Language and Thinking in Science

Some Investigations with Multiple Choice Questions

By

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James R.T. Cassels

TABLE OF CONTENTS | Page

LIST OF TABLES

LIST OF FIGURES | Page

LIST OF APPENDICES

Language and Thinking in Science

Some Investigations with Multiple Choice Questions

An Abstract

In this thesis the performance of secondary school pupils in multiple choice questions at two levels is considered :

(a) How the language of the question may influence performance

(b) How the superficial language of the question may be related to the necessary internal thinking process.

The relationship between language, learning and thinking is discussed by a literature review of Language across the Curriculum; Language Development, Abnormal Development, Cognitive Development and Cognitive Processes. With this background, the setting up of three major experiments using multiple choice questions is described. Multiple choice questions are used because it was felt that it would be possible to design questions which would investigate not only the effect of language on performance but also give some indication of the internal processes which may be involved in solving these questions. The multiple choice questions are used in two ways :

(a) in matched pairs where two questions have been designed to test the same chemical concept but the language used to form the question has been altered in a deliberate way

(b) as individual questions which have been designed to investigate a particular factor, e.g. pupil understanding of a word in a particular context.

The three experiments are called the Scottish, the Joint Matriculation Board and the Chemical Society after the areas or organisations who were involved. The Scottish experiment is a fairly tightly designed experiment using both matched pairs and individual multiple choice questions. The JMB experiment is a parallel investigation in some respects using almost entirely matched pairs questions with the added dimension of comparing pupil performance with their measured general ability, their social class and their sex. The Chemical Society experiment is an expansion of one of the areas touched upon in the other experiments, namely the understanding of non-technical words in science. It is the least well defined of the experiments but it may be close to reality because it is based on the responses of real pupils to both 'good' and 'bad' questions designed by real teachers in the large number of establishments involved in the experiment. In total the experiments included over 30,000 pupils.

After discussion of the results of these experiments the following conclusions are suggested.

(a) ability to respond correctly to multiple choice chemistry questions is associated strongly with measured verbal ability

(b) simplification of items materially helped the less able as well as girls without impairing the general efficiency of the test as a measuring instrument

(c) high social class groups achieve higher facility values in chemistry questions than lower class groups, reflecting the influence of social class on language development.

In addition to these personal factors the following are suggested as factors influencing performance in multiple choice questions.

1 Words : If a non-technical word that needs to be understood to answer its question is replaced by a word that is more easily understood then there is an improvement in performance.

If any word is capable of being misinterpreted then this influences performance.

In addition to the key words the other

words in the question may also have an influence eg.compressed formal language may depress performance.

2 <u>Expression of Quantity or Order</u> : If incompatible expressions like 'least abundant', 'least concentrated' are replaced by more compatible expressions like 'most abundant', 'most concentrated', then there is an improvement in performance.

3 <u>Negatives</u> : If a negative expression is removed, there can be an improvement in performance.

4 <u>Bits of Information</u> : If extraneous bits of information are removed, performance improves but if bits of information are removed to such an extent that the question becomes more abstract then performance deteriorates.

If the bits of information are arranged in simple sentences instead of longer sentences with embedded clauses, then performance improves.

If the item consists of information and a question, performance seems to be improved by not separating the question from the responses by the insertion of information.

Performance in multiple choice chemistry questions does not seem to be influenced by minor changes in parts of speech nor by changing the passive voice into the active voice.

From the individual multiple choice questions the following conclusions are offered :

(a) Technical vocabulary that is introduced early in the secondary school may not be recalled by O grade chemistry candidates.

(b) The language of the text book may not be the language with which the pupil is most comfortable.

(c) In learning definitions of technical expressions, certain cues or trigger words may play an important role.

(d) From the vocabulary questions certain non-technical words including logical connectives may be a barrier to the learning of chemistry.

(e) The meaning of a word is not absolute but varies from a general meaning to a more precise meaning.

(f) A combination of words can result in an expression with a difficult meaning.

(g) The meaning of a word depends on its connotation and on its context .

(h) A word in a scientific context is harder to understand than the same word in a non-scientific context.

These conclusions are then considered in relation to the theoretical background and research previously described and the following hypothesis is suggested:

In all of the experiments the same feature comes across. It is the meaning that is important and it is derived by an active interpretative process that is language dependant in two interrelated senses:

(a) the language of the question is being processed ie. words, expressions, and bits of information are moving into the memory units

(b) language could be being used for the processing, i.e. advance organisers (109), cognitive bridges (110), linking (116), cues (135) may be being used to manipulate, store and recall information within the memory units.

The superficial language of the question is responsible for (a) and will have an impact on (b) and both (a) and (b) together contribute to the active interpretative process. Thus the superficial language of the question is closely related to the necessary internal thinking process.

The thesis ends with some tentative recommendations and an account of some of the consequences of the research work.

CHAPTER 1

Language and Thinking

1.1 Introduction

In this dissertation it is hoped to consider the performance of secondary school pupils in multiple choice questions at two levels.

(a) How the language of the question may influence performance.

(b) How the superficial language of the question may be related to the necessary internal thinking process.

Before describing the experiments, which are designed to investigate these statements, a wider consideration of language and thinking may help to place the work in context. In particular this chapter will give more consideration to : Chemistry and Language; Language across the Curriculum; Language Development; Abnormal Development; Cognitive Development and Cognitive Processes.

1.2 Chemistry and Language

Words in chemistry are of fundamental importance. Evidence for this is provided by published schemes of educational objectives (1) which assign knowledge of terminology to a position of primary importance. Although Evans (2) may exaggerate a little when he states that secondary school pupils may be expected to learn as many new terms in a science subject as they encounter in studying a foreign language, his quotation (3) from a chemistry text where 19 of the 37 words, which compose a passage, are technical expressions illustrates the importance of specialised vocabulary in communicating scientific information.

This plea (4) from a thirteen year old girl strikes a chord with me.

> 'The words in chemistry are big and I think if the words were shortened, then pupils would understand better.'

A simplistic idea but she has my sympathy because like Sutton (5) I agree that it is not the processes inside test tubes which are mysterious, but our way of talking about them. Most of the difficulty pupils experience when they enter science rooms is of language: waves of words washing over them. As Creber (6) implies for many pupils it is a language with which they have not learned to think. Sutton illustrates this well by contrasting a pupil statement with a text book statement. Both are attempting to explain why powdered limestone reacts quicker with an acid than a lump of limestone does.

> Pupil statement : I think its coming off quicker because there's more sort of cut faces to the smaller bits.

Text book : The rate of a chemical reaction depends upon the state of division of the reactants.

This type of formalised writing, as Smith (7) states, leads pupils to believe that their own thinking does not count and that in examinations what is required is "regurgitation of someone else's thinking in someone else's language". The title of Perkes (8) article rings true when he talks about the tyranny of words and very often, as Jenkins states (9), mis-conceptions regarding a young secondary pupil's ability in science can arise in the use of words which often give an exaggerated idea of a child's level of understanding. In addition, because of the emphasis placed on formalised language, pupils can often suffer a sort of "verbal diarrhoea" when, in an attempt to mimic this language, words are used in incorrect situations. As Barnes (10) noted in his investigations with tape recorders in classrooms:

> 'The technical term is often taken to have a value of its own and its substitution for an alternative formulation is sometimes taken to have the weight of an explanation. Side-by-side with this some teachers are using specialist language without explicitly presenting it.'

The difficulty facing the pupil of chemistry is more than coming to grips with technical terms and these investigations begin to give an indication of the wider role of language in science.

(a) Williams (11) described an interesting investigation into the effect of re-writing certain scientific passages to a lower level of readability. 400 pupils, half given the original passage and half the simplified passage, were given a multiple choice test on comprehension of passages. The simplified group did significantly better. Three considerations governed the rewriting of passages to make them more readable: simplification of non-technical words by substitution; amplification of technical vocabulary through the addition of phrases or complete sentences; and rephrasing and shortening sentences to make their thoughts clearer and more distinct.

(b) Gardner's (12) Australian word survey is an attempt to gauge pupils' familiarity with non-technical words at various age levels. The non-technical words are deemed to be essential for the teaching and understanding of science and they were tested in multiple choice questions. This will be discussed in more detail in a later chapter (Chapter 5).

(c) Storey (13) with reference to Fullman (14) describes an investigation with 105 pupils taught by the same teacher and when half were given a multiple choice test in a simpler language than the other half, the mean score of the simplified language group was higher than the more difficult language group.

(d) O'Donnell (15) showed that language in examinations can even influence pupil choice of question. In O grade Physics he found that there was a positive relationship between the questions candidates chose most frequently to attempt and those that were least syntactically complex (16).

The chemistry pupil is faced not only with problems associated with technical terms, but with the related difficulties of a detailed conceptual content expressed in a formalised way. The language used in teaching should be an aid to learning but often it tends to be a barrier to learning. It is through my concern for chemistry pupils that this research work has been initiated and it is my hope that this work will make some contribution towards the real need identified in the Bullock report (17).

> 'We must convince the teacher of history or of science, for example, that he has to understand the process by which his pupils take possession of the historical or scientific information that is offered them; and that such an understanding involves his paying particular attention to the past language plays in learning.'

1.3 Language Across the Curriculum

Following the publication of the Bullock report, A Language for Life (17) a number of summaries or precis (18)(19)(20)(21)(22)(23) were published. These by their nature are general and are aimed at their own audience in the educational field from local authority administrators to classroom teachers, but they are all similar in that they emphasise the need for every school to develop a policy for language across the curriculum.

The expression 'language across the curriculum' is an unfortunate one because it is capable of many interpretations, i.e. the need for a spelling or punctuation policy, that detract from what I see as the important need, the need for a learning policy. The wooliness of the expression "language across the curriculum" does not seem far removed from this quotation of over fifty years ago.

> 'Every teacher is a teacher of English because every teacher is a teacher in English. We cannot give a lesson in any subject without helping or neglecting the English of our pupils ... In plain words, English is not a subject at all. It is a condition of life' (24).

It is not clear from this quotation what the author is implying. From more recent sources it is possible to find equally vague quotations.

> 'Language across the curriculum is essentially a name for a policy which is directing our attention to the varieties of language that are going on elsewhere than in the official English lesson. (25)

Britton, who has perhaps had most influence on the language across the curriculum movement, has apparently no doubts about the implications of a language policy. The theoretical core of his work appears in a very readable book with the title, Language and Learning (26). That title is a declaration of where he feels the emphasis should be. Marland (27), much influenced by Britton, puts it very succinctly.

'A language policy is a learning policy.'

Language is concerned with communication and it is obvious that teaching involves communication. Often such communication is, or ought to be, two way. Either way the vehicle is language - spoken or written - heard or read. However, language is concerned with more than communication. The actual learning process is dependent upon language - our own personal language in which we think.

1.4 Language Development

By way of an introduction to this, I would like to recall one incident from my own experience. While on holiday with my family on a Scottish island, my third daughter, who at that time was about eighteen months old, was sitting on a beach pointing and saying the word 'fire'. There was, however, no flame to be seen and it seemed she was using this label for the sea. Naturally we were puzzled as to how this apparent misconnection had arisen, but later it became clearer as we walked about the island. When we saw water moving down hillsides, streams, brooks, or rivulets, they were invariably called by the Scottish expression 'burn'. The child had understood and seen the connection between the moving water on the hills and the water on the beach, but our labels were causing the apparent confusion.

My experience would lead me to feel favourably inclined towards the ideas of Halliday (28) who considers that a child does not acquire a language nor does the child learn a language. He believes rather that there are strong implications that a child 'makes its language'.

As adults we can see all the time, if we pay attention to what is said by, to and in the presence of a small child, how in the course of the most ordinary linguistic interaction, he is constantly learning the structure of the environment in which he is growing up, in all its aspects, material, logical, institutional and social. He is also, at the same time developing his own unique personality which is being formed at the intersection of a whole number of role relationships. It is one thing of course to recognise that all this is taking place, and that it is taking place to a large extent through the medium of language.

It is quite another thing to explain how it happens and how the linguistic system is endowed with the potential for making it happen.

In Di Vesta's (29) book there is a useful general description for the stages of language development in young children. It is based closely on Menyuk's (30) summary of observations collected by experimenters. It should be noted that the times indicated are approximate and should not be construed as normative periods.

<u>The infant period</u> : (birth to six months)

The child produces such sounds as grunts, cries, gasps, shrieks, chuckling and cooing.

<u>The babbling period</u> : (six months to nine months)

Units of utterances - babbling.

<u>The jargon period</u> : (nine months)

Stresses and intonation patterns in strings of utterance units more closely correspond to those of the adult.

<u>The quiet period</u> : (nine months to one year)

Decrease in vocalisation.

<u>The holophrastic stage</u> : (one year to two years)

The child uses single words to indicate whole phrases. The child understands much of what he is told.

<u>The spurt in word development</u> : (two years)

Many conventional words appear. Produces two and three word sentences. A given word can be used with a number of intonations, e.g. declarative, emphatic (!) and interrogative(?).

The sentence period: (three years)
Uses functionally complete sentences that are grammatically incomplete.

Beyond this stage it is reported that the individual's language system shows more frequent use of sentences with complex structure, increases in the variety of sentences and increases in the length of sentence.

The assumption implied in this continual development may be a useful one, and it is not restricted to very young children: Edwards and Gillan (31) report the observed development of vocabulary over the five to seven year old period of children's growth; Chomsky (32) in a well constructed research exercise reports that active syntactic acquisition is taking place up to the age of ten and speculates that it may be happening beyond this age. Jakobson (33) talks of this continued development as the principle of language change where one cannot erect the superstructure without first having built the foundation and implies this type of stratified structure for linguistic development.

Why do children acquire language in the way they do, at the speed they do? The classical explanation of language learning is that it is essentially a process of imitation and reinforcement. Chomsky (34) was the first to discuss at length various fallacies in this behaviourist account (35) of the language acquisition process, and Crystal (36) states that two arguements were crucial in undermining the imitation theory.

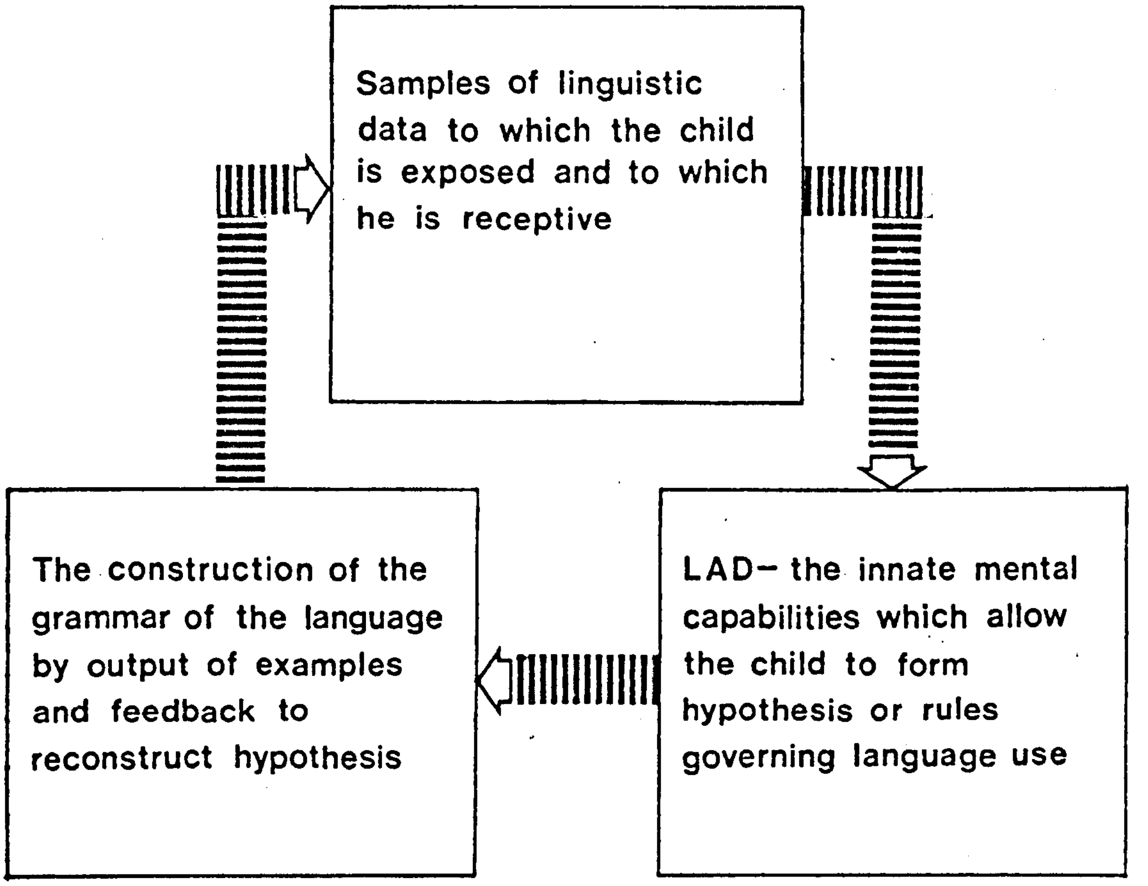
1 We would expect children to produce rather different patterns in their language than in fact they do: 'Nobody don't like me'.

2 We would not be able to explain some of the things that children actually do say in their utterances: 'I goed', 'mouses'.

It is my opinion that language is not learned solely by imitation. At eighteen months a child cannot be enticed into repeating in full a sentence such as 'The car has gone'. He may say 'car gone' or 'all car gone'. In other words the child is apparently using his own rules for constructing sentences and for interpreting them, and the implications behind the idea of a language acquisition device (LAD) in the brain are worth considering.

A LAD has been proposed in various sources (37)(38)(39)(40) as a model of how language might be acquired but it should be noted that this model says the child behaves as if LAD existed - the model does not imply that LAD really exists. In fact McNeill (39)(40) cautions that LAD is a fictitious aid for thinking about language.

Fig. 1.1- Language Acquisition Device



Lenneberg (41) suggests that language experiences are analyzed and resynthesised in a continuing spiral. The LAD seems rightly to emphasise the internalisation aspect of language development initiated by the input experiences and particularly in the early stages of development the role of the mother is crucial in structuring these input experiences. Effective methods for helping language development may be derived from the findings of recent studies (42)(43)(44)(45). These are based on the way that mothers, especially those of children who are considered to be linguistically advanced, structure their linguistic input to the child at successive stages of development using techniques that initially supported and encouraged the initial stumbling efforts. One attempt to try to improve the early interaction between mother and child was carried out in the West Riding within the Educational Priority Area action research programme (46). Mothers with a child over the age of eighteen months were visited every week and involved in play and activity with the child. One of the home visitors observations was that mothers assumed that their children's language and their learning of basic concepts (i.e. about colours) would develop without help. These mothers learnt how much more active they themselves could be in promoting their children's development. This attitude of active participation seems to me to be an improvement in one in an earlier HMSO publication (47).

> 'Teachers of English sometimes complain that when the children come to school they can scarcely speak a word at all. They should regard this as an advantage.'

The mother's role is not only crucial in developing language acquisition in the child, but it is also important in developing learning in general, and this influence has an impact on later achievement in school. The surveys carried out for the Plowden Committee by Peaker (48) and Wiseman (49) in this country and the report on Equality and Educational Opportunity (50) in the United States produced ample evidence that factors in the home much more than those in the school were responsible for variations in pupil performance. Smith (51) confirmed this and further re-analysis by Mayeski (52) led them to conclude that family background was by far the most influential factor in pupil achievement.

