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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Appendices

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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 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.
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.

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 projects[1] 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.

[1] see for example: *Comparability Exercise for Advanced Science*, SCAA/NCVQ, Coles, M, & Nelms R, (1995) *Comparing GNVQ Science and A level sciences*, The Science Technology and Maths Council

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?

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[2]Lord,K, Wake, G D, & Williams, J S, *Mathematics for Progression from Advanced GNVQs to Higher Education*; The Mechanics in Action Project, University of Manchester (1995), ISBN 0 948241 30 6

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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[3]Gagné, R M, (1985) *The conditions of learning and theory of instruction* (4th Ed). New York: Holt, Rinehart and Winston
Bloom, B S (ed.)(1956), *Taxonomy of Educational Objectives - Book 1 - Cognitive Domain*. Michegan: Longman
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

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:

Component context	Detail	Focus of performance

e.g.

Chemical reaction types	Acid-base (limited to neutralisation; indicators; salt formation; protonation; ionisation, buffers)	analysis

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.

primary domains	secondary domains
Chemical production	pharmaceutical bulk chemicals biotechnology chemical engineering
Engineering	mechanical electrical electronic civil transport
Public analysis	health and safety quality control environmental monitoring forensic
Food production	agriculture processing
Healthcare	medicine occupations supportive to medicine psychology
Materials extraction and processing	geology oil refining forestry

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

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

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 NUD.IST[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

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:

- 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 GNVQs 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;

- 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).
i.e.

Component context	Detail	Focus of performance

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.

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 dependant 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

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.

Feature of method	Success	Changes in future
Framework (component)	Quite useful organiser - broad structuring	None
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
Selection of qualifications	Unproblematic	Size of candidate entry key factor
Costs	£40,000 allocated - £5,000 spent - no officer costs incurred in this pilot, no users or claimers paid	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.
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	chemistry	physics
anatomy	analytical chemistry	control
biological materials	atomic structure and bonding	dynamics
biological structure	biochemistry	electricity
ecology	catalysts	electronics
flowering	chemical names	electrostatics
food supply	chemical properties	energy transfer
genetics	chemical reactions	fields
growth and medium for growth	environmental conservation,	fluid flow
human physiology,	extraction of materials	forces and motion
microbiology	physical chemistry	kinetic theory
osmosis,	quantitative chemistry	light
plant nutrition	solubility	light and sound
social biology	structures	materials
		mechanics
		network theory
		physical properties
		physics of measurement
		properties of matter
		quantum mechanics
		radioactivity
		structure and dynamics
		thermodynamics
		waves

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

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.

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).

physics	**scientific method and practice**	**general skills**
electricity	basic laboratory skills	comprehension
energy transfers in different systems	fieldwork	creativity
mechanics	judging reliability of data	evaluation
	making measurements and observations	health and safety awareness
	scientific method	human impact on the environment
		information handling
		IT skills
		oral communication
		personal skills - inc. independent working, time management,
		planning
		problem solving
		team working
		written communication

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:

