relationships
graphs/charts/tables, application
Interpretation of relationships
graphs/charts/tables, application

MATHMATICS
Logarithms
bases, scales, powers, application
Statistics
measures of significance of results, application
standard deviation, application
Vectors
addition, subtraction - two/three dimensions, application

SCIENTIFIC METHOD AND PRACTICE
Fieldwork
sampling (including limitation), practical
Measurements and observations
reliability of data, analysis
Scientific method
ability to follow instructions (standard procedures), practical
accurate observation, practical
make and test hypotheses, practical, analysis
observation, hypotheses, controls, measurements, conclusions, evaluation, practical, analysis
controls on variables, analysis
presentation of results, practical
drawing valid conclusions, analysis
evaluation of process, evaluation
Techniques
microscopy, practical
spectroscopy - principles, interpretation, application

PHYSICS
Dynamics
simple harmonic motion, application
simple harmonic motion, analysis
uniform motion and uniform accelerated motion, analysis, practical
Electricity
nature of electric current, nature of potential difference, Ohm’s law and power, interpretation, application
ohm’s law and power, application
capacitance, charge, interpretation
alternating/direct current, AC theory (three phase), interpretation, practical
Kirchhoff’s law, Energy stored, interpretation, practical
force on a current-carrying conductor, application

Energy Transfer
temperature scales, Absolute zero, analysis, practical
conductivity, interpretation
work and power, Conservation of energy, application
electromagnetic radiation, application
energy transfer, convection, diffusion, conduction, recall

Fields
electric and magnetic, recall
magnetic, application
magnetic effect of a current, Force on/in a field, application

Fluid Flow
Forces and motion
forces and balances (including Newton’s Laws), Moments of inertia, Linear & angular velocity, calculate
kinetic energy, F12

Kinetic theory
matter - non-ideality, interpretation

Light and sound
diffraction, application
phase difference and superposition optical instruments - operation of telescope, practical, application
progressive and stationary waves, different media of waves, polarisation, speed, practical, application
interference, practical, application
laws of reflection and refraction, structure of cameras, wave theory related to refraction, Sound systems
and other ‘sound’ machines, interpretation, application
principles of geometrical optics (laws of reflection and refraction), recall, practical

Mechanics
friction, analysis
work and power, application
motion in circle, application
moment of force, application

Network theory
resistivity - inductance, capacitance, resonance, application

Physical properties
scalar and vector quantities, interpretation

Physics of measurement

Radioactivity
range of natural sources, half-life, alpha, beta and gamma radiation, recall

Structure and dynamics
force, laws of motion, recall
force including gravity, laws of motion, analysis
principle of superposition (standing waves, interference, beats, diffraction), practical, application
wave motion (reflection, refraction, dispersion, polarisation, sinusoidal travelling waves), practical,
interpretation, application
Appendix L

Report: all sectors essential intersected with GNVQ mandatory content

BIOLOGY

Genetics
life-cycles - sexual, asexual, hermaphrodite, application, analysis
natural selection/artificial selection, application, analysis

Human physiology
brain/nervous system, application, synthesis

CHEMISTRY

Catalysts
catalysis, practical, application

Physical chemistry
kinetics, order, collision theory, rate constants, practical, application

Chemical properties
inorganic chemistry, practical, application

Atomic structure and bonding
atomic structure, recall

Chemical reactions
oxidation and reduction, addition of oxygen and hydrogen, addition and removal of electrons from metals, practical, application, analysis
chemical equations - balancing, interpretation
endothermic/exothermic, dehydration/reduction, application, practical

Environmental conservation,
human impact on environment, issues (industrial production and conservation, structure of the atmosphere, acid rain, ozone depletion, recycling, waste management), interpretation

Quantitative chemistry
Avogadro constant, mole, concentrations, application
energetics, enthalpy changes, entropy, free energy, practical, application

Structures
states of matter, application
shapes of molecules, recall

GENERAL SKILLS

Comprehension
checking validity of information, application, practical
integrate knowledge from different sources, practical, application, synthesis
note taking, application, practical
understanding information, application, practical

Ethics
applied to scientific applications, recall

Evaluation
ability to make recommendations, advantages and disadvantages, ability to work out important aspects, ability to discuss science, design/use of controls - understanding of role of controls, analysis, evaluation, synthesis
recognition of validity of answers, critical analysis of results - review of results, analysis, evaluation, synthesis

Health & Safety,
risk assessment, hazards/ideas that all situations have risks/safe lab practice, application

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Information handling
extrapolate from data gathered and draw conclusions, evaluation, practical
Information Technology,
data collection and storage, practical
data transfer, recall
generating graphs/data displays, practical, application
operating systems, application, practical
word processing, application, practical
Oral communication
adapting to audience level, interpretation, practical
clarity of expression, practical, application,
communicate ideas, application, practical
communicate information, application, practical
communicate problems & issues, application, practical
debatting/discussion skills, application, practical
fluency - command of language, practical, application
summarise information, application, practical
Personal skills
appreciate own strengths and weaknesses (self-criticism), practical
creativity and lateral thought, practical
independent working, practical
integrity - rigour, practical
motivation, practical
enquiring mind, practical
ambition, practical
enthusiasm, practical
time-management skills, setting priorities, meeting deadlines, managing own learning, setting project goals, application, practical
Planning
considering all options, evaluation of opportunities, application, practical
modifying (review and revision of plan), application, practical
aims - clarity of purpose, application, practical
prioritising tasks, target setting, application, practical
Problem solving
systematic approach to problems, practical, analysis
Social/economic/environmental issues
applied to scientific applications eg: public health, air & water quality, application
impact of industry on society and the environment, application
Team working
accepting guidance/feedback, application, practical
appreciation of alternative perspectives, application, practical,
appreciation of different roles in team, application, practical
appreciation of strengths and weaknesses of team members, application, practical
co-operative working - with others in team, application, practical
diplomacy, application, practical
flexibility/adaptability, application, practical