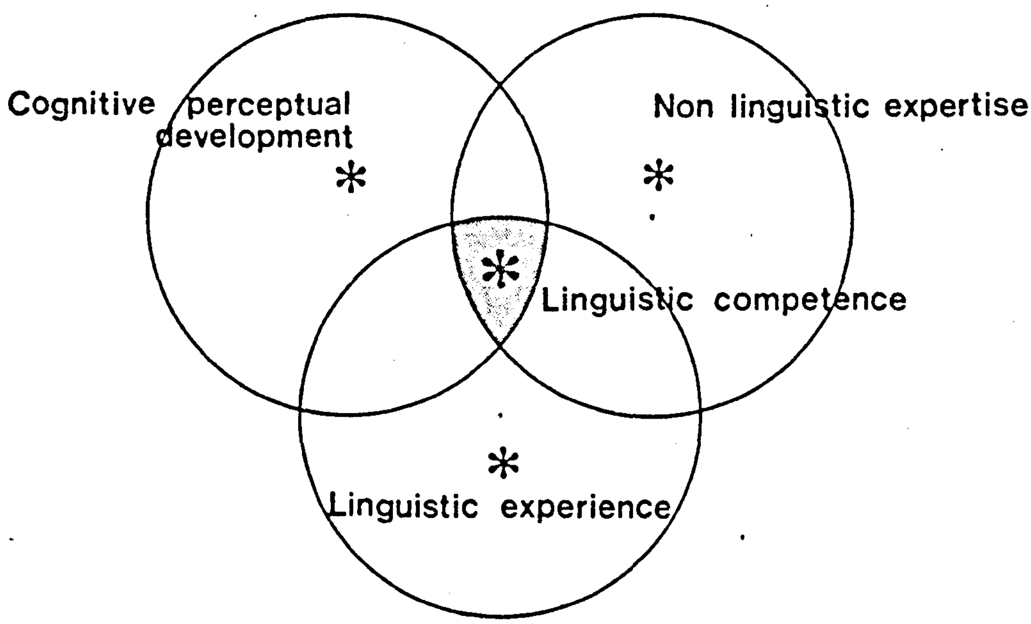
Piaget (53) argues that language development must be viewed within the context of the child's cognitive development as a whole but so far there have been few experimental studies of the way in which linguistic features can be shown to relate to Piaget's various stages. One such argument is given by Sinclair-de-Zwart (54).

During the first eighteen months of life, a child develops the idea that physical objects have an independent existence. At eighteen months the child accepts the existence of things that are separate from himself. The separation implies a distinction between objects and actions and this distinction now appears in speech as the distinction between nouns and verbs. This argument attempts to explain a structural arrangement in child language by reference to one of Piaget's stages of intellectual development; namely all children pass through the sensory-motor period and all therefore have nouns and verbs. Other scholars (55)(56) have argued along similar lines. As McNeil (40) states - it is impressive for Sinclair-de-Zwart's hypothesis that the chronology is correct. Nouns and verbs are present in child speech when words are first combined into sentences, roughly at eighteen months which also is when the sensory motor period comes to a close. The hypothesis is plausible but is perhaps premature and unnecessarily sweeping.

Whether it is cognitive advance that explains the improvement in using language or the reverse remains a fundamental problem for developmental psychology but the internalisation of language in inner speech seems to tie all of these advances together. Though this process of internalisation is difficult to study, it is surely one of the major milestones of human development.

Bloom's thinking (57) seems neatly to relate cognitive and language development. Bloom states that an ideal account of language development must specify at least three interrelated components: linguistic experience, nonlinguistic experience and cognitive-perceptual organisation with the three components interacting to affect the development of linguistic competence. A schematic representation is :

Fig.1.2-Cognitive and Language Development



This seems to be a useful representation showing language development dependent on experience and cognitive development.

1.5 Abnormal Development

From studies of deaf children, language deficient children, learning-disabled adolescents and brain damaged people, it is possible to draw some further ideas on normal language/cognitive development and it is these issues which I would like to consider in this section.

Furth's research (58)(59) was with deaf children who at the age of primary schooling possessed virtually no language. These deaf children solved cognitive problems in the same way as did normal children and at only slightly later ages provided the problems were adequately presented in a non verbal manner. This led to the conclusion that intellectual development is possible without language but language acquisition is bound to the elaboration of cognitive structures in general. The importance of interactive language experience is highlighted by these two examples.

(a) Sinclair (60) says 'No child learns to talk unless he hears other people talk'. Congenitally deaf babies and hearing children brought up by deaf parents do not acquire language before they are given special training.

(b) Jakobson (61). The observation of deaf children and dumb children shows clearly that for normal development the acoustic impression of one's own sound production is important and that the child reacts to this perceptual impression when he attempts to imitate his own sound productions.

In comparisons between language development of normal children and deficient children, there are contradictory reports. Lenneberg et al (62) suggest similar development while Menyuk (63) and Lee (64) report dissimilar development. Morehead and Ingram (65) attempted to resolve this controversy by matching normal and deficient populations on linguistic criteria (e.g. mean number of morphenes per utterance) rather than on the standard criteria of age, IQ and socio-economic level. Their comparative study gives a detailed linguistic analysis of a rather large population of children from which a number of specific linguistic measures are derived to compare aspects of productive use. They report highly similar linguistic systems in the two groups. An important difference found is that despite similar linguistic systems, the deficient children are not able to use their systems with the same degree of efficiency. They conclude that deficient children at least at the level studied (about three years old) add words to their existing constructions but fail to develop the combinational potential that is inherent in their grammars - a failure evidenced by less frequent use rather than complete absence of more complex structures. Their conclusion is similar to Stanton's (66) who found from working with pre-school children, again in a comparative exercise, that the overall impression is that the language delayed children were employing the same variety of cognitive strategies as are the normal children. From this type of work perhaps what is coming through is the importance of the quality of the internalisation language system (hints of LAD) in attempting to make efficient use of the linguistic input.

The following investigations also reflect on the importance of the internal linguistic processes. These investigations (67)(68)(69)(70) of the language processing abilities of learning-disabled children have indicated that deficits can be assigned to one or more of three broad categories. They may reflect -

(a) reductions in short term memory and immediate recall, and/or

(b) reductions in the acquisition of linguistic rules and in linguistic processing, and/or

(c) reductions in cognitive-semantic and logical processing.

Even in learning-disabled adolescents these categorisations of deficits seem to be reasonably applicable (71)(72). This seems to imply that various internal processes of the brain may be responsible for language and learning development and at this stage it may be worth considering the function of the brain itself.

Originally a theory for the working of the brain was developed which speculated that particular parts of the brain were responsible for particular functions (e.g. speech). This was called a localisation theory. Broca (1861) translated by Kann (73) argued that speech was controlled by either the second or more probably the third convolution of the frontal lobe of the left hemisphere. Wernicke (1874) (74) reported a different kind of language difficulty associated with a lesion to a posterior part of the left hemisphere. Broca's patient could comprehend speech but not produce speech whereas Wernicke's patient could produce speech but not comprehend speech. Acceptance of this type of localisation theory has been resisted by many other researchers. Jackson (75) argued that language is a psychological function rather than a physiological function and the brain operates as a functional unit - 'to locate the damage which destroys speech and to locate speech are two different things'. Head (76) stated a lesion in the brain like a break in the railroad track disrupts service but it does not locate the speech center. Eisenson (77) summarised the arguments that oppose the localisation theory and these included :

(a) patients who suffer similar lesions do not always exhibit the same defect.

(b) the same defects may be associated with lesions to different parts of the brain.

There is one aspect of the localisation theory in which there seems to be general agreement. Language functions seem to be controlled primarily by the left hemisphere of the brain. According to Geschwind (78) ninety-seven percent of language impairments result from injuries to the left hemisphere. The right hemisphere seems to be more related to spatial tasks, visual and tactile discriminations and music perception (79). Experiments by Sperry (80) on patients who have had the two hemispheres of their brain disconnected through surgical cutting in an attempt to control severe epilepsy have some interesting results. For example if the name of an object is flashed to the right eye and thus to the left hemisphere of the brain, the patients can readily identify the word by speaking or writing it but when a word is flashed to the left eye the patients deny seeing anything although if the patients are asked to point to a picture or object matching the word they will do so correctly despite the fact that they have just denied seeing it.

The one thing that is reflected in these investigations with brain damaged patients is the complex relationship between brain function, cognitive ability and language competence. Consider these two examples from Luria (81).

(a) Patient with a tumour in the left hemisphere was asked to repeat the sentence : 'Spring came and the leaves came out in the trees' : responded 'Well .... it was already warm and it turned out very nice'. It is easy to see that although the lexical content of speech has completely collapsed there is retention of some ability to comprehend the general meaning.

(b) Patients with lesions localised in the tertiary zones of the lower temporal and temporal-occipital areas of the left hemisphere lead to a different type of difficulty. They retain contextual speech but they are unable to use logical and grammatical codes, e.g. they can understand 'Father and mother went out to the theatre and grandma and the children stayed at home', but are quite unable to understand 'Olga went from the factory to the school that Katya attends, to tell what she had seen in the woods'. The thinking required to unravel this statement had been impaired.

Another example from the same source (81) gives some insight into the number of steps involved in the process of verbal expression - the turning of a thought by a number of stages into a statement. A patient with cortex damage (arteriosenous aneurism within the temporal-parietal lobes of the left hemisphere) giving an account of his illness.

> 'As I fill ... full ... fell ill. It was like this: things weren't so good ... and I went right dawn ... down ... down. They took me off to the armoury - no it wasn't ... it was to school - oh no! not school ... into the army ... no what am I saying the army!... it was you know where people go when they aren't well? To the infirmary? ... that's it ... the infirmary!'

Luria attempts to explain this by stating that every word represents a multidimensional matrix of connections from which the wanted (adequate) connections are chosen while secondary connections are inhibited;

in the condition described above, the process of inhibiting secondary (inadequate) connections is impaired and thus the appearance of any of the connections of this multi-dimensional matrix becomes equally likely. Competition between all the possible connections leads to forgetting and to the appearance of strange words that resemble the wanted word either in sound or in meaning.

As an expansion of this idea of a multidimensional matrix of connections, Luria makes three thought provoking statements.

(a) Every word represents a definite sound complex a small change in which may alter its meaning. Adequate understanding of any word presupposes that the wanted word can be distinguished from all the words that sound like it.

(b) Every word represents the designation not of one definite object but of a whole series of possible objects (the word 'go' can at one in the same time mean 'start', 'begin', 'move', 'walk', 'ride', etc.). Using a word in its wanted sense implies a choice of the wanted meaning of the word from among a great number of possible alternatives.

(c) Every word represents a very complex formation that alongside its designating function (or pertinence to an object) also includes a system of generalisations that is known in psychology as the words meaning.

These ideas seem to have been influenced by Vygotsky (82) who showed that in very young children every word had a compound meaning, e.g. a word such as 'Tpru' (Gee up! Whoa!) could equally mean 'horse' or 'off you go' or 'stop'. If a noun suffix were added making it into 'Tpru-n'ka' its range of meaning narrowed and although it still referred to an object (horse) it no longer signified an action. In a similar way for one of my own children all furry four legged animals were at one time called 'dog'. With age this is reported to be a narrowing of the range of meaning (83) and the change in the specific meaning of a word as the age of children increases is also reported (84).

This brings us back to language development, but what is the major point that can be taken from the observations on abnormal development? Perhaps with the complex interrelationship of cognitive ability and language ability it is easy to accept Lenneberg's point (85) that a whole brain theory is most sensible i.e. language is probably due to the particular way in which the various parts of the brain work together. If that is the case, it may be useful, in an attempt to gain a fuller appreciation of the interrelationship between the inner processes of the brain and language ability, to consider cognitive development and cognitive processes.

1.6 Cognitive Development and Cognitive Processes

Earlier in this dissertation some of the ideas of Piaget (53) are touched on - in particular his argument that language development must be viewed within the context of the child's cognitive development. At this stage his ideas may be worth considering in a little more detail. Piaget considered that there were four main stages to cognitive development: the sensorimotor stage (birth to 18 months/24 months); the pre-operational stage (18/24 months to 5 or 6 years): the concrete-operations stage; and the formal-operations stage (continuing from about twelve years old). It is mainly in the first of these stages that theconnections between language development and cognitive development have been considered. For example Piaget (86) argues that the development of the capacity to imitate is a pre-requisite to the acquisition of learning. He emphasises that the ability to imitate does not emerge full blown but develops gradually during the sensorimotor period. He states that children first learn to perform imitations with parts of their bodies such as their hands which are in their immediate visual field. Later an advance can be discerned when children learn to perform imitations which are not visible to them such as the imitation of facial gestures. He feels that the final product of this developmental hierarchy is the ability to perform deferred imitation and if a child cannot perform deferred imitations, then he cannot master language because speaking, at least in the initial stages, can be seen as one example of deferred imitation.

There is some evidence for a close relationship between the emergence of cognitive differentiation and linguistic differentiation. One example of this has been reported by Sinclair de Swart (87). She showed that children who have mastered the concept of conservation (i.e. that the volume of a liquid does not change as it is moved from one shape of container to another differently shaped container) differed in their use of language from children who had not mastered this concept. Conservers when presented with two objects such as a long thin pencil and a short thick pencil and asked to describe them tended to use comparative terms, e.g. 'this one is longer than that one' whereas non-conservers tended to use absolute terms saying such things as 'this one is long and this one is short'. She argued that non-conservers tended to think and to talk in one dimension at a time whereas conservers integrated information from different dimensions in both the conservation and the descriptive tasks. In a similar way Bloom (57) states that two-word utterances which typically omit 'functors' such as inflections on nouns and verbs, possessives, auxilliaries and articles, represent a lack of language development rather than a lack of cognitive development. For instance Bloom cites the example of one child who used the expression 'Mummy sock' in two different contexts: once when the mother was putting a sock on the child and once when the child picked up the mother's sock. Bloom argues that the first utterance is intended to convey 'Mummy is putting on my sock' and the second 'This is Mummy's sock'. Given the fact that a two year old child has considerable experience of his world and has mastered to a considerable extent the relation between his activities and their effect on various objects (Piaget (88)), this suggestion is plausible and is further strengthened by evidence on sentence comprehension. Brown and Fraser (89) report an experiment in which children between two and three years old were asked to repeat sentences. Children preserved the meaning of the original utterance by repeating the content words such as the nouns and verbs and by dropping the function words such as articles, prepositions and auxiliary verbs. Thus children appear to readily understand sentences which they cannot repeat with syntactic precision. Slobin (90) reports that this is a feature of all languages so far studied. In later work Brown

(91) claimed that children's earliest utterances semantically expressed the concepts which Piaget's theory would characterise as the achievements of sensorimotor intelligence.

It is difficult to find material related to Piaget's model of cognitive development, beyond sensorimotor stage, that relates to language development, beyond short utterances, and it was for that reason that I referred to the hypothesis of language development linked to Piaget's stages of cognitive development as being perhaps premature and too sweeping. Having advanced to two word utterances, the question arises as to how further development takes place and the answer does not apparently lie entirely within the framework of Piaget's stages of cognitive development.

The work of Bruner and his associates (92)(93)(94) provides a major supplement to Piaget's theory. Instead of four periods of cognitive development, Bruner suggested there are three different modes of representing the world:

enactive: representing the world in terms of action

iconic : representing the world in terms of static perceptual images

symbolic: the use of language and symbols

Bruner's theory accounts for the 'big leap' in cognitive processing that occurs at about age five to seven, partly by emphasising the increased power that language provides, i.e. the shift from iconic to symbolic representation. For example Brown and Berko (95) provide evidence for a major shift in the way language concepts are stored that occurs at about age six - from heterogeneous to homogeneous word associations. In addition, the work of the Kendlers (96)(97) revealed that reversal shifts were easier for children over six. A different kind of evidence comes from the work on eidetic imagery, Haber (98). When children were shown a picture and then asked about details when the picture was removed some were able to 'see' it in almost perfect detail and to answer questions about it. In a major study about eight percent of elementary school children possessed this ability - called eidetic imagery - while almost no adults had it. One explanation, Doob (99), is that our society demands that we encode information verbally rather than visually and that as the ability to read and write increases the use of image representation falls. White (100) has compiled a list of over twenty changes that occur between the ages of five and seven including these three :

(a) Far transposition: After learning a simple discrimination task, such as choosing the larger of two squares, older children also succeed in applying the principle to very different situations while younger children cannot (101)(102).

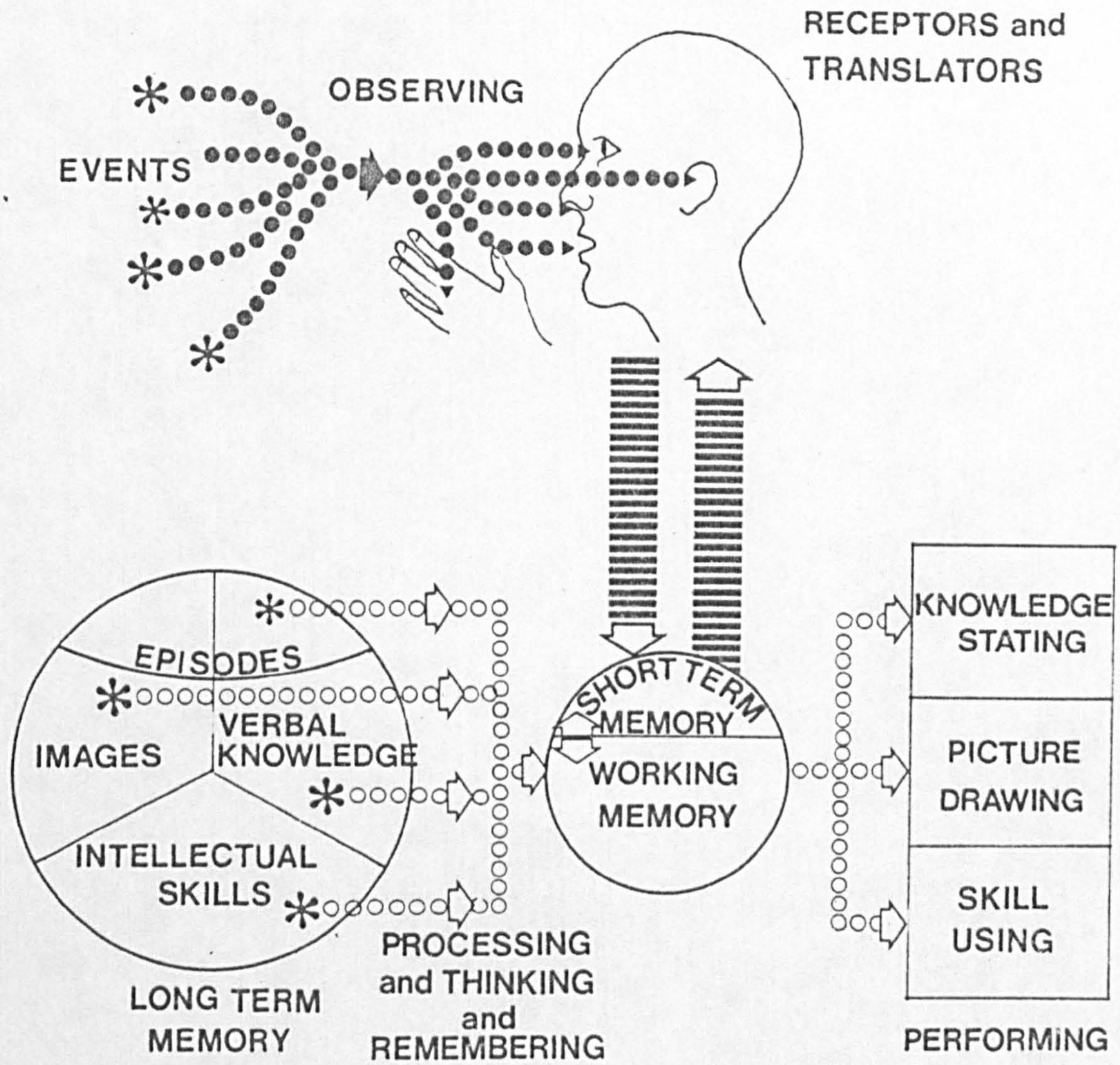
(b) Discrimination learning: Improvement in discrimination learning increases up to the age of about six and then declines perhaps because older children develop more complex hypothesis (102)(103).