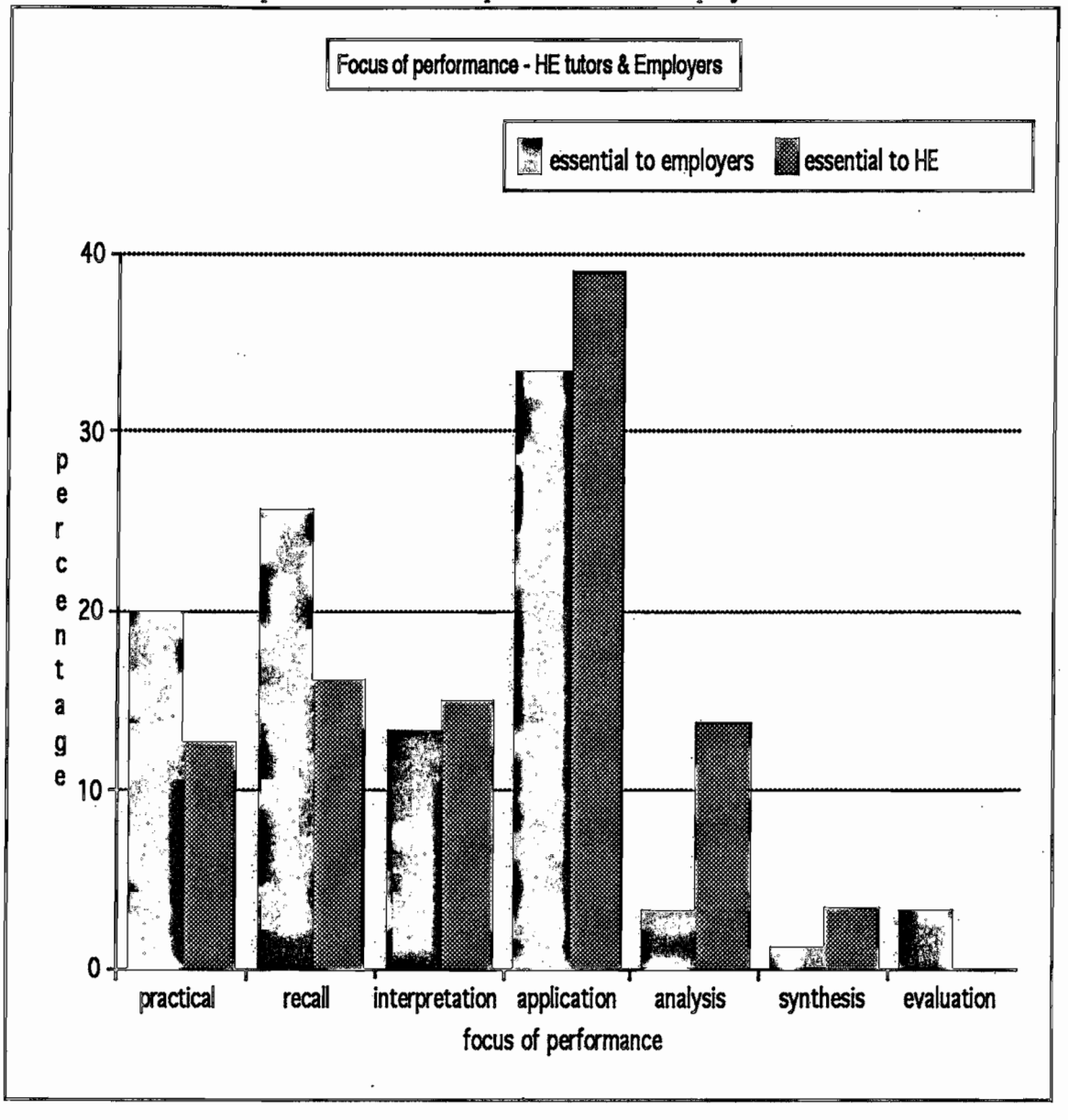
i) that only a limited range of physics components (and none for biology or chemistry) are seen as essential by representatives of all user domains;

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 commonalty.

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.

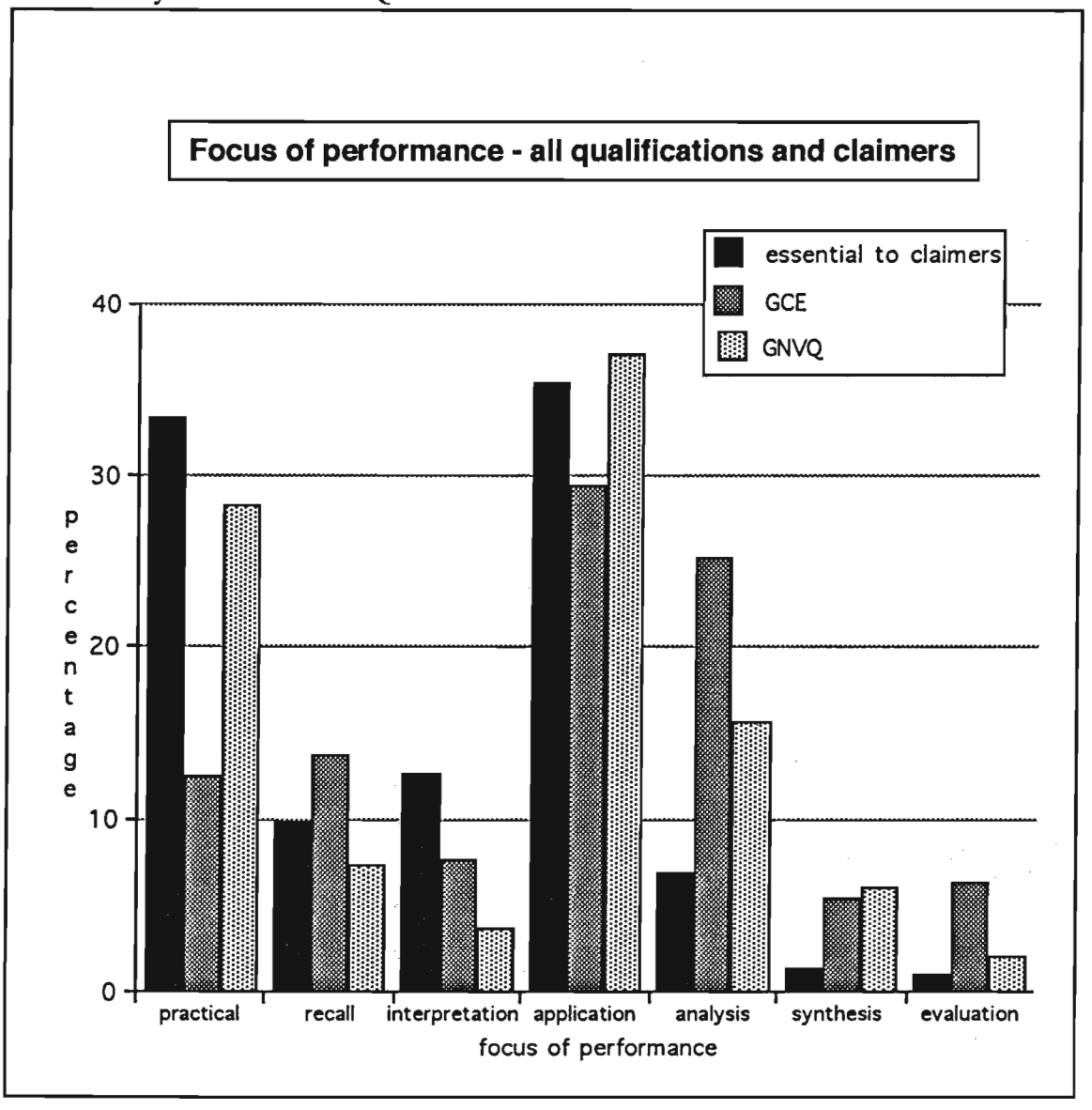
Analysis: users required little analysis, both GNVQ and GCE contained significantly more. GNVQ about twice as required by users, and GCE over three times as much.