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providing feedback to others, application, practical
work to agreed criteria, application, practical
work with new and different people, application, practical
Written communication
clarity of expression, application, practical
accuracy, application, practical
breadth of vocabulary, application, practical
essay writing, application, practical
fluency of expression (taken to be distinct from clarity), application, practical
forms of written communication, recall
grammar, application, practical
handwriting skills, practical
layout of documents, application, practical
presentation of graphs, tables & charts, images, application, practical
punctuation, sentence & paragraph construction, application, practical
spelling, application, practical
structure and write reports, application, practical
write using discussion format, application, practical
Accuracy and precision
error, application
Algebra
solving equations - up to quadratics, application
Presentation of relationships
graphs/charts/tables, application
Numeracy
add, subtract, multiply, divide, percentages, ratios, application
Statistics
measures of significance of results, application
regression, application
variance, application
SCIENTIFIC METHOD AND PRACTICE
Fieldwork
observation and recording, practical
Measurements and observations
accuracy, recall
information from instruments - spectrometers, recall
estimating errors, analysis
reading instruments (vernier, meters), practical, reliability of data, analysis.
chemical analysis - quantitative, practical
Scientific method
accurate observation, practical
observation, hypotheses, controls, measurements, conclusions, evaluation, practical, analysis
drawing valid conclusions, analysis
evaluation of process, evaluation
Techniques
Fitness for purpose as a means of comparing qualifications: Appendices

mass spectrometry, application
preparing substances, practical
purification, practical
microscopy - types of microscope, practical
microscopy, practical
evaluation of results, evaluation
spectroscopy - principles, interpretation, application

PHYSICS
Control
components of an automatic feedback system, monitoring and safety, application, practical
Electronics,
semiconductor properties, components of electronic data transfer devices and their functions, Features of electronic data transmission, Analogue techniques, application, practical
Electricity
nature of electric current, nature of potential difference, Ohm’s law and power, interpretation, application
Energy Transfer
heat capacity, analysis, practical
radiation, conduction, convection, internal energy, analysis, practical
work and power, Conservation of energy, application
Fluid Flow
fluid flow measurement, orifice plates, V-slots, practical, application
fluid flow - its measurement and control in industrial, medical, construction contexts including turbine flow meter, venturi meter, thermal flow meter, anemometers, orifice plates, v-slots, vortex meter, interpretation
Forces and motion
forces and balances (including Newton’s Laws), Moments of inertia, Linear & angular velocity, calculate F12
Light and sound
diffraction, application
Materials
assess the materials in an existing product or select materials for a given application in terms of potential or extent of modification, analysis
tensile & bulk properties (stress & strain), application, practical
alloying, heat treatment, chemical treatment, application
Mechanics
work and power, application
motion in circle, application
moment of force, application
Physical properties
Young modulus, application, practical
Structure and dynamics,
torque, angular acceleration, application
force including gravity, laws of motion, hydraulics, application

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Appendix M

Report: Intersection of GCE core, GNVQ mandatory and essential user requirements

BIOLOGY
Genetics
natural selection/artificial selection, application, analysis

CHEMISTRY
Physical chemistry
kinetics, order, collision theory, rate constants, practical, application
Atomic structure and bonding
atomic structure, recall
Chemical reactions
chemical equations - balancing, interpretation
Quantitative chemistry
Avogadro constant, mole, concentrations, application

Structures
states of matter, recall
states of matter, application

GENERAL SKILLS
Comprehension
integrate knowledge from different sources, practical, application, synthesis

Evaluation
ability to make recommendations, advantages and disadvantages, ability to work out important aspects, ability to discuss science, design/use of controls - understanding of role of controls, analysis, evaluation, synthesis

recognition of validity of answers, critical analysis of results - review of results, analysis, evaluation, synthesis

Planning
modifying (review and revision of plan), application, practical
prioritising tasks, target setting, application, practical

Written communication
fluency of expression (taken to be distinct from clarity), application, practical
layout of documents, application, practical
structure and write reports, application, practical
summarise, application, practical

Presentation of relationships
graphs/charts/tables, application

Statistics
measures of significance of results, application

SCIENTIFIC METHOD AND PRACTICE
measurement & observations
reliability of data, analysis

Scientific method
accurate observation, practical
observation, hypotheses, controls, measurements, conclusions, evaluation, practical, analysis
drawing valid conclusions, analysis
evaluation of process, evaluation

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Techniques
microscopy, practical
spectroscopy - principles, interpretation, application

PHYSICS
Electricity
nature of electric current, nature of potential difference, Ohm's law and power, interpretation, application

Energy Transfer
work and power, Conservation of energy, application

Forces and motion
forces and balances (including Newton's Laws), Moments of inertia, Linear & angular velocity, calculate

Light & Sound
diffraction, application

Mechanics
work and power, application
motion in circle, application
moment of force, application