(c) Development of personal left - right: Children become able to discriminate their left and right sides at about the age of six (104).

Apparently there is a major difference in the way the preverbal child and the older child think. The difference is not just a quantative one, with the older child being 'smarter' but rather a qualitative difference in the way thinking occurs. The reason for the differences is still not well understood; for example it is not clear whether the onset of language is the cause or the result of these emerging new cognitive powers. However, the curious coincidence of so many cognitive changes, cited by so many different experiments, suggests that something is happening and it seems that a better understanding of these changes that lead to adult thinking processes may also help to clarify what adult thinking processes are.

A useful model of cognitive processes, because it is more explicit than most about internal events is the one proposed by White (105). It is illustrated in Figure 1.3.

Fig. 1.3 - A Model of Cognitive Processes



White (105)

This model seems to me to have been influenced by previous models. For example, Ernst and Newell (106) have provided a simplified description of the problem solving process and Greeno (107) and Feigenbaum (108) have proposed a memory model. These are illustrated in Figure 1.4 and 1.5 respectively.

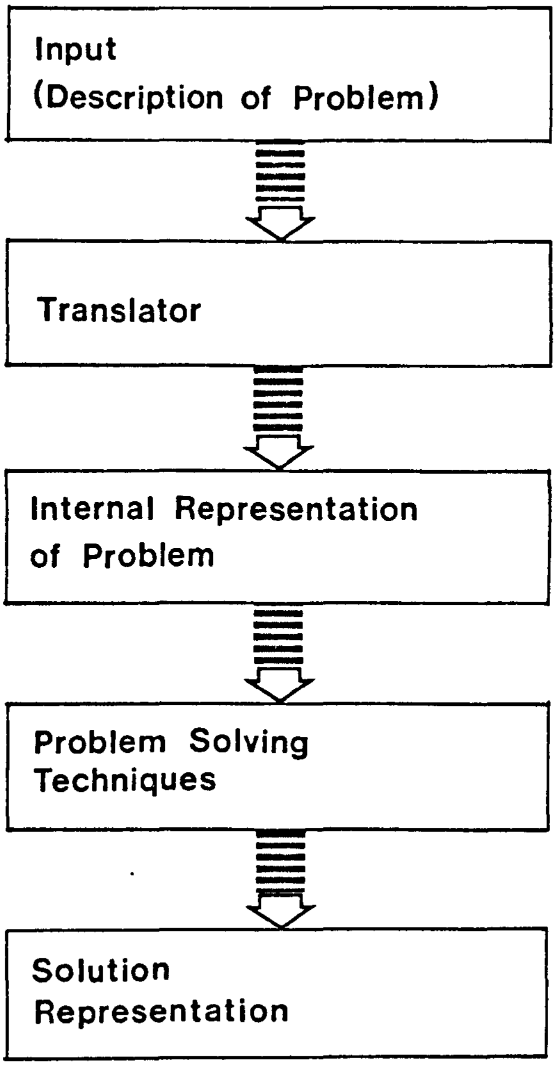


Fig. 1.4

The Problem Solving Process
(adapted from Ernst & Newell (106)

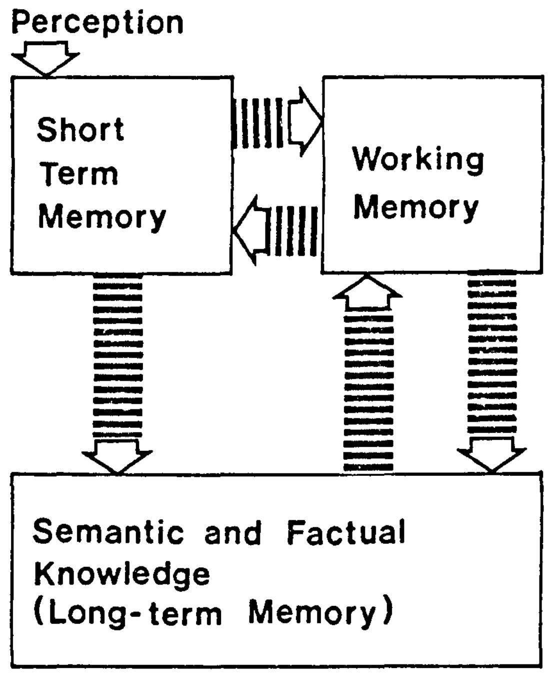


Fig. 1.5

Components of Memory
(adapted from Greeno (107) &
Feigenbaum (108)

What White has done is to marry together a number of ideas successfully and his model is worthy of further consideration.

Events are anything that goes on around the learner and the learner translates the observed stimuli into a more or less meaningful form which is held in the short-term buffer.

What Figure 1.3 does not bring out clearly is that the observing and translating are affected by the observer's cognitive structure. What attracts the learners attention and how he interprets the received stimuli are functions of the learner's knowledge and attitudes. In other words White perceives that the whole system is highly interactive.

Information held in short term memory can be forgotten or can be passed on to the working memory, which has a greater capacity than short term memory and can hold selected information for longer periods. If the information has to be retained then it needs to be processed: that is passed into long term memory.

Processing, White states, consists of linking new information to existing knowledge and this idea is the basis of Ausubel's (109) theory of learning. Ausubel places emphasis on the use of 'advance organisers' or as Novak (110) terms them 'cognitive bridges'. They also suggest that new learning must be linked to existing knowledge using ideas with which the learner will have some familiarity.

This processing could be language dependent in two senses, one language could be being processed, and two language could be used for the processing. These ideas of Slobin (111) could be considered as an example of the latter.

Slobin asks us to consider these three sentences :

(a) pie little blue mud make eye girl was

(b) the little pie with mud eyes was making a blue girl

(c) the little girl with blue eyes was making a mud pie

and states it is of interest that people can remember the sentences better than the unstructured string even although the sentences are longer. Order and various forms of markers (e.g. the, a, with) have been added and convert a disconnected string of words into a sentence. A collection of words is made into a sentence by grammar, and there seems to be a psychological equivalent to a system of grammatical rules whereby a learner can extend a limited amount of experience with a limited number of sentences to the capacity to produce and understand an unlimited number of sentences. Menyuk (112) examining this processing from another angle considers the role of memory in language acquisition should be emphasised. Menyuk feels the learner acquires some rules to understand and reproduce sentences, and subsequently from experience the set of rules of his grammar is expanded when computing space increases (number of rules increases) and when computing space is reorganised (e.g. into types of properties of lexical items). Another interesting insight into how people process material has been gained by using tape recorders. A click was placed in recorded sentences and people were later asked to place the click correctly in a script (113)(114)(115). The main conclusion of the work is that people seem to process what they hear in chunks or segments.

To try to link together these ideas on processing, it may seem facile to say that White's terms of processing, thinking and remembering could be considered to be cognitive processes that are closely interwoven with linguistic ability.

In Figure 1.3 as a result of processing, information is transferred from working memory to long term memory. Here White felt it would be useful to consider information as being stored in three possible forms: verbal knowledge, intellectual skills, and images. This model again provides opportunities for the absorption of other people's ideas.

The vast majority of information that people carry in their heads is largely verbal knowledge. Ausubel's (109) statements about meaningful verbal learning touched upon earlier are obviously applicable. White and Gagné (116) provide a similar description of linking, implying that linked verbal knowledge will be retained better than unlinked, and will be more readily employed in making inferences, i.e. in transfer.

Intellectual skills are stored memories of how to perform a class of tasks in contrast to single facts. Gagne (117) listed several subdivisions of skills the most important of which in secondary schools are concepts, rules and cognitive strategies. This form of storage would also seem to be related to linguistic ability.

Images are pictorial or diagrammatic representations of information in long term memory. There has been a lot of research into imagery mostly generated by Paivio (118) but it has barely touched on the effect of pictures on retention of verbal information and intellectual skills.

Episodes is White's description of a subset of verbal knowledge and images. They are recollections of personal involvement in an event. Remarkably little research work has been done in this area, which might include the value of field trips or science laboratories.

The last stage in White's useful model is performance and this dissertation will be mainly concerned with pupils' performance in multiple choice questions. The discussion so far seems clear on one major point that whether language is the cause or the result of cognitive power, the internalisation aspect of language (i.e. thinking) is of fundamental importance.

This manifests itself in : Halliday (28) a child makes a language; McNeil (39) the language acquisition device: Bloom (57) language development dependent on experience and cognitive development: Vygotsky (82) the importance of inner speech; Luria (81) multidimensional matrix of connectors; Ausubel (109) advance organisers; Novak (110) cognitive bridges; White and Gagne (116) linking: where these different people have indicated different aspects of this same point that the internalisation aspect of language (i.e. thinking) is of fundamental importance.

CHAPTER 2

The Three Experiments

2.1 Introduction

In this chapter it is my intention to give some background to the three experiments which make up this investigation and to indicate how they relate to each other. Later chapters will deal with each of them in turn.

At the beginning of chapter one, it is stated that in this dissertation, it is hoped to consider the performance of secondary school pupils in multiple choice questions at two levels.

(a) How the language of the question may influence performance

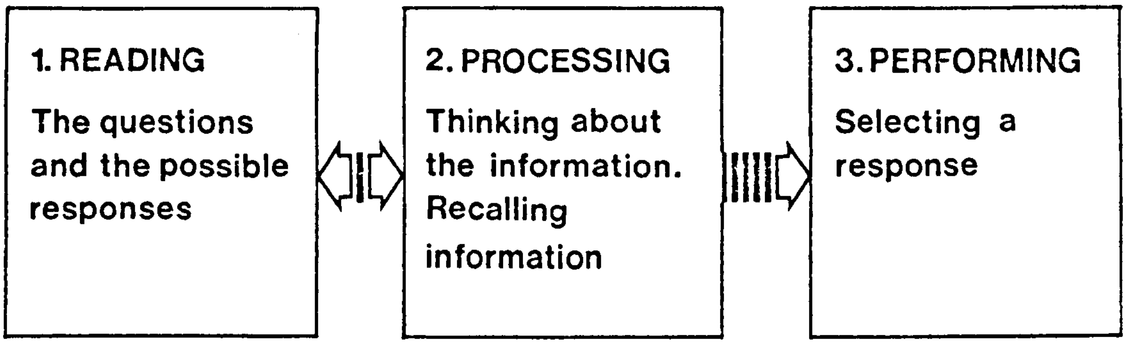
(b) How the superficial language of the question may be related to the necessary internal thinking process.

2.2 Why Multiple Choice Questions?

The simple answer is because I feel these are the most suitable instruments for what I am attempting to investigate but this statement requires some amplification.

A possible diagrammatic representation of the procedure for answering multiple choice questions is shown in Figure 2.1.

Fig. 2.1- Reading, Processing and Performing



Through a consideration of the performance it may be possible to become more aware of the two inter-related stages of reading and processing.

To think of reading as primarily a visual process would be erroneous (119). Reading involves the inter-action of information that the reader receives through his visual system and the information that the reader already has available in his brain. For example, we read faster when the material is familiar, or an example from Smith (120) - przyjezdzac - a Polish speaker would recognise at a glance but a non-Polish speaker would have difficulty with and would be unlikely to recall after a short time.

In Chapter 1 the cognitive processes and the role of the components of memory (105)(108) are con-sidered and in reading, the limitations of short term memory in effect restricts the number of items that can be attended to at any one time. Miller (121) observed invariances in memory-span experiments, indicating a short-term memory capacity of about "seven, plus or minus two" familiar units or chunks of any kind. The existence of chunks, i.e. coherent memory or perceptual units in language processing and recall has been established (114)(122). However, the size of each of the chunks that can be stored in short term memory is determined not so much by external considerations as by what the brain can do with the information (123), which brings us back to the processing, which consists of interaction between the widely supported idea (121)(124)(125) of short term memory and long term memory.

With multiple choice questions, where results are fairly easy to handle statistically, I felt it would be possible to design questions which would investigate not only the effect of language on performance but also give some indication of the internal processes which may be involved in solving these questions.

2.3 Possible Areas for Investigation

Within the wider area of language development and cognitive processes, which has already been described, rather more specific research results have had some influence on the direction of this investigation.

(a) Negative and Affirmative Statements

Wason (126)(127)(128). Subjects were presented with simple affirmative and negative sentences and were asked to decide whether each sentence was true or false. He found that they took longer and made more errors on the negative statements than the affirmative statements. Eifermann (129) had similar findings with Hebrew. The difficulty seems more a conceptual than a syntactic one.

(b) <u>Negative and Passive</u>

On the basis of lengthy data analysis, Savin and Perchonock (130) conclude that these grammatical features of English sentences are encoded in immediate memory apart from one another and apart from the rest of the sentence. The evidence for this claim is that sentences having these features require a larger part of the capacity of immediate memory than do otherwise identical sentences lacking these same features.

(c) <u>Negative Comparative</u>

Several investigations (e.g. Donaldson and Wales (131)) have found that children have more difficulty understanding negative comparative adjectives (e.g. shorter, less) than their opposites (e.g. taller, more) and in some cases interpret statements containing less as if they contained more (132)(133). Clark (134) has proposed that children often interpret both members of a comparative adjective pair in an absolute sense. The child may interpret both 'Which has less?' and 'Which has more?' as meaning 'Which has some?' and give the object with the most as the best example of some.

(d) Cues

Several investigations of the variables which influence the accuracy and speed with which words may be retrieved from long term memory have suggested cueing techniques. For example Tulving's (135) findings suggest cues which name the semantic class of a target word or word cues which are highly associated with the target word may be most effective in facilitating recall.

(e) Logical Connectives

Investigations by P. Gardner (136)(137)(138) in science to check the understanding of words like 'because', 'and', 'subsequently' have the following conclusions. Logical connectives are one of the principal ways in which linkage between propositions is achieved in English. By the fourth year of secondary school, most students can understand most connectives but there are still many connectives, particularly the less frequent ones, which prove difficult.

(f) Words and Meaning

Factor-analytic studies (139)(140)(141) indicate that in determining readability the factor accounting for the greatest percentage of variance is a semantic one, i.e. word difficulty. P.L. Gardner's investigation (142) attempted to measure science pupils understanding of words using multiple choice questions. The words investigated are non-technical words that are considered to be essential or valuable to the understanding of science, but by using only one multiple choice question to test each word he apparently overlooked the influence of factors like context and connotation on the meaning of the word. This complexity is well illustrated by an example from Lashley (143). The word pronounced 'rite' has four spellings, many meanings and can serve as a noun, adjective, adverb and verb:- The mill-wright on my right thinks it right that some conventional rite should symbolise the right of everyman to write as he pleases.

Words themselves are obviously important as labels and as Spiker (144) indicates a label attached to a new situation may modify the meaning of that situation and accordingly influence learning. For example, when aircraft-pilot trainees were given a verbal plan for take-off, ascent, cruising, descent and landing, the training time they required to solo was halved when compared to procedures that depend on practice only (145).

Luria's idea (81) of a multi-dimensional matrix of connectives between words stored in the long term memory is amplified by these two examples. Seibel (146) states that word associations influence the words that are retrieved or recalled. When a list of several words is presented singly and in random order, subjects group them as pairs during recall, the words being associated by conceptual categories even though they were not presented in that order. Deese (147) states that the two fundamental operations we have for sorting out meaningful words are contrast and grouping, and feels that within our own vocabulary we establish the position of every word by contrasting with other words and/or by grouping it with other words.

Although words themselves are fascinating the linking of words to produce meaningful sentences is equally interesting. These three different statements based on interpretation of research evidence are thought provoking. Very easily read sentences are not more than ten to fifteen words long (148). Nearly all reading material that wins a large audience has an average sentence length of less than twenty words (149). A sentence may be as long as the writer pleases provided that he confines it to a single connected range of ideas (150).

(g) Sentences and Meaning

As hinted at in the last reference, brevity by itself does not necessarily mean easier to understand. For example consider these two sentences :

John was hurt.

John was hurt by someone.

The first one is shorter and grammatically simpler but the second one is easier to understand (114). The relative ease of understanding seems to be related to its being more meaningful, conveying a more precise meaning and being psychologically less complex.

Memory span for sentences is not determined so much by the number of words as by grammatical structures that may themselves load the memory system. Negative and passive have already been discussed. Embedded information in sentences has been investigated by for example Miller and Isard (151). Subjects were asked to memorise sentences, all twenty two words in length, but with varying degrees of self embedding, e.g.

> She liked the man that visited the jeweller that made the ring that won the prize that was given at the fair.
>
> The prize that the ring that the jeweller that the man that she liked visited made won was given at the fair.

The greater the degree of self embedding the harder it was to recall the sentence. The embedding seemed to be placing a burden on the short term memory.

The important factor in the sentence is its meaning. Sach's work (152) again based on recall of information concludes that when the meaning is unravelled the syntax is forgotten. From her work it is clear that the formal structure of sentences is stored for only a brief period of time and a small change in wording, which is related to meaning, is easily detected. The findings are consistent with a theory of comprehension which contends that the meaning of the sentence is derived from the original string of words by an active interpretation process. The original sentence which is perceived is rapidly forgotten and the memory then is for the information contained in the sentence.

These are some of the more specific research findings that had an influence on the direction of the investigation.

2.4 The Three Experiments - the Overall Plan

Multiple choice questions were used throughout the investigation because it was hoped that the careful design of these highly structured questions would enable interpretation that would give information on the influence of the superficial language and also perhaps give inferred information on the internal processing of this language. The multiple choice questions were used in two ways :

(a) in matched pairs of multiple choice questions (MP) - where two questions have been designed to test the same chemical concept but the language used to frame the question has been altered in a deliberate way, e.g. a question may contain a negative expression and its match would not contain the negative expression.

(b) as individual multiple choice questions (IN) - where questions have been designed to investigate a particular factor, e.g. pupil understanding of a word in different contexts would be tested by using a number of individual multiple choice questions each reflecting the word in a different context.

The Scottish Experiment was carried out in twenty-four Scottish secondary schools; the Joint Matriculation Board Experiment was done with the administrative support of the JMB research unit; and the Chemical Society Experiment was done with the administrative support of the Education Division of the Chemical Society. Table 2.1 gives some general information on the three experiments.