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.

[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.

[7]see '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.

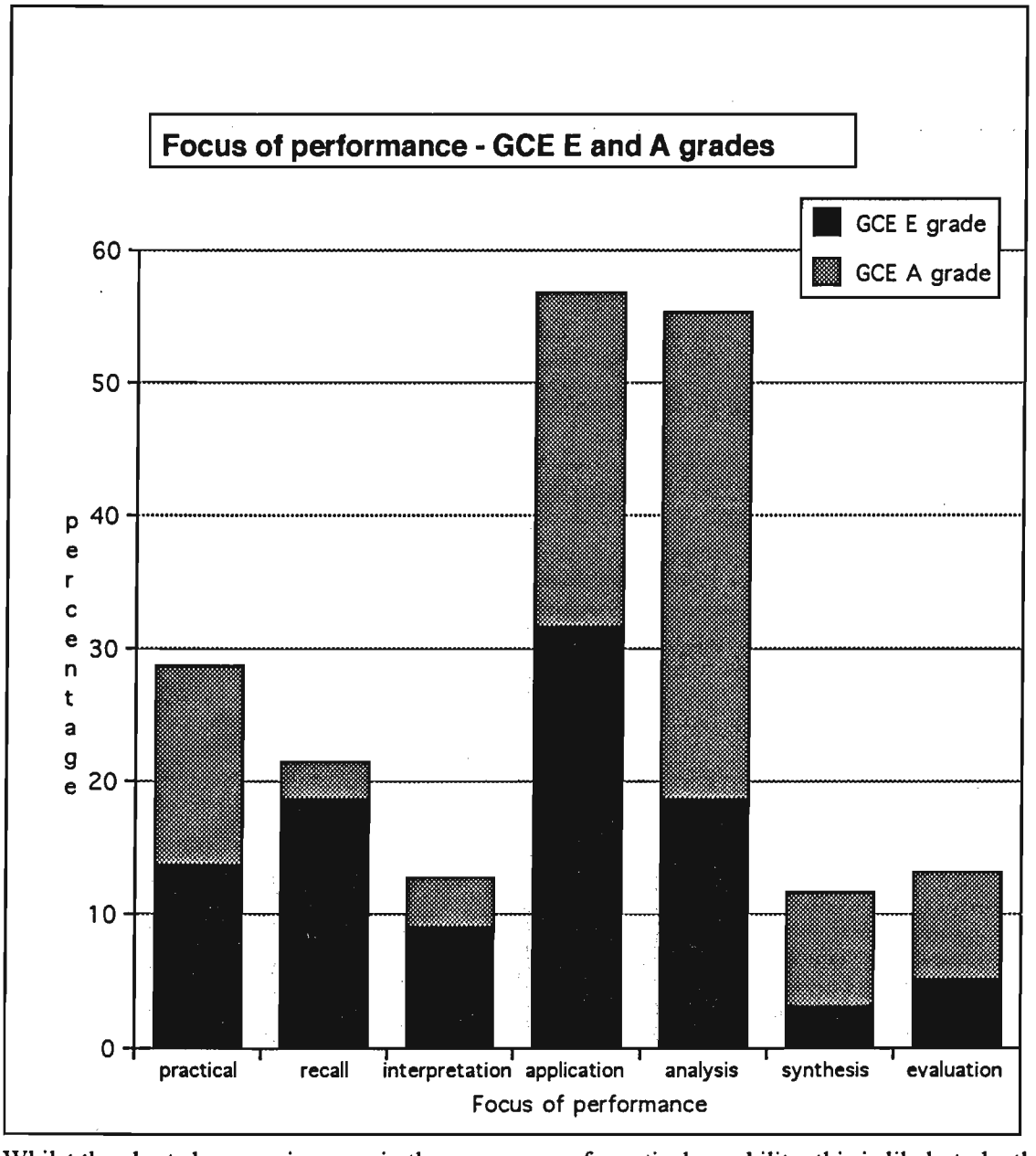
The differential between students in the GCE was often expressed as deeper treatment, by A grade students, of common content. In the GNVQ the differential tended to be in more advanced development of generic skills.