TABLE 2.1

General Information on the Experiments

Experiment	Year	No. of Pupils	Age range
Scottish	1977	1,297	15-16
	1978	1,272	"
	1979	1,282	"
JMB	1977	2,024	"
	1979	1,504	"
Chemical Society	1978	15,000	11-18
	1979	10,000	"

TABLE 2.2

Areas of Investigation

Area	Type of item	Scottish	JMB
Replacement of key words in the stem of the question	P.M.	X	X
Changing possible pompous non-technical terms	P.M.	X	X
The understanding of technical terms	IN.	X	-
Comparison of terms of quantity or order	P.M.	X	X
Replacing negative expressions	P.M.	X	X
Reducing the number of words	P.M.	X	X
Changing the arrangement of clauses	P.M.	X	X
Changing parts of speech of words	P.M.	X	-
Replacing passive expressions	P.M.	X	X
The understanding of non-technical terms	IN.	X	X
The understanding of logical connectives	IN.	X	-
Words in text-books:pupil preference and author choice	IN.	X	-
Pupil choice of definition : possible cues	IN.	X	-

The Scottish Experiment is a fairly tightly designed experiment using both matched pairs (MP) and individual (IN) multiple choice questions. It covers a wider range of areas than the JMB experiment. The JMB experiment is a parallel investigation in some respects using almost entirely (MP) multiple choice questions with the added dimension of comparing pupil performance with their measured general verbal ability, their social class and their sex. The areas of investigation are indicated in Table 2.2.

The Chemical Society Experiment is an expansion of one of these areas, namely the understanding of non-technical words in science, with reference to connotation and particularly context. In terms of the design of individual multiple choice items it is the least well defined of the experiments but it did generate a considerable amount of interest in the large number of establishments involved in the experiment. The following unsolicited comments are not untypical in letters from participating people.

(a) The work seems to have stimulated interest and similar work in other departments of the school.

(b) Some words we, as teachers, take for granted: the difficulties pupils have are shown here.

In the following sections of this thesis Chapter 3 is concerned with the Scottish Experiment; Chapter 4 the JMB Experiment and Chapter 5 the Chemical Society Experiment.

CHAPTER 3

The Scottish Experiment

3.1 Introduction

In this chapter it is my intention to look at the following hypotheses.

(a) Replacing words in key positions in multiple choice chemistry questions may influence performance.

(b) Changing possible pompous non-technical terms in multiple choice chemistry questions may influence performance.

(c) Technical terms which have been introduced in first or second year of the secondary school may not be recalled by the O grade candidates.

(d) Expressions of quantity or order (e.g. more, less, increasing, decreasing) in multiple choice chemistry questions may influence performance.

(e) Replacing a negative expression by an affirmative expression in multiple choice chemistry questions may influence performance.

(f) Reducing the number of words in multiple choice chemistry questions may influence performance.

(g) Changing the arrangement of clauses in multiple choice chemistry questions may influence performance.

(h) Changing parts of speech of words in multiple choice chemistry questions may influence performance.

(i) Replacing passive expressions by active expressions in multiple choice chemistry questions may influence performance.

(j) O grade chemistry candidates may have a poor understanding of useful non-technical words.

(k) O grade chemistry candidates may have a poor understanding or logical connectives, e.g. consequently.

(l) In text books there may be a disparity between what the author feels is appropriate terminology and what the O grade pupil audience feels is appropriate.

(m) When pupils recall definitions of chemical terms, verbal cues in the definitions may play a helpful role.

These hypotheses represent to some extent an expansion of Table 2.2 and their formulation has been influenced by some of the research work described in part 2.3 of Chapter 2. For example the reported difficulty of small children with negative comparative adjectives (i.e. less) led to thinking about the terms of quantity and order in chemistry (e.g. most concentrated, most dilute) some of which may be creating difficulties for O grade chemistry candidates.

In addition the formulation of these hypotheses has been influenced by a desire to confirm, consolidate and expand on some of the tentative conclusions from my M.Sc. thesis (153). These conclusions were as follows :

(i) words in key positions in multiple choice chemistry questions influenced performance

(ii) the effect of a large number of unnecessary words in a multiple choice chemistry question could be to impede candidates

(iii) the presence of negatives depressed performance in multiple choice chemistry questions

(iv) the way in which clauses or sentences were put together in multiple choice questions influenced performance

These conclusions are restricted to the examining situation and the hypotheses for this chapter attempts to explore some wider aspects of teaching chemistry, e.g. the language of the text book.

Also in the M.Sc. thesis no attempt was made to relate the improvements in performance brought about by the language change to the possible influence of this change on the internal thinking process. In this thesis in Chapter 1 the backcloth to the investigation is described in terms mainly of language development and cognitive development and although it is not possible to say whether language is the cause or the result of the cognitive power many of the sources quoted in that chapter report on the importance of the internalisation aspect of language. It is hoped that the hypotheses of this chapter will not only lead to conclusions about how the superficial language of the question influences performance but also lead to a clear understanding of how the superficial language may be related to the necessary internal thinking process.

3.2 Research Design

The experiment was conducted over three years 1977, 1978 and 1979 and in each year two matched tests were prepared. The tests were made up of multiple choice questions. The multiple choice chemistry questions were prepared in two forms. One form was similar to Scottish Certificate of Education Examination Board (SCEEB) questions and the other form was in simplified language. Possible questions were scrutinised by a panel of chemistry teachers to try to ensure that the chemical content of the questions was the same and from these questions, two tests were prepared one in the original language and the other in simplified language.

In 1977 the alternative forms of the two tests contained 28 questions made up as follows.

1 Seven items on vocabulary from an Australian word survey (142)

2 Three items on Chemistry common to both tests to act as control questions.

3 Eighteen items on Chemistry each having two versions designed to investigate the effect of the following :

(a) possible difficult words such as 'pungent', 'stable' in key positions

(b) the removal of negative expressions

(c) the presence of large numbers of words

(d) the arrangements of bits of information in the stem

In 1978 the alternative forms of the two tests contained 28 questions made up as follows.

1 Three items on Chemistry common to both tests to act as control questions

2 Nine items on the language of text books

3 Five items on definitions

4 Five items on technical vocabulary from first and second year science courses, e.g. solution

5 Six items on chemistry each having two versions designed to investigate the influence of changes in parts of speech, e.g. products and produced.

In 1979 the alternative forms of the two tests contained 36 questions made up as follows.

1 Three items in Chemistry common to both tests to act as control questions

2 Three items on the language of text books

3 Two items on logical connectives, e.g. 'consequently', 'therefore' (138)

4 Three items on definitions

5 Four items on technical vocabulary from first and second year science courses e.g. element

6 Twenty one items on Chemistry each having two versions designed to investigate the effect of the following :

(a) the presence of possibly pompous expressions, e.g. distinguish visually

(b) the use of the passive voice

(c) terms of quantity or order, e.g. most abundant, increasing

(d) the presence of negatives in both stem and responses

(e) the arrangement of bits of information in the stem, e.g. embedded clauses.

3.3 Administration

Twenty four schools chosen to give a representative cross-section of schools varying in type, catchment area, and region, offered to help (Table 3.1).

TABLE 3.1

Schools

Campbeltown Grammar	:	All Saints, Glasgow
Denny High	:	Craigbank Secondary, Glasgow
Dollar Academy	:	Eastwood High, Newton Mearns
Dunblane High	:	Grange Secondary, Glasgow
Eastbank Secondary, Glasgow	:	Greenock High School
Glenwood Secondary, Glasgow	:	Kilmarnock Academy
Govan High, Glasgow	:	Lochend Secondary, Glasgow
Kelso High	:	Nicolson Institute, Stornoway
Kingsridge Secondary, Glasgow	:	Portobello High, Edinburgh
Knox Academy, Haddington	:	St. Mungo's Academy, Glasgow
Madras College, St. Andrews	:	Rothesay Academy
Williamwood High, Clarkston	:	Victoria Drive Secondary, Glasgow

TABLE 3.2

Number of Pupils

1977	-	1,297 pupils
1978	-	1,272 pupils
1979	-	1,282 pupils

A comparison between this sample and all Scottish secondary schools presenting O grade chemistry candidates shows a reasonable similarity. Consider the ratio of total number of schools; to city schools; to Roman Catholic schools; to non-Certificate of Sixth Year Studies schools; to private schools (independent and grant aided)

	total :	city :	RC :	non SYS :	private
Scotland	10	3	2	2	1
my sample	10	4	2	2	0.5

Of the seventeen regions and divisions in Scotland the sample involved schools in nine of them namely, Fife, Lothian, Borders, Central, Western Isles, Argyll and Bute, Ayr, Glasgow and Renfrew.

The number of O grade candidates involved in the exercise in March each year are shown in Table 3.2.

To try to achieve some uniformity in the method of administering the tests in the various schools an Information Sheet (Appendix A) was prepared and issued to the school.

To assist with organisation the tests were printed on yellow and pink paper to match the appropriate computer answer card. The tests used each year are shown in three Appendices 1977 (Appendix B), 1978 (Appendix C), and 1979 (Appendix D).

In essence within each school the pupils were numbered and those with an even number got a pink test and a pink answer grid while those with an odd number got a yellow test and a yellow answer grid. In this way it was hoped to achieve similar test groups. The answer grids were processed in appropriate batches by the computing department of the University of Glasgow.

3.4 Results

The results of the three exercises have been organised as follows :

Table 3.3	Control Questions
Table 3.4	Key Words (1977)
Table 3.5	Difficult/Pompous Non-technical Words (1979)
Table 3.6	Technical Terms (1978)
Table 3.7	Technical Terms (1979)
Table 3.8	Terms of Quantity or Order (1979)
Table 3.9	Negatives
Table 3.10	Large Number of Words (1977)
Table 3.11	Arrangement of Clauses
Table 3.12	Minor changes in parts of speech (1978)
Table 3.13	Passive voice (1979)
Table 3.14	Vocabulary Questions (1977)
Table 3.15	Logical Connectives (1979)
Table 3.16	Words in Text Books (1978)
Table 3.17	Words in Text Books (1979)
Table 3.18	(See over)

Table 3.18	Pupil's choice of definition (1978)
Table 3.19	Definitions (1979)

Matched questions in which the simplification has brought about a change which is significant at least at the five percent level, have been marked with an asterisk.

TABLE 3.3

Control Questions

A sample of element X contains the following types of atom:

$^{13}_{7}X$ $^{15}_{7}X$ $^{16}_{7}X$

The electronic configuration of the element is

A 2,4

B 2,5

C 2,6

D 2,7

An isotope of aluminium has an atomic number of 13 and a mass number of 27.

An atom of this isotope will contain

A 14 protons and 13 neutrons.

B 13 protons and 14 neutrons.

C 14 protons and 13 electrons.

D 13 protons and 14 electrons.

Some atoms of an element are heavier than other atoms of the same element.

This is because they have different numbers of

A neutrons.

B nuclei.

C protons.

D electrons.

Question No. \ % correct	1977		1978		1979	
	Pink	Yellow	Pink	Yellow	Pink	Yellow
No. in sample	671	626	626	646	641	641
1	66	67	69	70	69	68
2	70	71	72	71	67	67
3	60	60	59	61	58	56
*	6		6		6	

* Difference required for significance at least at the 5% level.

TABLE 3.4

Key Words (1977)

Original Question	% correct	Simplified Question	% correct
Which one of the following is a pungent gas? A. Carbon dioxide B. Nitrogen C. Sulphur dioxide D. Methane	56	Which one of the following is a choking gas? A. Carbon dioxide B. Nitrogen C. Sulphur dioxide D. Methane	63 *
Which is the least stable sulphide among the following? A. Lead sulphide B. Sodium sulphide C. Calcium sulphide D. Zinc sulphide	40	Which one of the following sulphides is easiest to break down to its elements? A. Lead sulphide B. Sodium sulphide C. Calcium sulphide D. Zinc sulphide	49 *
Which one of the following requires a non-aqueous solvent to dissolve it? A. Salt B. Sugar C. Sodium nitrate D. Sulphur	34	Which one of the following requires a liquid other than water to dissolve it? A. Salt B. Sugar C. Sodium nitrate D. Sulphur	49 *

TABLE 3.5

Difficult/Pompous Non-Technical Words (1979)

Original Question	% correct	Simplified Question	% correct
To distinguish visually between ethene and propanol, one would have to know that A. The molecules of propanol are larger than those of ethene. B. Ethene molecules contain a double bond whereas propanol molecules do not. C. Ethene is a gas and propanol is a liquid. D. Propanol is an alcohol and ethene is not.	67	To tell ethene and propanol apart, just by looking at them, you would have to know that A. The molecules of propanol are larger than those of ethene. B. Ethene molecules contain a double bond whereas propanol molecules do not. C. Ethene is a gas and propanol is a liquid. D. Propanol is an alcohol and ethene is not.	74 *
In which one of the following compounds is there a tendency for covalency to predominate? A. Calcium fluoride. B. Sulphur chloride. C. Sodium bromide. D. Potassium iodide.	51	Which one of these compounds is covalent? A. Calcium fluoride. B. Sulphur chloride. C. Sodium bromide. D. Potassium iodide.	55
Which of the following procedures would be expected to produce an exactly 0.1 Molar solution of sodium chloride (formula weight = 58.5)? A. Dissolving 5.85g of sodium chloride in 100 ml of water. B. Dissolving 5.85g of sodium chloride in water and making up with water to 1 litre of solution. C. Adding 100 ml of a molar solution of sodium chloride to 1 litre of water. D. Adding 5.85g of sodium chloride to 1 litre of water and shaking until dissolved.	36	To make an exactly 0.1 Molar solution of sodium chloride (formula weight = 58.5) what would you do? A. Dissolve 5.85g of sodium chloride in 100 ml of water. B. Dissolve 5.85g of sodium chloride in water and make up with water to 1 litre of solution. C. Add 100 ml of a molar solution of sodium chloride to 1 litre of water. D. Add 5.85g of sodium chloride to 1 litre of water and shake until dissolved.	40

TABLE 3.6

Technical Terms (1978)

Question	% correct
Evaporation What do we call the change when water turns into gas? A. Freezing. B. Condensing. C. Evaporation. D. Melting.	85
Filtration When making water fit to drink, mud is removed from pond water by: A. Chlorination. B. Distillation. C. Filtration. D. Precipitation.	79
Distillation Crude oil is refined by: A. Filtration. B. Sublimation. C. Distillation. D. Condensation.	69
Colloid Particles in a colloid: A. Can be seen without a microscope. B. Will not go through filter paper. C. Settle to the bottom of their container in time. D. Can reflect light and make a beam.	64
Emulsion Which of these is an emulsion? A. Bleach. B. Ink. C. Sugar dissolved in water. D. Milk	39
Saturated solution A saturated solution of a substance is one A. in which 1g of the substance is dissolved. B. which is made by dissolving the substance in boiling water. C. in which no more of the substance will dissolve at a given temperature. D. in which the substance is dissolved without stirring at a given temperature.	80
Solution When a gas dissolves in a liquid, the mixture of the gas and the liquid is called a A. Bubble. B. Solute. C. Solution. D. Solvent.	45

Table 3.6 contd.

Solute
When a solid dissolves in a liquid, the solid part is called: 41

A. Solvent.
B. Solution.
C. Residue.
D. Solute.

Solvent
When a solid dissolves in a liquid, the liquid part is called: 50

A. Solute.
B. Soluble.
C. Solution.
D. Solvent.

Non aqueous solvents
Which one of the following is a non aqueous solvent? 41

A. Water.
B. Starch.
C. Petrol.
D. None of these.

TABLE 3.7

Technical Terms (1979)

In each of these questions choose the substance that is an element — % correct

Question	A	B	C	D	% correct
1.	Chlorine	Salt	Sugar	Water	88
2.	Alcohol	Milk	Solder	Tin	92
3.	Acid	Iron	Litmus	Rust	88

In each of these questions choose the substance that is a compound

Question	A	B	C	D	% correct
1.	Rust	Air	Lead	Tin	56
2.	Iron	Milk	Sulphur	Salt	88
3.	Copper	Ice	Silver	Sulphur	77

Which method would be best for separating a mixture of an insoluble solid and a liquid? — 79

A. Crystallisation
B. Distillation
C. Evaporation
D. Filtration

Which of the substances in the diagram below could be called the filtrate? — 59

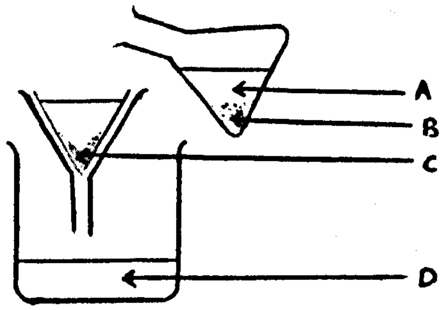
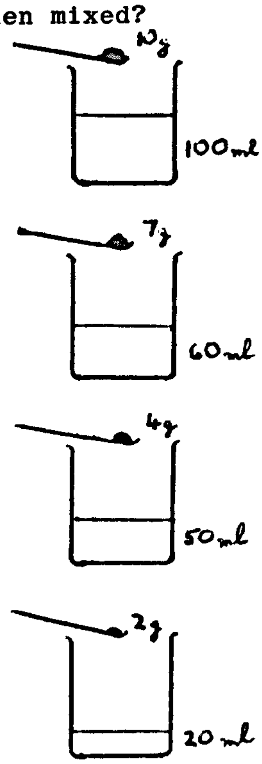
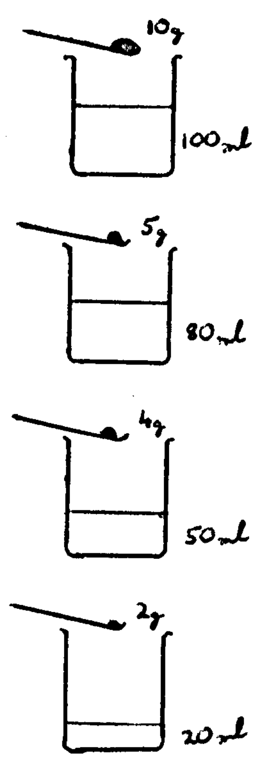
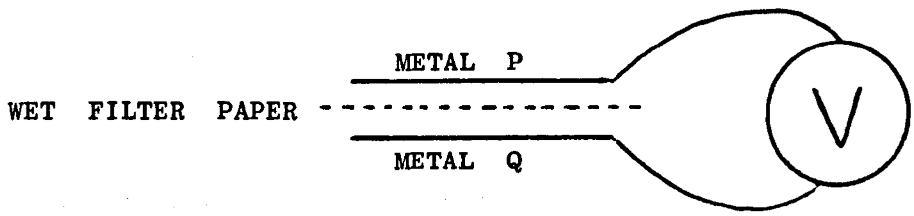


TABLE 3.8

Terms of quantity or Order (1979)

Original Question	% correct	Simplified Question	% correct
A brass contains 75 per cent copper, 22 per cent zinc, 2 per cent aluminium and 1 per cent lead. What is the most abundant element in this brass? A. Aluminium. B. Copper. C. Lead. D. Zinc.	84 *	A brass contains 75 per cent copper, 22 per cent zinc, 2 per cent aluminium and 1 per cent lead. What is the least abundant element in this brass? A. Zinc. B. Lead. C. Copper. D. Aluminium	75
Which one of the following solutions of a salt in water is the most concentrated? A. 11g of salt dissolved in $10cm^3$ of water. B. 9g of salt dissolved in $10cm^3$ of water. C. 7g of salt dissolved in $5cm^3$ of water. D. 5g of salt dissolved in $5cm^3$ of water.	85 *	Which one of the following solutions of a salt in water is the least concentrated? A. 11g of salt dissolved in $15cm^3$ of water. B. 8g of salt dissolved in $10cm^3$ of water. C. 7g of salt dissolved in $15cm^3$ of water. D. 5g of salt dissolved in $10cm^3$ of water	59
Which beaker of water and spatula of salt would make the most concentrated solution when mixed?  	71 *	Which beaker of water and spatula of salt would make the most dilute solution when mixed?  	63

In which of the following are the metals arranged in decreasing order of activity? A. Iron, calcium, sodium. B. Calcium, iron, sodium. C. Iron, sodium, calcium. D. Sodium, calcium, iron.	82*	In which of the following are the metals arranged in increasing order of activity? A. Sodium, calcium, iron. B. Calcium, iron, sodium. C. Iron, sodium, calcium. D. Iron, calcium, sodium.	63



Which pair of metals would give the highest reading on the voltmeter? METAL P — METAL Q A. Zinc — Copper B. Iron — Tin C. Magnesium — Silver D. Lead — Platinum	55*	Which pair of metals would give the lowest reading on the voltmeter? METAL P — METAL Q A. Zinc — Copper B. Magnesium — Silver C. Iron — Tin D. Lead — Platinum	47

TABLE 3.9

Negatives

1977 Exercise

Original Question	% correct	Simplified Question	% correct
Which of these statements is incorrect? The elements of column 4 of the Periodic Table. A. all form the same number of bonds. B. all form dioxides. C. are all metals. D. do not dissolve readily in water.	52	Which of these statements is correct? The elements of column 4 of the Periodic Table. A. are all metals. B. do not form dioxides. C. all form the same number of bonds. D. dissolve readily in water.	59*
1979 Exercise			
Which one of the following particles does <u>not</u> have the same number of electrons as a calcium ion? A. A potassium ion. B. A potassium atom. C. An argon atom. D. A chlorine ion.	24	Which one of the following particles has the same number of electrons as a calcium ion? A. A potassium atom. B. A potassium ion. C. A magnesium ion. D. A chlorine atom.	80*
Which statement is <u>not</u> true? A. The proton does not have the same mass as an electron. B. The hydrogen molecule contains two atoms. C. Isotopes of chlorine do not have different numbers of protons in their atoms. D. The element with Atomic Number 13 is a non metal.	60	Which statement is true? A. The proton has the same mass as an electron. B. The hydrogen molecule contains three atoms. C. Isotopes of chlorine have different numbers of protons in their atoms. D. The element with Atomic Number 13 is a metal.	80*
In which of the following elements do most of the atoms contain unequal numbers of protons and neutrons? A. Carbon. B. Fluorine. C. Nitrogen. D. Oxygen.	62	In which of the following elements do most of the atoms contain equal numbers of protons and neutrons? A. Fluorine. B. Oxygen. C. Chlorine. D. Hydrogen.	58

TABLE 3.10

Large number of Words (1977)

Original Question	% correct	Simplified Question	% correct
When a metal Z was added to the sulphate of a metal X, the metal X was precipitated and there was no effervescence. When the test was repeated using the metal T in place of Z no reaction occurred. When a metal Y was added to a solution of the sulphate of X, a brisk effervescence occurred. Which one of the following is the correct order of decreasing activity (i.e. the most reactive first) of the four metals? A. Y Z X T B. Y X T Z C. Z X T Y D. T X Y Z	47	Three metals Z, T and Y were added to separate solutions containing metal X ions. Z precipitates X; T had no effect; and with Y a gas was given off from the solution. Which one shows the metals in the correct order of activity (the most reactive first)? A. Y Z X T B. Y X T Z C. Z X T Y D. T X Y Z	67*
Around the symbol for an element there are four positions where further information may be given. Which of these positions is used to indicate the atomic number? A. Top left B. Top right. C. Bottom right. D. Bottom left.	47	If X is the symbol for an element, which position is used for the atomic number? A B X D C	54*

TABLE 3.11

Arrangement of Clauses

1977 Exercise

Original Question	% correct	Simplified Question	% correct
Calcium is a metal which burns in oxygen to form an oxide which, when added to water, gives a solution whose pH value is A. between 2 and 5. B. between 5 and 7 C. 7. D. above 7.	46	What would be the pH of the solution formed when calcium oxide dissolves in water? A. between 2 and 5. B. between 5 and 7. C. 7. D. above 7.	51

1979 Exercise

Original Question	% correct	Simplified Question	% correct
Atoms of element X, which have two electrons in the outer shell, combine with atoms of element Y, which have seven electrons in the outer shell. Which one of the following statements is true? A. The compound formed has the formula XY_2. B. X^+ ions are formed. C. Y^{2-} ions are formed. D. The compound formed is covalent.	38	Atoms of X have two electrons in the outer shell. Atoms of Y have seven electrons in the outer shell. Atoms of X and Y combine. Which one of the following statements is true? A. The compound formed has the formula XY_2. B. X^+ ions are formed. C. X^{2-} ions are formed. D. The compound formed is covalent.	48*
From an analysis of 24g of antimony oxide, which showed that 20g were antimony and 4g were oxygen, which of the following formulae would correctly represent antimony oxide, knowing that the atomic weight of antimony was 120 and that of oxygen was 16? A. SbO. B. SbO_2 C. SbO_3 D. Sb_2O_3	51	An analysis of 24g of antimony oxide showed that 20g were antimony and 4g were oxygen. Knowing that the atomic weight of antimony was 120 and that of oxygen was 18, which of the following formulae would correctly represent antimony oxide? A. SbO. B. SbO_2 C. SbO_3 D. Sb_2O_3	52

Which of the following could be a salt which, when a solution is electrolysed, gives a brown deposit at the negative electrode and evolves a yellowish green gas at the positive electrode? A. Potassium bromide. B. Lead chloride. C. Copper chloride. D. Calcium iodide.	56	A solution of a salt is electrolysed. At the negative electrode a brown deposit forms and at the positive electrode a yellowish green gas is evolved. Which of the following could have been the salt? A. Potassium bromide. B. Lead chloride. C. Copper chloride. D. Calcium iodide.	56

TABLE 3.12

Minor changes in parts of speech (1978)

Original Question	% correct	Simplified Question	% correct
In which one of the following compounds does covalency predominate? A. Potassium bromide. B. Carbon tetrachloride. C. Silver iodide. D. Aluminium chloride.	69	Which one of the following compounds is predominantly covalent? A. Potassium bromide. B. Carbon tetrachloride. C. Silver iodide. D. Aluminium chloride.	71
Which one of the following solutions would have an appreciable electrical conductivity? A. A glucose solution. B. A salt solution. C. A sugar solution. D. A starch solution.	81	Which one of the following solutions would conduct electricity appreciably? A. A glucose solution. B. A salt solution. C. A sugar solution. D. A starch solution.	79
When calcium is added to water which of the following are the products? A. An acid and oxygen. B. An acid and hydrogen. C. An alkali and oxygen. D. An alkali and hydrogen.	59	When calcium is added to water which of the following are produced? A. An acid and oxygen. B. An acid and hydrogen. C. An alkali and oxygen. D. An alkali and hydrogen.	59
An unknown metal X was found to be more reactive than sodium. Which one of the following predictions is most likely to be correct? A. It will oxidise readily in air. B. It should be stored under water. C. Its compounds will be unstable. D. It will be obtained from its oxide by reduction with carbon.	57	An unknown metal X was found to be more reactive than sodium. Predict which one of the following is most likely to be correct. A. It will oxidise readily in air. B. It should be stored under water. C. Its compounds will be unstable. D. It will be obtained from its oxide by reduction with carbon.	57

TABLE 3.13

Passive Voice (1979)

Original Question	% correct	Simplified Question	% correct
A compound with the general formula XY_3 would be likely to be formed from which of the following pairs of elements? A. Phosphorus and Hydrogen. B. Hydrogen and sulphur. C. Sulphur and chlorine. D. Chlorine and carbon.	57	Which of the following pairs of elements are likely to form a compound with the general formula XY_3? A. Phosphorus and hydrogen. B. Hydrogen and sulphur. C. Sulphur and chlorine. D. Chlorine and carbon.	58
Equal numbers of protons would be contained in which one of the following pairs of particles? A. Na and Na^+ B. Na^+ and Ne C. CI^- and Ar D. K^+ and Ca^{2+}	69	Which one of the following pairs of particles would contain equal numbers of protons? A. Na and Na^+ B. Na^+ and Ne C. Cl^- and Ar D. K^+ and Ca^{2+}	67
Iron (11) oxide is reduced when it is heated with carbon, but magnesium oxide is unaffected by this treatment. Which of the following statements is a correct deduction from these facts? A. Magnesium ions accept electrons less easily than do iron(11) ions. B. Iron is a more active metal than magnesium. C. Oxides of metals are stable compounds. D. Iron(11) oxide forms iron(11) carbonate with hot carbon.	50	Carbon reduces iron(11) at high temperature but does not reduce magnesium oxide. Which of the following statements is a correct deduction from these facts. A. Magnesium ions accept electrons less easily than do iron(11) ions. B. Iron is a more active metal than magnesium. C. Oxides of metals are stable compounds. D. Iron(11) oxide forms iron(11) carbonate with hot carbon.	50

TABLE 3.14

Vocabulary Questions (1977)

Some students are studying the fundamental laws of physics.
What does fundamental mean?

A. Modern and newly discovered.

B. Difficult and hard to understand.

C. Easily explained.

D. Most important.

If two things happen simultaneously, they happen

A. at the same time

B. quickly

C. one after the other

D. once a year

The remainder of the vocabulary questions are given in Appendix B.

Words Tested	Percentage correct
Disintegrates	70
Percentage	86
Theory	86
Diversity	65
Fundamental	77
Simultaneously	70
Probability	83
Sample size	1297

TABLE 3.15

Logical Connectives (1979)

% each response

In the following questions choose the word or phrase you feel fits best into the blank space.

Carborundum and diamond are both made of giant molecules. All substances made of giant molecules have melting points above 1000°C. Silicon is also made of giant molecules.
____________, silicon has a melting point above 1000°C.

A	However	A	12
B	Yet	B	5
C	Namely	C	5
D	Therefore*	D	78

Ionic salts dissolve in water to form solutions which conduct electricity.
Sodium chloride and potassium chloride are both ionic salts, ____________ solutions of both salts will conduct electricity.

A	On the other hand	A	8
B	Consequently*	B	72
C	Conversely	C	6
D	However	D	14

The formula of carbon dioxide is CO_2; ____________ a carbon dioxide molecule contains one carbon atom and two oxygen atoms.

A	For example	A	18
B	Such as	B	2
C	Conversely	C	6
D	That is*	D	74

Students shall not taste acids and bases; ____________ they should not taste any dangerous chemicals.

A	Nevertheless	A	7
B	Indeed*	B	55
C	Although	C	6
D	Consequently	D	32

TABLE 3.16

Words in Text Books (1978)

The instructions for the questions in the following table are as follows.

In the following questions you have to choose the answer to fill in the blank space. There may be more than one answer that is correct. I would like you to choose the ONE answer which you prefer to use.

* Words used by the author of the text book.

Question	% choosing each response
1. Different colours ________ to different amounts of energy.	
C. mean	2
B. relate	39
A. accord	1
* D. correspond	56
2. ________ the Periodic Table at the front of the book and remind yourself of the names of the noble gases.	
A. Look at	26
B. Examine	23
* C. Refer to	48
D. Peruse	1
3. Atoms cannot lose electrons easily because this ________ pulling a negative particle (the electron) away from the attraction of the positive nucleus.	
A. means	13
* B. involves	72
D. signifies	2
C. entails	13
4. We have already ________ charged atoms.	
B. come across	55
A. met	13
* C. encountered	26
D. confronted	5
5. Does this ________ anything about the colour of the dichromate ions?	
A. suggest	43
C. tell us	22
* D. indicate	27
B. signify	7

6. We learned that the nucleus of an atom is __________ in the heart of the atom.

	A. found	19
	D. situated	67
*	B. concentrated	10
	C. focused	2

7. The gas which you are able to smell at the anode during the electrolysis of copper chloride __________ molecules of chlorine.

	A. was made up of	16
	C. consisted of	41
*	B. was composed of	30
	D. comprised of	11

8. In electrovalent compounds each __________ ion is attracted to all its neighbours.

	A. no word is needed.	40
	B. individual	13
	C. separate	42
*	D. constituent	5

9. The energy is __________ as light.

	D. given out	17
*	B. released	28
	A. discharged	20
	C. emitted	35

TABLE 3.17

Words in Text Books (1979)

% each response

In the following questions you have to choose the answer to fill in the blank space. There may be more than one answer that is correct. I would like you to choose the ONE answer which you would prefer to use.

When lithium is added to the water you can see______

A. efflorescence.	A	8
B. bubbles.	B	49
* C. effervescence.	C	18*
D. frothing.	D	25

Substances which conduct electricity when dissolved in water or when molten are called electrolytes. These substances are_________by electricity.

A. separated.	A	17
* B. decomposed.	B	50*
C. broken down.	C	26
D. resolved.	D	7

Sodium chloride solution conducts electricity_________

A. no word necessary.	A	49
B. sufficiently.	B	24
C. greatly.	C	13
* D. appreciably.	D	14*

Two elements have the electronic arrangement 2, 8 and 2, 8, 8. These elements are particularly____________

A. unreactive.	A	14
B. inert	B	36
* C. stable	C	41*
D. inactive.	D	9

Place a small crystal of blue copper(11) sulphate in the water at one side of the dish and a small crystal of potassium ferrocyanide at the other. These should give evidence for the_________of the ions.

A. movement.	A	28
* B. diffusion.	B	43*
C. spreading.	C	16
D. dispersion.	D	13

The copper coloured wires which you have been using in your electrolysis are_________not composed of blue copper ions.

A. plainly.	A	9
B. obviously.	B	54
C. manifestly.	C.	7
* D. evidently.	D	30*

* Words used by the author of the text book.

TABLE 3.18

Pupils choice of Definition (1978)

Question	% choosing each response
In the following questions all the answers are correct but we would like to find out which ONE you prefer.	
If you were asked to explain the meaning of the word ELEMENT which ONE of the following statements would you prefer to use?	
A. An element is a substance which is made of only one type of atom.	52
B. An element is composed of atoms all of which have the same atomic number.	28
C. Elements are substances where atoms all contain the same number of protons in the nucleus.	20
If you were asked to explain the meaning of the word ISOTOPES which ONE of the following statements would you prefer to use?	
A. Isotopes of an element are composed of atoms that have the same atomic number but different mass numbers.	34
B. Isotopes are atoms of the same element with different numbers of neutrons.	28
C. Isotopes are atoms of an element with different mass numbers.	5
D. Isotopes are atoms with the same atomic number but different mass numbers.	33
If you were asked to explain the meaning of the words ATOMIC MASS which ONE of the following statements would you prefer to use?	
A. The Atomic Mass of an element is the weighted mean of the isotopic masses on the scale in which an atom of 12C is taken as 12 exactly.	10
B. The Atomic Mass of an element is the average mass of one atom of an element on a scale where the carbon 12 isotope $^{12}_{6}C$ has a mass of 12.00000 a.m.u.	21
C. The Atomic Mass of an element is the average mass of an atom of the element, taking into account the proportion of each isotope present.	40
D. The Atomic Mass of an element is the average mass of the isotopes of the element in their proportion.	29
If you were asked to explain the meaning of the words MASS NUMBER which ONE of the following statements would you prefer to use?	
A. The total number of protons and neutrons in an atom is called the Mass Number.	33
B. The Mass Number of an atom is the number of protons plus the number of neutrons in its nucleus.	37
C. The Mass Number of an atom is the sum of the number of protons and neutrons in that atom.	22
D. The Mass Number of an isotope of an element is the number of protons and neutrons in the nucleus of an atom of the isotope.	8

If you were asked to explain the meaning of the words ATOMIC NUMBER which ONE of the following statements would you prefer to use?

A.	The Atomic Number of an element is the number of protons in the nucleus of an atom of an element.	17
B.	The Atomic Number of an atom is the number of protons in the nucleus of that atom.	35
C.	The Atomic Number of an element is the number of protons in an atom of the element.	25
D.	The Atomic Number of an element is the number of protons in the nucleus of one of its atoms.	23

TABLE 3.19

Definitions (1979)

% each response

In the following questions more than one answer may be correct but we would like to find out which one you prefer.

If you were asked to explain the meaning of the word element which ONE of the following statements would you prefer to use?

A. An element is a substance which is made of only one type of neutron.	A	3
B. An element is composed of atoms all of which have the same mass number.	B	10
C. Elements are substances where atoms all contain the same number of protons in the nucleus.	C	24
D. An element is made of only one type of atom.	D	63

If you were asked to explain the meaning of the word isotopes which ONE of the following statements would you prefer to use?

A. Isotopes of an element are composed of atoms that have the same atomic number.	A	6
B. Isotopes are atoms of the same element with different numbers of protons.	B	13
C. Isotopes are atoms of an element with different mass numbers.	C	17
D. Isotopes are atoms with the same atomic number but different mass numbers.	D	64

If you were asked to explain the meaning of the words Mass Number which ONE of the following statements would you prefer to use?

A. The total number of protons and electrons in an atom is called the mass number.	A	23
B. The mass number of an atom is the number of protons plus the number of electrons in its nucleus.	B	12
C. The mass number of an atom is the sum of the number of protons and neutrons in that atom.	C	53
D. The mass number of an isotope of an element is the number of protons and neutrons in the nucleus of an atom of the isotope.	D	12

3.5 Discussion

The results for the control questions (Table 3.3) indicate that the samples sitting the tests were very similar and consequently it is assumed that differences exhibited between any pair of matched questions were due to factors operating within the question rather than factors associated with differences in the sample population sitting each test. The similarity in the results for these control questions even between the years hints at the reproducability of the experimental conditions.

In multiple choice chemistry questions the replacement of words, whose meaning needs to be understood, by simpler words has an influence on how that multiple choice item operates. Such words could be called key words (Table 3.4). When 'pungent' is replaced by 'choking', 'least stable' by 'easiest to break down', and 'non-aqueous solvent' by 'liquid other than water', then a significant improvement in performance is the result. In multiple choice items in addition to the key words there are obviously other words. It may initially appear that it is not quite so essential to understand these words in order to answer the question. However, alterations to these words can influence performance (Table 3.5). Replacement of the expressions 'distinguish visually', 'tendency to predominate', 'following procedures ... expected to produce' brought about an improvement in performance though not all of the improvements were significant at the five percent level. In multiple choice items it is important that the language is precise and so there is a tendency for the style of the question to be formal in order to achieve this precision. If, however, this formality becomes pompous then it may make the questions more difficult.

The discussion has so far considered the influence of non-technical words on performance. The understanding of technical terms is part and parcel of the understanding of chemistry. The teaching of the subject requires the careful presentation of new technical terms. However, there may be technical terms used in the O grade course which it is assumed the pupils understand since they have already been introduced to them in the first and second year, and consequently these are not so carefully presented. The results (Table 3.6 s 3.7) for the questions in technical terms are interesting. From the pupils performance the terms 'evaporation' and 'filtration' seem to pose little problem but it should be remembered that the percentage correct will be a function not only of the term but also of the context of the question in which it is used. This may help to explain the poor performance for 'emulsion' and 'distillation'. The terms may be known but not related to 'milk' or 'crude oil/refined'. The questions on 'saturated solution', 'solution', 'solvent' and 'solute' are thought provoking. A large percentage of the pupils seem to understand the expression 'saturated solution' but are confused by the terms 'solution', 'solvent' and 'solute'. 'Saturated solution' may be an expression that has been carefully presented whereas the other three similar sounding terms prove more difficult for even O grade candidates to distinguish. They also have difficulty in distinguishing between 'compound' and mixture but the word 'element' is more readily understood. From the results the term 'filtration' seems easier to understand than 'filtrate' perhaps because the latter term is less widely used. It would apparently be wrong to assume that because the pupils may have come across certain technical terms in first and second year that they understand these terms. These may need to be presented to the pupils as carefully as new technical terms, like isotope, if the pupils are to be able to use and understand the terms competently.