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.

[8]see methodology section, stage 8, above for more detail

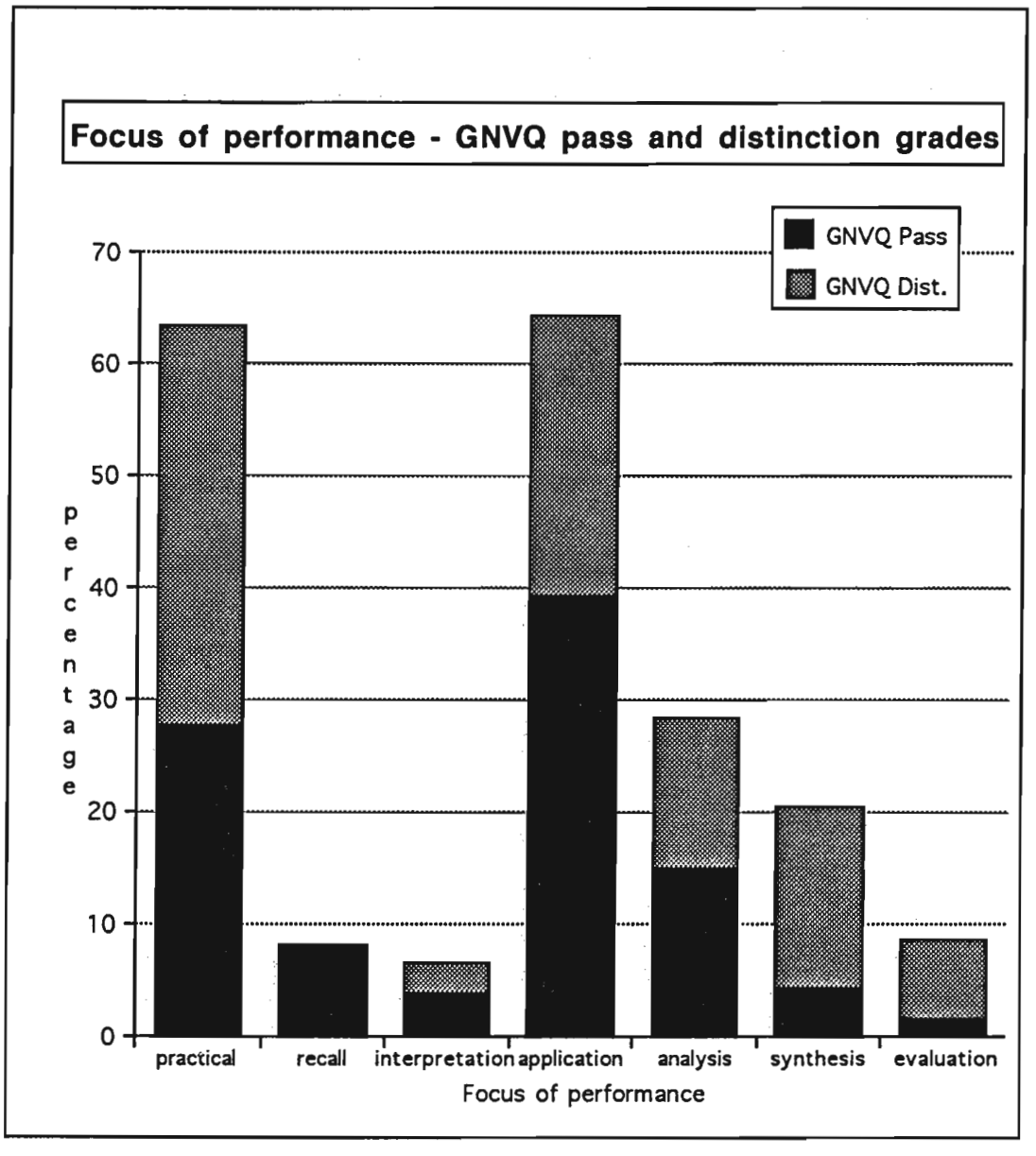
Chart C: shows how scrutineers view E grade and A grade performance in GCE in terms of their focus of performance. The information is shown in terms of the percentage incidence of each focus.