Changes in expressions of quantity can influence performance (Table 3.8). 'Most abundant' seems to be easier to understand than 'least abundant'. Similarly 'most concentrated' seems to be easier to understand than either 'least concentrated' or 'most dilute'. The candidates can pick out a 'decreasing order of activity' more readily than an 'increasing order of activity' of metals and when the metals are considered in pairs to give readings on a voltmeter it is apparently easier to pick out the 'highest' rather than the 'lowest' reading. Some of these changes may be a reflection of the teaching, for example, the activity order is usually presented as a decreasing order, but these changes may also reflect the language change influencing the thinking necessary to solve the question. Consider the comparison between 'most abundant' and 'least abundant'. Most is an expression indicating a positive measure of magnitude as is abundant. Least is an expression indicating a negative measure of magnitude and consequently by this arguement is an opposite to abundant. Therefore 'most abundant' may be easier to understand because it does not involve the unravelling of the double think of 'least abundant'. In other words there may be fewer thinking stages necessary to solve the questions containing 'most concentrated', and 'most abundant' and more thinking stages may be necessary to cope with 'least concentrated', 'most dilute' and 'least abundant'.

In Table 3.9 there are matched questions some with negative expressions, e.g. 'not', 'incorrect', 'unequal' and others with the negative removed. In one of the items the negative expressions are in both the stem of the question and the responses. The removal of these negatives, in general, seems to improve the performance and again this may reflect the language change influencing the thinking necessary to answer the question. In a question without a negative there are a number of thinking stages to go through in order to get to the correct answer but in a question with a negative it may be possible that there is at least one additional thinking stage to go through because of the presence of the negative. This influence of the negative may not always be apparent in the matched questions because in the attempt to get matched questions sometimes the content of certain responses has to be changed and this may also have an influence on performance.

In multiple choice chemistry questions information has to be read and considered by the candidate before a response is made. The organisation of this information in the question has an influence on performance (Table 3.10 and Table 3.11). The removal of extraneous information by reducing the number of apparently unnecessary words is a simplification. Presenting the information in a clear organised fashion or in simple sentences rather than larger complicated sentences with embedded clauses can bring about an improvement in performance. This may again reflect the language change influencing the thinking necessary to answer the question. If the external organisational changes in the presentation of the information in the question reduces the internal intellectual organisation necessary in order to answer the question, then that linguistic change brings about a change in performance.

Some language changes do not apparently influence performance (Table 3.12 and Table 3.13). Minor changes in parts of speech, e.g. 'products' to 'produced' 'predominate'to 'predominantly', do not seem to influence performance and framing the question in the passive or active voice seems to have little effect. A possible reason may be that these language changes do not alter the underlying meaning of the question as a change in vocabulary would do nor do they bring about any major organisational changes in the presentation of information, and so since these changes have little influence on the thinking necessary to answer the question, they have little influence on measured performance.

The remaining tables of information do not consist of matched multiple choice chemistry questions designed to test the possible influence of a linguistic change on performance. Although they concern multiple choice questions they are designed to cast some diffuse light on the teaching/learning situation rather than on assessment. The results in Table 3.14 are from vocabulary questions originally designed for an Australian exercise (12). Some of these technical words cause even O grade candidates difficulty. The questions are designed to be straightforward yet for some of the words, i.e. 'disintegrates', 'diversity', 'fundamental', 'simultaneously', more than one candidate in five gets these items wrong. The interest in trying to assess the understanding of non-technical words in science led to a much wider investigation which is described in a later chapter (Chapter 5).

The questions used to investigate logical connectives are also based on Australian exercises (136)(137)(138). Logical connectives, e.g. 'therefore', 'however' or expressions which serve as links between pieces of information: sentences, clauses or phrases and the original research concluded that by the fourth year of secondary school most pupils can understand most connectives but there are still many connectives, particularly the less common ones, which prove difficult. Although only four items are displayed in Table 3.15, the results would tend to support the Australian findings. For all of the questions at least one in four of the candidates chose an incorrect response and the question testing 'indeed' had the lowest percentage correct, 'consequently' being the best distractor. In the assimilation of chemical knowledge, it is necessary for the pupils on occasions to be able to follow linked chains of logical argument and a faulty understanding of the link words may be an additional barrier to the understanding of chemistry.

The results in Tables 3.16 and 3.17 are in questions designed to try to get a pupil's eye view of text books. The sentences are from a much used chemistry text book (154). A word is omitted and four plausible responses are offered from which the pupils were asked to choose the one which they would prefer to use. In Table 3.16 the responses for each question have been rearranged according to Thorndyke Lorge (155) word frequency, i.e. from the most commonly used word to the least commonly used. It is not being advocated that the most commonly used word is always the most appropriate. Indeed one of the richnesses of the English language is the wide variety of words which are available for any given situation. However, from these results there may be some evidence that the language of the text book is not necessarily the language the pupil is most comfortable with and the teacher of chemistry may need to be concerned with ways in which to improve the vocabulary of the pupil, to try to make the information of the text book more accessible to the learner.

The learning of the meaning of technical terms is important in chemistry and when a pupil is faced with a number of correct definitions and asked to choose the one preferred definition, the results are interesting (Table 3.18). What factors may influence choice? There are many including: is it in a familiar form from a popular text book; is it in a concise form; or is it its position among the other definitions? The following statements are obviously very speculative. In few of the choices in the questions in Table 3.18, is there a clear cut favourite but the results might indicate the importance of cues in learning and where the cues are missing the pupils tend to avoid this definition. Consider some of the questions. For 'element' the cue may be 'only one type'. Response A the most popular choice has that cue. For 'isotopes' the cue may be 'some' but 'different'. Response C does not have this cue and is the least popular choice. For 'Mass Number' the cue may be an expression like 'sum', 'plus', 'total'. Response to D does not have such a cue and is the least popular choice. To try to test this tentative idea that the presence of cues, useful in the learning of definitions, may be influencing the choice in these multiple choice situations, these three definitions were tested again, including examples where the correct cue was present but the definition was wrong. The results are shown in Table 3.19. From the percentage choosing each response the substance of the definition, i.e. whether it is correct or not is more important than the presence or absence of the speculated cues but for each one the most popular response does contain the cue.

3.6 Conclusions

In all three years 1977, 1978 and 1979 the evidence of the common control questions suggests that the samples of pupils who attempted the paired tests were closely matched. It is assumed that because the two groups of pupils are closely matched, differential performances are due to the changes made in the questions and not to the characteristics of the pupils.

Bearing in mind the hypotheses for this chapter and the subsequent discussion, performance in multiple choice chemistry questions seems to be influenced by :

(1) Words :

If a non-technical word that needs to be understood to answer the question (a key word) is replaced by a word that is more easily understood then there is an improvement in performance. In addition to the key words the other words in the question may also have an influence on performance and compressed formal language (pompous) may depress performance.

(2) Negatives :

If a negative expression is removed there can be an improvement in performance.

(3) Expressions of quantity or order :

If incompatible expressions like 'least abundant', 'least concentrated' are replaced by more compatible expressions like 'most abundant', 'most concentrated', then there is an improvement in performance.

(4) Bits of information :

If extraneous bits of information are reduced by removing unnecessary words, then performance improves. If the bits of information are arranged in clear organised simple sentences rather than larger complicated sentences with embedded clauses, then performance im proves.

Performance in multiple choice chemistry questions does not seem to be influenced by minor changes in parts of speech nor by changing the passive voice into the active voice. A possible reason for this may be that these changes do not alter the underlying meaning of the question whereas changes (1-4) not only alter the surface structure of the question but they may alter the thinking necessary to solve the problem. If the change either reduces the number of thinking stages or makes the thinking stages easier, then the performance is improved. If on the other hand the change does not influence the thinking, then there is no influence on performance.

In addition to these conclusions on the paired matched chemistry questions, some tentative conclusions on the individual multiple choice questions are suggested.

1 Technical vocabulary that is introduced early in the secondary school may not be recalled by O grade chemistry candidates

2 From the vocabulary questions certain non-technical words including logical connectives may be a barrier to the learning of chemistry.

3 The language of the text book may not be the language with which the pupil is most comfortable

4 In learning definitions of technical expressions certain cues or trigger words may play an important role.

From both the conclusions in the paired matched multiple choice chemistry questions and the individual multiple choice questions, by the consideration of the performance (section 3.5) the interrelationship between the superficial language of the question and this language's influence on the internal thinking process necessary to answer the questions is being inferred. For example in the paired matched multiple choice chemistry questions on organisation of information in the stem of the question (Table 3.10 and Table 3.11) it is suggested that if the external organisational changes in the presentation of the information in the question reduces the internal intellectual organisation necessary to solve the question then that linguistic change brings about a change in performance.

CHAPTER 4

The Joint Matriculation Board (JMB) Experiment

4.1 Introduction

In an attempt to consolidate and widen the conclusions of the Scottish experiment, it was decided to approach the Universities of Manchester, Liverpool, Leeds, Sheffield and Birmingham Joint Matriculation Board (JMB) in order to involve their O level candidates. It was felt that if the JMB were to administer a carefully designed experiment to a representative cross section of their schools and some of the conclusions were the same as the Scottish experiment, then it may indicate that the results are not due to accent, Scoticisms, locality, regional quirks, or the sample of Scottish schools but rather give more substance to the idea that the factor that is affecting performance in multiple choice questions is the influence of language on the internal processing or thinking necessary to solve the question. Some differences were expected. In Scotland whereas there is, at present, only one examination at age sixteen, i.e. the O grades, in England there are two, namely C.S.E. and O level and it was anticipated that as a group the O level candidates would be a more able group than the Scottish O grade candidates.

In 1975 the JMB was approached by the Science

Education Research Group of the University of Glasgow with a view to a co-operative exercise relating to matched pairs of multiple choice chemistry questions. The Research Advisory Committee of JMB considered the proposal in January 1976 and agreed that the results of this work might be of use to the JMB in the setting of future examinations in O level Chemistry and agreed to include a representative cross section of JMB schools in the testing programme. The Examinations Council subsequently endorsed this recommendation and formal contact between the JMB and the Science Education Research Group of the University of Glasgow was established.

The hypotheses that are to be considered in this chapter are as follows :

(a) Ability to respond to multiple choice chemistry questions may be associated strongly with measured general verbal ability.

(b) Ability to respond to multiple choice chemistry questions may be related to factors that influence language development namely social class and sex.

(c) Replacing words in key positions in multiple choice chemistry questions may influence performance.

(d) Changing possible pompous non-technical terms in multiple choice chemistry questions may influence performance.

(e) Expressions of quantity or order (e.g. more, less, increasing, decreasing) in multiple choice chemistry questions may influence performance.

(f) Replacing a negative expression by an affirmative expression in multiple choice chemistry questions may influence performance.

(g) Reducing the number of words in multiple choice chemistry questions may influence performance.

(h) Changing the arrangement of clauses in multiple choice chemistry questions may influence performance.

(i) Replacing passive expressions by active expressions in multiple choice chemistry questions may influence performance.

(j) O level chemistry candidates may have a poor understanding of useful non-technical words.

These hypotheses represent to some extent an expansion of Table 2.2 and, as with Scottish experiment, their formulation has been influenced by some of the research work described in part 2.3 of Chapter 2. The JMB experiment is in this respect a parallel investigation.

It differs from the Scottish experiment in that it is almost exclusively involved with paired matched multiple choice questions with little attempt to explore aspects of teaching chemistry, e.g. text book language.

This is understandable since the JMB, an assessment organisation, is interested in how the language in which a test item is couched may influence performance. The JMB experiment also differs from the Scottish experiment in that the JMB experiment has the added dimension of comparing pupil performance with the pupils measured general verbal ability, their social class and their sex.

As in the Scottish experiments, within the theoretical background detailed in Chapter 1, it is hoped that these hypotheses will not only lead to conclusions about how the superficial language of the question influences performance but also lead to a clearer understanding of how the superficial language may be related to the necessary internal thinking process.

The investigation is in two parts - one conducted in March/April 1977 and the other in March/April 1979.

4.2 Design of the test items used in the 1977 Investigation

The test items used in this experiment were assembled in much the same way as had been done in the Scottish experiment. It was decided that the alternative forms of the two tests should contain thirty items made up as follows :-

1 Five items on vocabulary from the Australian word survey.

2 Four items on Chemistry common to both tests to act as control questions.

3 Twenty-one items on Chemistry each having two versions designed to investigate the effect of the following :

   (a) possibly difficult words, such as pungent or diatomic in key positions
   (b) the removal of a negative
   (c) the presence of large numbers of words
   (d) the removal of a possible ambiguity
   (e) different formulations in terms of the number or arrangement of clauses.

Some of these items were the same as had already been used in the Scottish exercise, but there were a number of items which were specially adapted for use in the joint experiment. These items had been pretested, they had been found suitable for use, but had never actually been used in an operational Ordinary Level examination. These items were selected by the Chairman of Examiners for Chemistry (Ordinary) and were adapted by myself working in conjunction with him so as to provide alternative simplified forms.

To obtain a measure of the general verbal ability of the candidates since it was not possible to obtain verbal reasoning quotients in addition to the Chemistry test, each pupil attempted forty verbal items taken from Test 100. This is a test of scholastic ability constructed by the National Foundation for Educational Research for use in its GCE and CSE monitoring studies. It contains eighty items designed to test verbal and numerical ability. In order to provide an indication of the verbal ability of the pupils the items testing verbal skills are isolated and a test containing these items only was re-printed.

The General Ability Test (Verbal) (Appendix E) was timed for thirty minutes. This was followed by one of the Chemistry tests (Appendix F) which was timed for forty minutes, so that the entire testing process, including preparation and a short break, lasted only a little more than one hour and a quarter.

In addition to completing an answer sheet (Appendix G) each candidate was asked to indicate his/her sex and the occupation of one or both parents. The responses were anonymous, but since schools were invited to indicate whether they wished to receive the scores of their candidates, they were asked to use some means of identifying the candidates on the answer sheets.

4.3 Organisation and Administration of the 1977 Investigation

It was decided that to produce stable results from which meaningful conclusions could be drawn, it was preferable to have about 1,000 pupils attempting each of the Chemistry tests. For ease of administration, not only for the JMB but also for the schools taking part, it was agreed that the unit of sampling would be the school. The schools selected are a representative sample of those entering candidates for JMB Chemistry (Ordinary). A total of 40 schools accepted the invitation to take part and in all 2024 pupils sat the tests including a few who had not been entered for the Chemistry (Ordinary) examination although they had formed part of the O-level teaching group.

The test materials sent to schools included Instructions to Supervisors (Appendix H). The two forms of the Chemistry test were coded X (printed on pink paper) and Y (printed on yellow paper) and schools were asked to distribute them to pupils alternately, i.e. the first pupil received Text X, the second Test Y, the third Test X and so on. The use of different coloured paper was for convenience so that schools would have no difficulty in distributing the booklets correctly and pupils would have no difficulty in indicating on the answer sheet which test they had attempted.

When the tests had been completed, all materials were returned to the JMB. Most candidates had provided the information on the answer sheets which was requested. From the indication of parental occupation, pupils were classified into one of three social class based on the categories used by the Registrar General (156).

Group 1 Professional and skilled workers

Group 2 Semi-skilled workers

Group 3 Unskilled workers

Where the occupations of both parents were shown, the higher of the two was used in the classification. In some cases parental occupation was not given and in a very few instances, candidates omitted to show their sex on the answer sheet. Nevertheless the responses of all pupils were processed and their scores have been included in the appropriate category with the result that, in some of the results which follow, the numbers do not always add up to the same total. When returning the answer sheets schools were asked to indicate which sheets related to the non-GCE pupils (if any) so that this information could be entered on the sheets.

4.4 Results of items common to all pupils, in 1977 Investigation

It was intended that by utilising fairly large samples overall, the sub-groups of pupils would themselves be fairly large so that sampling errors would be reduced and that differences noted would be real differences, subject to the usual limits of significance. All pupils offered the Test of Verbal Ability, the questions on vocabulary common to both Chemistry Tests and the control questions on Chemistry which were also common to both tests. The facility values (expressed as percentages) for the two groups of candidates offering Test X and Test Y respectively in the questions which were common are shown in Table 4.1. It should be noted that all the questions have been numbered sequentially with the items in the Chemistry Tests numbered, for convenience, 41-70. Throughout this report, Test X refers to the test containing the items in their original form and Test Y refers to the test with items in simplified form.

It may be seen from Table 4.1 that the facility values for the individual common items are extremely similar for the two groups of pupils who completed Test X and Test Y. Of the 55 items, 17 have identical facility values; 35 items differ by 2 per cent or less. Two items (No. 25 and No. 42) differ by 3 per cent. The greatest discrepancy (of 4 per cent) is between the performance of pupils taking Test X and those taking Test Y in relation to item No. 26 (a Verbal Ability item). There is thus clear evidence that the two groups of pupils who took Test X or Test Y may be considered to be very closely matched.

TABLE 4.1

Facility values in the common questions for the two main groups of pupils.

Question (Verbal Ability)	Pupils offering Test X	Pupils offering Test Y
1	79	78
2	77	75
3	92	92
4	95	95
5	85	85
6	77	77
7	77	75
8	58	59
9	81	82
10	76	78
11	63	62
12	73	73
13	47	46
14	84	84
15	75	75
16	88	90
17	42	43
18	62	62
19	91	92
20	67	67
21	92	92
22	90	93
23	44	45
24	66	66
25	31	32
26	57	61
27	93	93
28	45	45
29	81	80
30	63	62
31	55	57
32	48	48
33	61	62
34	71	72
35	45	45
36	31	28
37	34	35
38	25	27
39	35	37
40	40	41
Mean facility	65.4	65.7

Question (Vocabulary)	Pupils offering Test X	Pupils offering Test Y
41 (negative)	85	84
42 (correspond)	84	87
43 (efficient)	97	96
44 (converse)	34	34
45 (valid)	87	86
Mean facility	77.4	77.4

(The word in parenthesis is the word the understanding of which is being tested.)

Control questions (Chemistry)	Pupils offering Test X	Pupils offering Test Y
52	71	71
53	67	65
54	57	58
55	66	66
Mean facility	65.3	65.0

	Test X	Test Y
Number of pupils	1 004	1 120

TABLE 4.2

Facility values for the sub-groups in the common questions

Question	Verbal Ability						Social Class						Sex				Examination			
	Group 1		Group 2		Group 3		Group 1		Group 2		Group 3		Boys		Girls		GCE		Non-GCE	
	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
52	86	86	73	71	57	58	76	77	69	67	62	68	73	73	70	69	76	76	37	35
53	83	81	67	62	53	55	71	73	64	64	57	61	69	66	65	66	70	69	36	38
54	79	80	57	53	36	42	65	65	51	54	45	46	61	61	52	54	61	61	30	32
55	80	85	66	64	53	53	73	74	63	64	55	59	66	66	66	68	70	71	39	38
Sample Size	318	324	364	367	322	329	419	380	362	410	93	93	606	619	393	398	899	902	105	118
Estimated difference necessary for 5% significance	8		8		8		7		7		14		6		7		5		12	

As has been pointed out each of the two main groups consisted of more than 1,000 pupils so as to ensure that numbers in sub-groups would not be small. Details of the sub-groups and the numbers of pupils in each are as follows.