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.

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:

biology	**chemistry**	**physics**
biological materials	atomic structure and bonding	dynamics
biological structure	chemical names	electricity
genetics	chemical reactions	energy transfer
osmosis	physical chemistry	fields
	quantitative chemistry	forces and motion
	structures	kinetic theory
		light and sound
		mechanics
		network theory
		physical properties
		physics of measurement
		radioactivity
		structure and dynamics

scientific method and practice	**general skills**	**mathematics and numeracy**
fieldwork	comprehension	
measurements and observations	evaluation	statistics
scientific method	interpretation of relationships	vectors
techniques	presentation of relationships	logarithms
	oral communication	
	planning	
	written communication	

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:

biology	chemistry	physics
genetics	atomic structure and bonding	electricity
human physiology	catalysts	electronics
	chemical properties	energy transfer
	chemical reactions	fluid flow
	environmental conservation	forces and motion
	quantitative chemistry	light and sound
	structures	materials
		mechanics
		physical properties
		structure and dynamics

scientific method and practice	general skills	mathematics and numeracy
fieldwork	accuracy and precision	algebra
measurements and observations	comprehension	calculus
scientific method	ethics	numeracy
techniques	evaluation	statistics
	health & safety	trigonometry
	information handling	
	information technology	
	oral communication	
	personal skills	
	planning	
	presentation of relationships	
	problem solving	
	social/economic/ environmental issues	
	standards	
	team working	
	written communication	

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

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]

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

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:

no	sector	HE/ Emp	discipline	representative	Position	Organisation
201	chemical production	HE	chemist	John Lloyd	Admissions tutor, chemical engineering	Loughborough University of Technology
202	chemical production	Emp	chemist	Anil Kumar	Education Development Manager	Glaxo Wellcome Research & Development
203	chemical production	Emp	chemist	Dr Anne Cook	Senior Scientist	British Biotech Pharmaceuticals
204	chemical production	Emp	chemist	Norman Carlile	Manager	Unilever
205	chemical production	Emp	chemist	Frank Ellis	Group leader - Medicinal Chemistry	Glaxo Wellcome Research & Development
206	chemical production	HE	chemist	Geoff Hawkes	Admissions Tutor for Chemistry	Queen Mary & Westfield College
207	chemical production	HE	chemist	Trevor Toube	Lecturer, Department of Chemistry	Queen Mary & Westfield College
208	chemical production	HE	chemist	Margaret Goodgame	Admissions Tutor for Chemistry	Imperial College London
209	chemical production	HE	chemist	Bryan Levitt	Director of Undergraduate Studies	Imperial College London
210	public analysis	HE	biologist	Professor Stephen Hawkins	Professor of Environmental Biology	University of Southampton
211	public analysis	Emp	chemist	Dr Elizabeth Prichard	Consultant on Education & Training	Laboratory of the Government Chemist
212	public analysis	Emp	biologist	Nicky Court	Ecologist	County Planning Department
213	public analysis	Emp	chemist	John Eastwood	Principal Scientist	Thames Region NRA
214	public analysis	Emp	chemist	Dr Roger Purvis	Additional Public Analyst	Liverpool City Council's Public Analyst's Laboratory
215	public analysis	Emp	-	Mark Gibson	Education & Training Manager	Institute of Wastes Management
216	engineering	HE	physicist	Dr Trevor Bacon	Admissions Tutor, Physics	Imperial College of Science, Technology and Medicine
217	engineering	HE	physicist	Professor Jim Croll	Chadwick Professor of Civil Engineering and Head of Department	University College London
218	engineering	HE	physicist	Dr Tony Price	Director of Undergraduate Admissions (Engineering)	University of Warwick
219	engineering	HE	physicist	Dr Peter J White	Admissions Tutor, Electronic Engineering	University of Plymouth
220	engineering	HE	physicist	Dr George Harland	Director of studies Manufacturing systems engineering	University of Hertfordshire
221	engineering	Emp	physicist	Ron Broom	Technical PA to the Chairman	Aerial Group Ltd
222	engineering	Emp	physicist	Terry Hand	Head of Department - Quality	REME Training & Development Team