Verbal Ability	Test X	Test Y
Group 1 : Test scores 30-40	318	324
Group 2 : Test scores 24-29	364	367
Group 3 : Test scores 0-23	322	329

(Test score ranges were chosen so as to make the groups approximately equal in size).

Social Class*		
Group 1	419	380
Group 2	362	410
Group 3	93	93
Sex*		
Boys	606	619
Girls	393	398
GCE status		
GCE candidate	899	902
Non-GCE candidate	105	118

*Because of missing data the totals do not sum to 2024.

Table 4.2 shows the facility values for the sub-groups of pupils who attempted Test X and Test Y in respect of the four common Chemistry questions. As was noted for the main groups of pupils the facility values are very close. Apart from an apparent sex difference in item No. 54 there are discrepancies between facility values within Verbal Ability Groups 2, 3 and 1 for item Nos. 53, 54 and 55 respectively. None of these differences, however, reach statistical significance as may be seen from the bottom row of Table 4.2. The evidence leads to the conclusion that in all major respects the two groups of pupils who completed Tests X and Y are sufficiently matched. Thus differences in performance between those items which are in original and those in simplified form may be said to be the result of the wording and not to the different characteristics of the candidates responding to them.

TABLE 4.3

Facility values for individual questions for total sample

	Question number	Ability Group 1	Ability Group 2	Ability Group 3	Social Class 1	Social Class 2	Social Class 3	Boys	Girls	GCE pupils	Non-GCE pupils
Vocabulary questions	41	92	86	78	88	84	82	85	86	87	72
	42	95	88	75	88	84	85	86	86	87	80
	43	100	99	93	98	97	96	97	98	98	91
	44	36	34	34	37	33	32	34	35	35	33
	45	95	88	79	89	87	82	88	86	88	82
Chemistry control questions	52	86	72	58	76	68	65	73	69	76	36
	53	82	65	54	72	64	54	67	65	69	42
	54	80	55	39	65	52	45	61	53	61	31
	55	83	65	53	73	63	57	66	67	70	31
Number of pupils*		642	731	561	799	772	186	1225	791	1801	223

* Because of missing data some totals do not sum to 2024

4.5 Analyses of individual questions in 1977 Investigation

The five common vocabulary questions (Table 4.1) are numbered 41-45 in each version of the two tests (original and simplified). The four common Chemistry control questions are numbered 52-55 in thetwo tests. Table 4.3 shows thefacility values for these common questions for the total sample of 2,024 pupils. As is to be expected Ability Group 1 pupils found the common questions easier than either Ability Group 2 or 3 pupils. Except for item no. 44 the mean facility values for Ability Group 3 pupils are lower than that for either Group 2 or Group 1. Except for item no. 42 lower Social Class groups show numerically inferior mean facility values than higher Social Class groups. Sex differences are small except for item no. 54 and (to a lesser degree) 52. As may be seen the facility values for item no. 54 are 53 for girls and 61 for boys: no explanation is offered for this difference. The item is as follows.

54. Some atoms of an element are heavier than other atoms of the same element. This is because they have different numbers of

    A. neutrons

    B. nuclei

    C. protons

    D. electrons

Option B was not popular; options C and D attracted approximately equal proportions of pupils.

Separate analyses were made of the facility values for the Chemistry questions in their original form and in their simplified form for each of the sub-groups into which the main samples of pupils have been divided. These multiple choice items are numbered 46-51 and 56-70. (Subsequent to the analysis it was discovered that there was an error in the simplified version of question 61. This question has been omitted therefore from all the following tables.)

Table 4.4 gives the mean facility values for the Chemistry questions in their original form for each sub-group. It may be seen that there is a marked tendency for facility values to fall as one goes from Ability Group 1 to Ability Group 2 to Ability Group 3. In item no. 48 the trend is reversed between Ability Groups 2 and 3 and in item no. 66 between Groups 1 and 2. Of the 40 differences tested for significance, 32 were found to be statistically significant. A similar overall pattern is to be seen between Social Class Groups. Items nos. 46, 60 and 69 upset the trend between Groups 2 and 3; item 46 has extremely high facility values. Differences in facility values between Social Class Group 1 and Group 2 were tested; 11 differences were found to be statistically significant.

TABLE 4.4

Facility values for Chemistry questions in original form

Question number	Ability Group 1	Ability Group 2	Ability Group 3	Social Class 1	Social Class 2	Social Class 3	Boys	Girls	GCE pupils	Non-GCE pupils
46	99	98	90*	97	95	98	97	94	97	88*
47	80	59*	39*	67	54*	52	62	54*	63	25*
48	61	59	62	63	56*	57	65	54*	61	58
49	76	60*	43*	63	58	52	63	54*	63	31*
50	48	34*	29	44	32*	23	39	34	39	24*
51	66	56*	46*	57	55	51	60	51*	59	34*
56	60	49*	43	54	52	38	55	45*	52	39*
57	81	65*	56*	69	66	59	69	64	70	40*
58	64	51*	39*	56	49*	46	53	49	54	31*
59	47	32*	24*	35	32	28	39	28*	36	21*
60	81	66*	41*	68	58*	60	68	54*	65	38*
61	W	I	T	H	D	R	A	W	N	
62	85	68*	45*	73	61*	55	68	64	69	45*
63	31	23*	16*	26	22	19	24	22	24	14*
64	71	59*	39*	64	52*	45	58	53	59	32*
65	68	56*	44*	56	55	54	59	52*	57	44*
66	65	52	37*	58	47*	50	55	45*	52	41*
67	46	36*	30	41	35*	16	36	36	38	20*
68	65	45*	37*	53	45*	50	50	46	51	26*
69	43	35*	32	39	36	41	35	40	37	35
70	65	55*	40*	58	50*	44	54	53	56	35*
Number of pupils	318	364	322	419	362	93	606	393	899	105

* The differences between Ability Group 1 and Ability Group 2, between Ability Group 2 and Ability Group 3, between Social Class Group 1 and Social Class Group 2, between boys and girls and between GCE pupils and non-GCE pupils for individual questions have been tested; those marked* are significant at the 5 per cent level.

TABLE 4.5

Facility values for Chemistry questions in simplified form

Question number	Ability Group 1	2	3	Social Class 1	2	3	Boys	Girls	GCE pupils	Non-GCE pupils
46	99	100	99	100	99	100	99	100	99	100
47	90	79*	67*	83	74*	75	79	78	83	48*
48	68	59*	63	65	62	68	64	61	63	64
49	77	64*	46*	71	58*	53	65	58*	65	42*
50	42	26*	21	34	26*	28	32	27	31	16*
51	75	57*	52	65	58*	57	63	57*	64	39*
56	73	61*	54	69	61*	57	64	60	66	40*
57	84	65*	54*	72	66	60	68	68	70	49*
58	58	44*	34*	55	41*	38	49	40*	48	21*
59	49	32*	27	40	34	22	38	32*	38	23*
60	75	54*	40*	62	52*	55	60	51*	59	38*
61				W I	T H	D R A	W N			
62	88	70*	61*	79	68*	74	73	73	75	55*
63	31	26	25	33	26*	14	30	23*	28	22
64	77	52*	41*	67	52*	44	56	57	61	26*
65	59	49*	43	52	49*	56	54	45*	51	42
66	67	50*	43	61	50*	57	55	50	55	39*
67	51	37*	31	47	37*	24	41	38	41	30*
68	80	59*	42*	63	61	52	59	63	64	36*
69	65	50*	41*	56	47*	45	52	49	52	40*
70	67	49*	34*	56	56	40	52	47	53	23*
Number of pupils	324	367	329	380	410	93	619	398	902	118

* The differences between Ability Group 1 and Ability Group 2, between Ability Group 2 and Ability Group 3, between Social Class Group 1 and Social Class Group 2, between boys and girls and between GCE pupils and non-GCE pupils for individual questions have been tested; those marked * are significant at the 5 per cent level.

TABLE 4.6

Differences in facility values between simplified and original forms of Chemistry questions

Question number	Ability Group 1	Ability Group 2	Ability Group 3	Social Class 1	Social Class 2	Social Class 3	Boys	Girls	GCE pupils	Non-GCE pupils
46	0	2*	9*	3*	4*	2	2*	6*	2*	12*
47	10*	20*	28*	16*	20*	23*	17*	24*	20*	23*
48	7	0	1	2	6	11	-1	7*	2	6
49	1	4	3	8	0	1	2	4	2	11
50	-6	-8*	-8*	-10*	-6	5	-7*	-7*	-8*	-8
51	9*	1	6	8*	3	6	3	6	5*	5
56	13*	12*	11*	15*	9*	19*	9*	15*	14*	1
57	3	0	-2	3	0	1	-1	4	0	9
58	-6	-7	-5	-1	-8*	-8	-4	-9*	-6*	-10
59	2	0	3	5	2	-6	-1	4	2	2
60	-6	-12*	-1	-6	-6	-5	-8*	-3	-6*	0
61				W I	T H	D R A	W N			
62	3	2	16*	6*	7*	19*	5	9*	6*	10
63	0	3	9*	7*	4	-5	6*	1	4	8
64	6	-7	2	3	0	-1	-2	4	2	-6
65	-9*	-7	-1	-4	-6	2	-5	-7*	-6*	-2
66	2	-2	6	3	3	7	0	5	3	-2
67	5	1	1	6	2	8	5	2	3	10
68	15*	14*	5	10*	16*	2	9*	17*	13*	10
69	22*	15*	9*	17*	11*	4	17*	9*	15*	5
70	2	-6	-6	-2	6	-4	-2	-6	-3	-12*

* Difference statistically significant at the 5 per cent level

One question only (item no. 69) produced a facility value numerically higher for girls than for boys although the difference is not statistically significant. Nine differences are statistically significant in favour of the boys, that is, the facility values are higher for boys than girls. Two differences between GCE pupils and non-GCE pupils are not statistically significant.

Table 4.5 gives the mean facility values for the Chemistry questions in simplified form in each of the sub-groups of pupils. By and large the pattern of the trends to be observed between sub-groups is similar to the pattern among the items in their original form. Discrepancies are to be found between Ability Groups 2 and 3 for item no. 48; between Social Class Groups 2 and 3 for item nos. 47, 48, 50, 60, 62, 65 and 66 and between the sexes for item nos. 46, 64 and 68 although none of the differences reaches statistical significance.

Of the 200 differences tested for statistical significance in each of Tables 4.4 and 4.5, 70 differences are statistically significant in Table 4.4 and 64 differences are statistically significant in Table 4.5. Table 4.6 shows the differences for each sub-group of pupils between the mean facility value for the simplified version of individual Chemistry questions and the original version. As may be seen the majority of differences are positive, that is, the mean facility values are higher for the simplified versions of questions than the facility values calculated on the questions in their original form. Statistically significant differences are indicated by an asterisk*.

Inspection of Table 4.6 shows that, when statistically significant differences only are taken into account, the items may be placed into the following groups.

(a) No change in facility values: nos. 48, 49, 57, 59, 64, 66 and 67.

(b) Change in the hypothesised direction, that is, simplification leads to a significant rise in facility value: nos. 46, 47, 56, 68, 69. Three items (nos. 51, 62 and 63) show some significant differences but not on the scale of the five other items in this group.

(c) Change in the opposite direction to that hypothesised, that is, such items have higher facility values before 'simplification': nos. 50, 58, 60, 65 and 70.

Thus it may be seen that, of the 20 Chemistry questions which were produced in two versions, alterations to five questions although intended to make the questions easier had the reverse effect. Alterations to the remaining 15 questions either had little effect on facility values or raised them significantly. The Appendix I shows each item in its two forms and includes information on the differences resulting from the simplifications made with particular reference to the data in Table 4.6.

There is clear evidence that, in general, ability to respond correctly to the Chemistry questions is associated strongly with verbal ability since higher verbal ability groups are achieving higher facility values than lower ability groups: this is true for the questions in their original form and when simplified. Similarly higher social class groups achieve higher facility values than lower social class groups. Facility values for boys were generally higher than those for girls; for the majority of questions girls showed greater improvements on the simplified questions than did the boys. As is to be expected, those pupils (the majority) who were intended to be GCE candidates for the 1977 examination were significantly superior to the small number of pupils who were not.

Similar trends to those found in facility values for items as originally written and for revised items appear when the differences between the facility values of items in their two forms are considered (Table 4.6). Two questions, however, appear to run against the general trend. Greater improvements are to be found for nos. 68 and 69 for higher ability groups and higher social class groups than respective lower groups.

4.6 Comparison Between Scottish and JMB Pupils in 1977 Investigation

As stated in the introduction to this chapter, differences were expected in the performance of the two groups, the O level candidates being a more able group than the Scottish O grade candidates.

The five vocabulary items common Test X and Test Y had already been used in the Scottish experiments. Three of the four Chemistry control questions had also been used in Scotland. Table 4.7 shows the facility values obtained in the joint JMB/Glasgow experiment and those obtained in the second Scottish experiment. All the differences in facility values between the JMB/Glasgow figures are statistically significant. Thus it may be seen that except for item no. 44 (which related to the word 'converse') the English pupils showed greater ability than the Scottish pupils. On the common Chemistry questions there is little to choose between the two sets of pupils; only on item no. 52 is there a statistically significant difference.

TABLE 4.7

Comparative performances in common (control) questions.

	Question number	Facility value Joint JMB/Glasgow	Scottish
Vocabulary	41	85	82
	42	86	76
	43	96	88
	44	34	41
	45	86	82
Chemistry (control)	52	71	66
	53	60	66
	54	57	56
Number of pupils		2024	1752

Other Chemistry questions had been used in Scotland as well as in the joint experiment. In item no. 46 the replacement of the word 'pungent' by 'choking' brought about an improvement among the JMB pupils from 96 per cent correct to 99 per cent correct whereas among the Scottish pupils the improvement was from 80 per cent correct to 95 per cent correct.

The results for the question relating to the more technical word 'valency' were interesting. For Scottish pupils in the 1975 exercise the improvement was from 51 per cent correct to 62 per cent correct. For JMB candidates the change made virtually no difference, 61 per cent to 62 per cent correct. Page 24 of the 1969 version of the Scottish syllabus (157) reads "the term 'valency' need not be mentioned", whereas in the 1977 JMB syllabus (158) the word valency is given a paragraph to itself (page 209). In the 1976 Scottish exercise when a similar simple question was used to test 'valency' there was no significant improvement on that occasion perhaps because of a revision in the Scottish syllabus (159). The revision was fairly minor but page 24 now reads "While the word 'valency' should be used in its proper context, no formal definition will be required". The vocabulary of syllabuses has an impact!

Different emphases in the teaching of various points may also explain certain differences in results. This may be true of item no. 59.

In the 1976 Scottish exercise this reduction of 'noise' by recurring words brought about a change from 31 per cent correct to 43 per cent correct whereas in the JMB exercise the original had 34 per cent correct and the simplified 35 per cent correct.

Original Question (X)

59 Which statement is true about the ions $^{8}_{3}Li^{+}$ and $^{8}_{4}Be^{2+}$?

A. They contain the same number of neutrons.

B. Their atoms contain the same number of protons.

C. They will combine with the same number of F^{-} ions.

* D. They contain the same number of electrons.

* Correct option.

Simplified Question (Y)

$^{8}_{3}Li^{+}$ and $^{8}_{4}Be^{2+}$ have the same number of

A. neutrons

B. protons

C. charges

D. electrons

4.7 Discussions and conclusions of 1977 Investigation

Clear evidence has been produced to show that the two main samples of pupils who attempted Test X and Test Y were closely matched on the variables which had been taken into account: verbal ability as measured by test items taken from NFER Test 100, Social Class groupings, sex and -- examination status. Performance in the common Chemistry questions adds to this evidence except that a significant sex difference (which remains unexplained) was found in one question (Table 4.2). Similarly performance in the common vocabulary items were singularly similar.

Analyses have been made of the facility values for 20 Chemistry multiple-choice items in their original form and in a revised but simplified form. It is assumed that because the two groups of pupils were closely matched, differential performances are due to the changes made and not to the characteristics of the pupils. The results for five items ran contrary to the hypothesis and the attempted simplification lead to a decrease in facility values. Seven of the remaining 15 items showed no significant changes; five very clearly showed changes in the anticipated direction and three other items produced changes as expected but to a lower degree.

The nature of the alterations made to the original questions in order to simplify them varied. But with 20 questions, three of which covered two types of change, it is not possible to judge which type(s) of change would be likely to have given the best advantage. On the other hand, only one question (item no. 50) in which a change in the key word had been made, produced a change in the wrong direction.

Pupils in Ability Group 3, consisting of approximately the lower third of pupils in terms of scores in Test 100 made more gains than those in either of the other Ability Groups as a result of the alterations to items although the pattern did not hold for item nos. 68 and 69. Facility values for the girls were, on the whole, lower than those of the boys in both versions of the Chemistry questions. The differences in facility values between boys and girls tended to be reduced as a result of the simplification. The small sub-group of non-GCE pupils found both versions of the Chemistry questions very difficult (except for no.46). Social Class Group 1 pupils produced higher facility levels than either of the other two Social Class sub-groups and tended to make slightly higher gains also.

As has been reported many of the Chemistry items were potential Ordinary Level questions. Two items (nos. 46 and 63) have facility values that are outside the range of values (30-75) usually used in constructing attainment tests. Despite the overall increases in facility values which resulted from the simplification of the items, one other item only (no. 47) falls outside this range of normally accepted values. Thus it seems reasonable to assume that were all items prepared for pre-testing to be produced in a more simplified form than at present there would not be a great increase in the proportion of items found to be unsuitable, by virtue of their high facility values, for possible inclusion in operational examination papers.

The biserial correlation coefficients for two items (nos. 48 and 69) were in the original version lower than is normally expected (0.26 and 0.27 respectively). Both these figures increased as a result of simplification (to 0.30 and 0.42 respectively). The biserial coefficient for item no. 63 fell from 0.35 to 0.26. There is no evidence from this experiment that the discriminatory power of items would be adversely affected by simplification. The internal consistency of Test Y (simplified) was marginally higher at 0.781 than that of Test X (original) at 0.775.

4.8 Design of the test items used in the 1979 Investigation

The test items used in the joint experiment were assembled in much the same way as in the 1977 investigation. It was decided that the alternative forms of the two tests should contain 33 items made up as follows :-

1 Four chemistry items common to both tests to act as control questions.

2 Twenty-nine items on chemistry each having two versions designed to investigate the effects of the following -

(a) the effect of qualifying words (e.g. increasing/decreasing)

(b) the presence of negative expressions (e.g. incorrect, not)

(c) the number of bits of information in the stem

(d) the arrangement of the bits of information in the stem (e.g. embedded clauses)

(e) the presence of pompous expressions (e.g. tendency for covalency to predominate)

(f) the use of the passive voice

Some of these items had already been used in Scottish exercises, but others were specially adapted from items in the JMB chemistry O level item bank.

As in the 1977 exercise it was decided to use the General Ability Test (Appendix E) timed for thirty minutes followed by one of the Chemistry tests (Appendix J) timed for forty minutes, so that the entire testing process, including preparation and a short break, lasted only a little more than one hour and a quarter.