223	engineering	Emp	physicist	Michael P Sargent	Training Manager/Europe Liaison	County Surveyor's Department
224	engineering	Emp	physicist	Geoff Deakin	Group Training Manager	Bloxwich 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 Co-ordinator	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. Grigson	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 Hinxman	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 Heinegen 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

Claimers:

no	sector	HE/ Emp	discipline	representative	Position	Organisation
101	chemical production	HE	chemist	John Lloyd	Admissions tutor, chemical engineering	Loughborough University of Technology
102	chemical production	Emp	chemist	Anil Kumar	Education Development Manager	Glaxo Research & Development
103	chemical production	Emp	chemist	Dr Anne Cook	Senior Scientist	British Biotech Pharmaceuticals

104	chemical production	Emp	chemist	Norman Carlile	Manager	Unilever
105	chemical production	Emp	chemist	Frank Ellis	Group leader - Medicinal Chemistry	Glaxo Research & Development
106	chemical production	HE	chemist	Geoff Hawkes	Admissions Tutor for Chemistry	Queen Mary & Westfield College
107	chemical production	HE	chemist	Trevor Toube	Lecturer, Department of Chemistry	Queen Mary & Westfield College
108	chemical production	HE	chemist	Margaret Goodgame	Admissions Tutor for Chemistry	Imperial College London
109	chemical production	HE	chemist	Bryan Levitt	Director of Undergraduate studies	Imperial College London
110	public analysis	HE	biologist	Professor Stephen Hawkins	Professor of Environmental Biology	University of Southampton
111	public analysis	Emp	chemist	Dr Elizabeth Prichard	Consultant on Education and Training	Laboratory of the Government Chemist
112	public analysis	Emp	biologist	Nicky Court	Ecologist	County Planning Department
113	public analysis	Emp	chemist	John Eastwood	Principal Scientist	Thames Region NRA
114	public analysis	Emp	chemist	Dr Roger Purvis	Additional Public Analyst	Liverpool City Council's Public Analyst's Laboratory
115	public analysis	Emp	-	Mark Gibson	Education & Training Manager	Institute of Wastes Management
116	engineering	HE	physicist	Dr Trevor Bacon	Admissions Tutor, Physics	Imperial College of Science, Technology and Medicine
118	engineering	HE	physicist	Dr Tony Price	Director of Undergraduate Admissions (Engineering)	University of Warwick
119	engineering	HE	physicist	Dr Peter J White	Admissions Tutor, Electronic Engineering	University of Plymouth
121	engineering	Emp	physicist	Ron Broom	Technical PA to the Chairman	Aerial Group Ltd
122	engineering	Emp	physicist	Terry Hand	Head of Department - Quality	REME Training & Development Team
123	engineering	Emp	physicist	Michael P Sargent	Training Manager/Europe Liaison	County Surveyor's Department
124	engineering	Emp	physicist	Geoff Deakin	Group Training Manager	Bloxwich Engineering Ltd
125	materials extraction	HE	physicist	Professor Steve Sparks	Professor of Volcanology	University of Bristol
126	materials extraction	HE	physicist	Lynn Gabrielson	Admissions Tutor Materials Science & Technology	Brunel University
127	materials extraction	HE	physicist	Peter Hymans	Head of Department of Minerals Engineering	Doncaster College
128	materials extraction	Emp	Process Developme nt Manager	Dr David Barnes	Process Development Manager	English China Clay International (Europe)
129	materials extraction	Emp	chemist	Mark Farrar	Fibre Research Manager	St Regis Paper Company Ltd
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131	healthcare	HE	chemist	Dr Keith Elliott	Senior Lecturer in Biochemistry	University of Manchester
132	healthcare	HE	biologist	Dr Pat Judd	Senior Lecturer in Nutrition & Dietetics	Kings College London

133	healthcare	HE	biologist	Alan White	Senior Lecturer - Pre-Registration Nursing	Leeds Metropolitan University
134	healthcare	HE	biologist	Jane Lockwood	Senior Lecturer School of Physiotherapy	University of Nottingham
135	healthcare	Emp	biologist	Gareth Morgan	Biomedical Science Coordinator	NESCOT
136	healthcare	HE	biologist	Dr Ian Todd	Senior Lecturer - Division of Immunology	University of Nottingham Medical School
137	healthcare	HE	biologist	Ian Grigor	Senior Tutor in Biomedical Sciences	Leeds College of Health
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141	food production	HE	-	Mr Richard Hinxman	Academic Director	Writtle College
142	food production	Emp	-	John Nullis	Chairman of Employment and Education	National Farmers' Union
143	food production	Emp	-	Ben Brough	Associate Tutor	Agriculture Training Board
144	food production	Emp	biologist	Mr Chris White Moncrieff	Operations Manager	Westend Nursery Van Heinegen Bros.
145	food production	Emp	-	Johanna Hignett	Group Nutrition & Sensory Manager	Nestlé UK Ltd
146	food production	Emp	biologist	Peter Reeve	technical production manager	Bass Brewers Ltd
147	food production	HE	biologist	Dr Alistair Grandison	Course Tutor for Food Technology	University of Reading
148	materials extraction	HE	chemist	Keith Wadhams	Admissions Tutor for Paper Science	UMIST
149	food production	HE	biologist	Dr Hugh Martin	Head of Department of Agricultural Science	Royal Agricultural College
150	materials extraction	HE	physicist	Professor D E G Briggs	Professor of Palaentology	University of Bristol
151	chemical production	HE	chemist	Professor S K Scott	Head of Physical Chemistry	University of Leeds
153	chemical production	Emp	chemist	Jim Dingwall	Training Adviser	BP Chemicals Ltd (Hull)
154	chemical production	Emp	chemist	Peter Bonavia	HR Adviser	BP Chemicals Ltd (Hull)
155	chemical production	Emp	chemist	David Luke	Technical Director	Lea Ronal plc
156	chemical production	Emp	chemist	E Beacock	Project Leader - Research and Development	SCM Chemicals
157	chemical production	Emp	physicist	Rod Cook	Head of Personnel	British Biotech Pharmaceuticals Ltd
158	chemical production	Emp	chemist	R M Stephens	Senior Manager - Analytical Methods	Rhone Poulenc Chemicals Ltd
159	chemical production	Emp	chemist	T N Ramsay	Section Manager - Effluence	Rhone Poulenc Chemicals Ltd
160	healthcare	HE	biologist	Julia Henderson	Principal Lecturer in Radiography	University of Hertfordshire
161	healthcare	HE	biologist	I Henderson	Programme Coordinator - Radiographic Reporting	Southbank University

162	chemical production	HE	chemist	Dr Bill Prichard	Director of Undergraduate Studies in Chemistry	Warwick University
163	chemical production	Emp	physicist	John Pardon	General Manager of Corporate Division	British Biotech Pharmaceuticals Ltd
164	public analysis	Emp	chemist/ biologist	T Catterick/ Nigel Burns/ Ginny Saunders	Analytical Chemist/Molecular Biologist	Laboratory of the Government Chemist
165	materials extraction	Emp	physicist	Dr R Brown	Quality/technical manager	English china clay international
166	food production	Emp	chemist	Dr A Mundy	Corporation QA lab standards manager	Bass Brewers Ltd
167	food production	Emp	chemist	R A Marsh	Technical Director	RHM Grocery Ltd

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:

Descriptor	code
interpretation	F01
application	F02
practical	F03
analysis	F04
recall	F05
synthesis	F06
application/practical	F07
analysis/practical	F08
evaluation	F09
fieldwork	F10
practice	F11

Syllabus/specification reference

Descriptor	code
A level general - biology	S01
A level general - chemistry	S02
A level general - physics	S03
A level core biology	S04
A level core chemistry	S05
A level core physics	S06
A level non core biology	S07
A level non core chemistry	S08
A level non core physics	S09
GNVQ general - biology	S10
GNVQ general - chemistry	S10
GNVQ general - physics	S10
GNVQ mandatory biology	S13
GNVQ mandatory chemistry	S14
GNVQ mandatory physics	S15
GNVQ optional biology	S16
GNVQ optional chemistry	S17
GNVQ optional physics	S18

Level of performance

A level unspecified	L1
A level grade E	L2
A level grade A	L3
A level grade E&A	L4
GNVQ unspecified	L5
GNVQ pass	L6
GNVQ distinction	L7
GNVQ pass & distinction	L8

Appendix B

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.

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 your represent please can you give us the following information*

Name: _____ **Discipline:** _____

Department & organisation: _____

Contact address: _____

Component	detail	focus of performance	required	essential	covered	current
awareness of work	business skills (supply and demand, _quality assurance, quality control, packaging/advertising, market forces, costing, budget planning, management styles)	recall				
awareness of work	careers guidance	application				
awareness of work	work experience	practical				
comprehension	checking validity of information	application practice				
comprehension	integrate knowledge from different sources	practice application synthesis				
comprehension	note taking	application practice				
comprehension	reading complex texts	evaluation				
comprehension	reading fluently	application practice				
comprehension	selecting relevant sources	application practice				
comprehension	selection/abstraction of information	application practice				
comprehension	understanding information	application practice				
comprehension	using information sources - literature	application practice				

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

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 (eg. *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 (eg. dilutions, percentages, ratios)
- spelling and grammar

Study skills

- facility in accurately memorising terminology and facts
- inter-relate knowledge presented in different ways (eg. 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 (eg. 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 (eg. 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 intersected - claimers/identifiers - specified by one or more claimer[10]

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/maturation/ageing, 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%.

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*

Microbiology

commensal bacteria and pathogens, role of bacteria in disease,

applications using bacteria eg fermentation, *application*, *practical*

role of micro organisms in food production, effects on food including benefits, growth of microbes, disease-causing bacteria, *analysis*, *practical*

Osmosis

mechanism, *application*

Plant nutrition

nitrates, nitrogen cycle/carbon cycle, food chain-use of agricultural chemicals, why used and effect on food, *analysis*, *practical*

Social biology,

water purification, sewage disposal, housing issues, pollution, spread of infection, *interpretation*

public health, general awareness, social structure, health services, prevention rather than cure, environmental and genetic influence in health, *interpretation*

CHEMISTRY

Analytical Chemistry

water quality testing, neutralisation, universal indicators, pH, titration, chromatography, precipitation methods, *practical*, *recall*

chemical tests for cations/anions, *practical*, *interpretation*

analytical chemistry, absorption spectroscopy, *application*

Biochemistry

molecule types (proteins, carbohydrates, lipids and their combinations), *interpretation*

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,

common elements and compounds, *recall*

elements, periodic table, *recall*, *practical*

Physical chemistry

Particle size, colloidal behaviour, particle charge, packing, *practical*, *application*

first order reaction kinetics, *recall*, *practical*

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

behaviour at interfaces eg dispersion, flocculation, coagulation, *recall*, *practical*

osmosis, diffusion, *recall*, *practical*

states of matter, *recall*

colligative Properties, vapour pressure lowering, osmosis, *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*

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*

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

extrapolate 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)

basic working knowledge (not fluency), reading/speaking / listening, some cultural awareness, *practical, application*

Oral communication

accuracy, *application, practical*

adapting 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*

debating/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*

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*

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 anions, cations, group separation, *practical*
collecting samples, *practical*
NH3, BOD, COD, suspended solids, gas emission (CO2, CH4),dissolved solids, *practical*
pH, *practical*
refractometer, *practical*
Science in society
opinions 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

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*

Lens 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*

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, *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, 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*

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 - Boyles/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 - Boyles/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*

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[11]

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 pro active + 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, enquiring 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*

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[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 every day 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*

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 , *analysis*

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[12]

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, skeleta, blood, muscle, lung), *practical, interpretation*

biological structure, Physiology: Tissues - composition, differentiation; Systems (gastro intestinal, cardio vascular, 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

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[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%.

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[13]

Biology

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

Biological materials, main 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 transfer/, 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*

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[13]Total 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 = 6.3%. All documents have a total of 2163 text units, so text units found in these documents = 3.4%.

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*

fluid flow, mass flow through tubes - poissulle 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 (gastro intestinal, cardio vascular, 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

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*

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*
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*

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

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*
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*

Lens 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*

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

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, 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 - Boyles/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 - Boyles/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*

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

Measurements and observations

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 technology, *interpretation* , *practical*

fibre optics technology, *recall*

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* ,

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*

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 F12

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 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*

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*

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*
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*

Newton's laws, Conservation of momentum, Collisions, Energy P.E./K.E. conservation, Force as a vector, Pressure - Boyles/Charles law, *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*
MATHEMATICS
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* ,
Kirchoff'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 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*

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*
debating/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*

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

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* 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

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*

Newton's laws, Conservation of momentum, Collisions, Energy P.E./K.E. conservation, Force as a vector, Pressure - Boyles/Charles law, *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*

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*

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*