4.9 Organisation and Administration of the 1979 Investigation

This was similar to the 1977 investigation. A total of twenty-two schools accepted the invitation and 1504 pupils sat the tests.

The test materials sent to schools included Instructions to Supervisors (Appendix K). The two forms of the Chemistry test were coded X (printed on pink paper) and Y (printed on yellow paper) and schools were asked to distribute them to pupils alternately, i.e. the first pupil received Test X, the second Test Y, the third Test X and so on. The use of different coloured paper was for convenience so that schools would have no difficulty in distributing the booklets correctly and pupils would have no difficulty in indicating on the answer sheet which test they had attempted.

In addition to completing an answer sheet (Appendix L) each candidate was asked to indicate his/her sex.

4.10 Results of items common to all pupils in 1979 Investigation

As in 1977 it was intended that by using fairly large samples overall, the sub-groups of pupils would themselves be fairly large so that sampling errors would be reduced and that differences noted would be real differences subject to the usual limits of significance. It should be noted that all the questions have been numbered sequentially with the items in the Chemistry tests numbered, for convenience 41-73.

It may be seen from Table 4.8 that the facility values for the individual common items are extremely similar for the two groups of pupils who completed Test X and Test Y. Of the 44 items, 9 have identical facility values; 32 items differ by two per cent or less; and the greatest discrepancy of 4 per cent is between the performance of pupils in items Nos. 18 and 40 (both Verbal Ability items). There is thus clear evidence that the two groups of pupils who took Test X or Test Y may be considered to be very closely matched.

Details of the sub-groups and the numbers of pupils in each are as follows :- (see over)

Verbal Ability	Test X	Test Y
Group 1 : Test Scores (26-40)	246	259
Group 2 : Test Scores (19-25)	254	244
Group 3 : Test Scores (0-18)	247	254
Sex		
Boys	484	503
Girls	263	254

Table 4.9 again demonstrates the similarity of the matching of the sub-groups. Differences in performances between items may be said to be the result of the wording and not to the characteristics of the candidates responding to them.

TABLE 4.8

Facility values in the common questions for the two main groups of pupils. (1979)

Question (Verbal Ability)	Pupils offering Test X	Pupils offering Test Y
1	67	66
2	62	59
3	81	84
4	89	90
5	74	73
6	67	67
7	66	68
8	44	47
9	77	74
10	67	66
11	51	52
12	58	60
13	37	39
14	76	76
15	60	59
16	80	81
17	38	35
18	48	52
19	86	88
20	54	56
21	85	85
22	91	90
23	31	30
24	52	53
25	23	27
26	45	43
27	82	83
28	40	42
29	77	77
30	49	48
31	49	50
32	37	37
33	47	51
34	53	56
35	33	32
36	24	23
37	27	27
38	14	19
39	20	20
40	26	30
Mean facility	54.8	55.5

Control Questions (Chemistry)	Pupils offering Test X	Pupils offering Test Y
41	69	69
42	60	60
43	49	49
48	53	53
Mean facility	57.8	57.8

	Test X	Test Y
Number of pupils	747	757

TABLE 4.9

Facility values for the sub-groups in the common questions (1979)

	Verbal Ability						Sex			
Question	Group 1		Group 2		Group 3		Boys		Girls	
	X	Y	X	Y	X	Y	X	Y	X	Y
41	83	82	71	65	53	58	71	70	65	65
42	78	78	55	56	48	41	61	62	60	52
43	71	70	45	48	32	31	51	53	45	44
48	70	65	52	53	37	42	56	54	47	52
Sample size	246	259	254	244	247	254	484	503	263	254
Estimated difference for 5 per cent significance	8		8		8		7		8	

4.11 Analysis of individual questions in 1979 Investigation

Separate analyses were made of the facility values for the Chemistry questions in their original form and in their simplified form for each of the sub-groups into which the main samples of pupils have been divided. These multiple choice items are numbered 44-47 and 49-73.

Table 4.10 gives the mean facility values for the Chemistry questions in their original form for each sub-group. It may be seen that there is a marked tendency for facility values to fall as one goes from Ability Group 1 to Ability Group 2 to Ability Group 3. Of the 58 differences tested for significance, 46 were found to be statistically significant. Four differences between the facility values for boys and girls are statistically significant in favour of the boys, that is, the facility values are higher for boys than girls.

Table 4.11 gives the mean facility values for the Chemistry questions in simplified form in each of the sub-groups of pupils. In general, the pattern of the trends to be observed between sub-groups is similar to the pattern among the items in their original form. In the Ability Groups, of the 58 differences tested for significance, 45 were found to be statistically significant. Nine differences between the facility values for boys and girls are statistically significant in favour of the boys, that is, the facility values are higher for boys than for girls.

Of the 87 differences tested for statistical significance in each of Tables 4.10 and 4.11, 50 differences are statistically significant in Table 4.10 and 53 are statistically significant in Table 4.11.

Table 4.12 shows the differences for each sub-group of pupils between the mean facility values for the simplified version of individual Chemistry questions and the original version. As may be seen, the majority of differences are positive, that is, the mean facility values are higher for the simplified versions of questions than the facility values calculated on the questions in their original form. Statistically significant differences are indicated*.

TABLE 4.10

(1979) Facility values for Chemistry questions in original form.

Question Number	Ability Group 1	Ability Group 2	Ability Group 3	Boys	Girls	Total Sample
44	42	23*	17	27	28	27
45	64	47*	41	51	49	50
46	78	56*	41*	59	57	58
47	31	23*	22	23	29	24
49	61	48*	38*	51	45	49
50	36	27*	27	35	21*	30
51	65	52*	35*	51	50	50
52	88	76*	54*	74	71	73
53	92	78*	53*	74	75	74
54	84	69*	63	71	74	72
55	79	65*	49*	65	64	64
56	72	54*	34*	56	48*	53
57	85	72*	54*	72	67	70
58	48	35*	30	38	36	37
59	26	23	19	23	21	22
60	86	74*	57*	72	73	73
61	85	70*	51*	68	69	68
62	85	72*	52*	68	72	69
63	83	55*	34*	61	52*	58
64	53	33*	30	40	35	39
65	65	51*	41*	54	50	52
66	58	43*	31*	46	41	44
67	15	13	13	15	11	13
68	81	63*	48*	62	68	64
69	78	54*	36*	56	56	56
70	70	50*	38*	53	52	53
71	74	58*	42*	61	53*	58
72	65	49*	45	53	53	53
73	88	78*	60*	74	79	76
No. of Pupils	246	254	247	484	263	747

The differences between Ability Group 1 and Ability Group 2, between Ability Group 2 and Ability Group 3, and between boys and girls for individual questions have been tested; these marked * are signifiaant at the 5 per cent level.

TABLE 4.11

(1979) Facility values for Chemistry questions in simplified form.

Question Number	Ability Group 1	2	3	Boys	Girls	Total Sample
44	27	27	30	28	28	28
45	65	45*	26*	48	40*	45
46	75	57*	38*	59	52	57
47	33	29	24	29	28	29
49	64	48*	36*	51	47	49
50	36	25*	24	33	20*	28
51	64	52*	40*	53	50	52
52	87	73*	48*	73	62*	69
53	92	86	63*	80	82	81
54	85	75*	63*	76	73	75
55	76	70	59*	68	69	69
56	90	84	62*	83	71*	79
57	83	71*	55*	72	64*	70
58	56	35*	34	44	36*	45
59	21	19	19	20	19	20
60	83	71*	54*	71	66	69
61	77	68*	47*	67	59*	64
62	82	73*	58*	71	72	71
63	70	48*	30*	54	42*	50
64	57	35*	23*	40	37	39
65	71	54*	45*	57	57	57
66	66	40*	38	51	43*	49
67	17	9*	9	14	7	12
68	86	76*	57*	72	75	73
69	69	53*	30*	54	49	52
70	77	68*	46*	63	65	64
71	75	54*	35*	58	48	55
72	67	54*	39*	54	53	54
73	86	82	67*	79	76	78
Number of Pupils	259	244	254	503	254	757

The differences between Ability Group 1 and Ability Group 2, between Ability Group 2 and Ability Group 3, and between boys and girls for individual questions have been tested; these marked * are significant at the 5 per cent level.

TABLE 4.12

(1979) Differences in facility values between simplified and original forms of chemistry question.

Question Number	Ability Group 1	Ability Group 2	Ability Group 3	Boys	Girls	Total Sample
44	-15*	+ 4	+13*	+ 1	0	+ 1
45	+ 1	- 2	-15*	- 3	- 9*	- 5*
46	- 3	+ 1	- 3	0	- 5	- 1
47	+ 2	+ 6	+ 2	+ 6	- 1	+ 5*
49	+ 3	0	- 2	0	+ 2	0
50	0	- 2	- 3	- 2	- 1	- 2
51	- 1	0	+ 5	+ 2	0	+ 2
52	- 1	- 3	- 6	- 1	- 9*	- 4
53	0	+ 8*	+10*	+ 6	+ 7	+ 7*
54	+ 1	+ 6	0	+ 5	- 1	+ 3
55	- 3	+ 5	+10*	+ 3	+ 5	+ 5*
56	+18*	+30*	+28*	+27*	+23*	+26*
57	- 2	- 1	+ 1	0	- 3	0
58	+ 8*	0	+ 4	+ 6	0	+ 8*
59	- 5	+ 4	0	- 3	- 2	- 2
60	- 3	- 3	- 3	- 1	± 7	- 4
61	- 8*	- 2	- 4	- 1	-10*	- 4
62	- 3	+ 1	+ 6	+ 3	0	- 2
63	-13*	- 7	- 4	- 7*	-10*	- 8*
64	+ 4	+ 2	- 7	0	+ 2	0
65	+ 6	+ 3	+ 4	+ 3	+ 7	+ 5*
66	+ 8*	- 3	+ 7	+ 5	+ 2	+ 5*
67	+ 2	- 4	- 4	- 1	- 4	- 1
68	+ 5	+13*	+ 9*	+10*	- 7	+ 9*
69	- 9*	+ 4	- 6	- 2	- 7	- 4
70	+ 7	+18*	+ 8*	+10*	+13*	+11*
71	+ 1	- 4	- 7	- 3	- 5	- 3
72	+ 2	+ 5	- 6	+ 1	0	+ 1
73	- 2	+ 4	+ 7	+ 5	- 3	+ 2

* Differences statistically significant at the 5 per cent level.

Inspection of Table 4.12 shows that, when statistically significant differences only are taken into account, the items may be placed into the following groups:-

(a) No change in facility values : Nos. 46, 49, 50, 51, 54, 57, 59, 60, 62, 64, 67, 71, 72, 73.

(b) Change in the hypothesised direction, that is, simplification leads to a significant rise in facility value: Nos. 44, 47, 63, 55, 56, 58, 65, 66, 68, 70.

(c) Change in the opposite direction to that hypothesised, that is, the attempted simplification makes the question harder : Nos. 44, 45, 52, 61, 63, 69.

The Appendix M shows each item in its two forms and includes information on the differences resulting from the simplifications made with particular reference to the data in Table 4.12.

4.12 Discussion and Conclusions

Clear evidence has been produced in both the 1977 and 1979 exercises to show that the two main samples of pupils who attempted Test X and Test Y were closely matched on the variables which had been taken into account.

Analysis have been made of the facility values for all the Chemistry multiple choice items in their original form and in a revised simplified form. It is assumed that because the two groups of pupils were closely matched, differential performances are due to the changes made to the question and not to the characteristics of the pupils.

Bearing in mind the hypothesis for this chapter in general on both the 1977 and 1979 exercises -

(i) there was clear evidence that ability to respond correctly to the Chemistry questions is associated strongly with verbal ability since higher verbal ability groups achieve higher facility values than the lower groups: this is true for the questions in their original form and when simplified.

(ii) simplification of items materially helped the less able as well as the girls without impairing the general efficiency of the test as a measuring instrument.

(iii) from the 1977 exercise higher social class groups achieve higher facility values in chemistry questions than lower social class groups.

The effect of the alterations made to the original questions in order to simplify them are discussed in detail in Appendix I and Appendix M and conclusions drawn are necessarily tentative.

Performance in multiple choice chemistry questions seems to be influenced by :

(1) Words :

If a non-technical word that needs to be understood to answer the question is replaced by a word that is more easily understood then there is an improvement in performance (1977: 46, 47, 51 and 1979: 56, 58, 68). If any word is capable of being misinterpreted then this influences performance (1977:69).

(2) Negatives :

If a negative expression is removed, there can be an improvement in performance. (1977: 56 and 1979: 70, 44).

(3) Bits of Information :

If extraneous bits of information are removed performance improves (1977: 62, 63 and 1979: 55, 53) but if bits of information are removed to such an extent that the question becomes more abstract then performance deteriorates (1977:60). If the bits of information are arranged in simple sentences instead of longer sentences with embedded clauses, then performance improves (1979: 65, 47). If the item consists of information and a question, performance seems to be improved by not separating the question from the responses by the insertion of information (1979: 66, 65).

On the other hand the removal of certain words that were considered to be pompous had little effect (1979: 59, 60, 62, 73). This is unlike the Scottish experiment and may reflect on the greater ability of the JMB candidates. Changing questions from passive voice to active voice also had little effect (1979: 46, 49, 50). The balance between precise formal language and difficult pompous language is delicate as is the balance between simple accurate language and brief compressed language. But why do some changes in the language of a question influence performance and other changes have no influence?

A possible interpretation may lie not in the superficial change of the question but in the possible influence of the change on the thinking necessary to solve the problem. If the change either reduces the number of thinking stages ((2) & (3) above) or makes the thinking easier ((1) & (3) above) then performance is improved - if on the other hand the change does not influence the thinking then there is no influence on performance.

These conclusions are in essence the same as the conclusions for the Scottish exercise (section 3.6) and this suggests that the observed changes in performance do not arise out of regional factors, such as dialect or school organisation. The similarity in the findings may give some support to the idea that the factor that is affecting performance in multiple choice questions is the influence of language on the internal processing or thinking necessary to answer the question.

CHAPTER 5

The Chemical Society Experiment

The Understanding of Non-technical Words in Science

5.1 Introduction

This investigation is an expansion of one of the areas touched upon in both Chapters 3 and 4, namely the understanding of non-technical words in science. In education the principal means of communication is by words; words spoken and written. Whether the teaching is didactic or discursive teachers' use and pupils understanding of words is of prime importance. In the previous two chapters there are a number of examples of the influence of pupil understanding of words on their performance in matched multiple choice questions. Here are some examples.

(a) Replacing words in key positions improves performance :
'least stable' replaced by 'easiest to break down' (Table 3.4)
'pungent' replaced by 'choking' (Appendix I No. 46)

(b) Changing possible pompous non-technical terms improves performance 'tendency to predominate', 'distinguish visually' (Table 3.5) 'fused', 'appreciable electrical conductivity' (Appendix M No. 58, 68).

(c) Expressions of quantity or order influencing performance 'most abundant', 'least abundant' (Table 3.8) 'increasing', 'decreasing' (Appendix M No. 56).

Thus even in matched multiple choice questions investigations (160)(161) show that scores in these questions can be improved by minor, often one word changes. In individual questions two of the types used in chapters 3 and 4 indicate the importance of words.

(a) The disparity between author and pupil choice of appropriate vocabulary 'encountered', 'come across', 'effervescence', 'bubbles' (Table 3.16 s 3.17)

(b) The understanding of certain non-technical words (Tables 4.1, 4.3, 3.14).

The latter questions are based on work done by Gardner (12) in the early seventies as part of the Australian Science Education project.

He found that many words beloved of science teachers were just not accessible to their pupils. The project included the testing of 599 words. The words are amongst the 20,000 most frequently encountered words of English listed in Section 1 of Thorndyke and Lorge (155). All the words had survived a four-phase selection, rating, discussion, and re-rating procedure involving science teachers and educational researchers and are rated as essential or valuable for school science pupils. The words are deemed to be non-technical words and did not include physical concepts (e.g. force), names of chemicals, processes, apparatus etc. The words were tested in multiple choice test items of various kinds (Appendix N). In general the distractors required a low level of discrimination. Over 7,000 pupils in 270 classes in 39 different schools contributed data and the results were published in 1972 (142).

At the Education Division conference 'Research for the Classroom and Beyond' at Loughborough in July 1977, it was proposed that the Chemical Society should conduct a similar investigation in Britain but with a major modification. Gardner's findings were based on the results of only one question testing each word and from my findings with matched multiple choice questions it seemed to me that the meaning of a word was dependant on its context. It was the relationship between words which gave words meaning, and this did not seem to be accounted for by the one question technique of Gardner. In addition his approach did not reflect on the apparently sensible ideas discussed previously (Section 1.5) for example :

(a) Vygotsky (82) who reported that there seemed to be degrees of understanding of a word and as one became more familiar with a word there was a narrowing of the range of meaning from a generalised meaning to a more specific meaning

(b) Luria (81) who used the expression 'multi-dimensional matrix of connections between words' in our own vocabulary, implying that our understanding of words depends on our understanding of other words.

It was for these reasons that in the Chemical Society experiment it was proposed to try to test each of Gardner's 599 words by several questions. It would require the active involvement of many teachers in secondary and tertiary centres not just receiving multiple choice questions and administering tests but also preparing questions to test word knowledge and then returning results for processing. The proposal was accepted and notices inviting interested people to participate appeared in various Chemical Society publications (162)(163)(164)(165).

The Scottish Experiment and JMB Experiment, described in Chapters 3 and 4 respectively are fairly precise experiments involving selected schools, designed questions, using common control questions, and adopting procedures to try to achieve matched samples. This Experiment, by involving other volunteer people in preparing questions and administering tests, lacks this type of precision. It is a kind of field research, not contrived, and perhaps close to reality because it is based on responses of real pupils to both good and bad questions designed by real teachers and as reported in Section 2.4 it did generate a considerable amount of interest in the large number of establishments involved in the experiment.

The hypotheses that are to be considered in this chapter are as follows :

(a) Gardiner's findings are in the main applicable to Britain.

(b) The meaning of a word is not absolute but may vary from a general meaning to a more precise meaning.

(c) A combination of words may result in an expression with a difficult meaning.

(d) The meaning of a word depends on its connotation and its context.

(e) A word in a scientific context is harder to understand than the same word in a non-scientific context.

As in the Scottish and JMB Experiments it is hoped that these hypotheses may lead to a clearer understanding of the influence of language on the internal thinking process.

5.2 The 1977-78 Investigation

5.3 Administration

In the schools exercise interested participants were given (a) approximately 24 words with questions from the Australian exercise, (b) approximately 24 words for which participants had to design their own questions, (c) instructions for administering the test and completing the response sheets. There were twenty-six tests. It was hoped to end up with about 500 words tested in several question matrices on the whole age range of secondary school and over a wide distribution of places in the U.K.

In the tertiary exercise participants were given questions for the 51 words (see Appendix O) which had proved the most difficult in Gardner's survey and some instructions for administering the test and returning the data.

The school exercise included some sixty schools and approximately 15,000 pupils. The tertiary exercise included 12 establishments and 800 students.

5.4 Results and Discussion

(a) Tertiary Exercise

Although the mean facility values for all groups (Table 5.1) are high, it must be remembered that the questions are designed to be easy and the tertiary students should be our most able citizens. A figure of 80% means that one student in five does not understand that word in that question and Tables 5.2, 5.3 and 5.4 indicate from the original fifty-one words (see Appendix O) those which may cause problems for certain students.

The results also give a possible indication of the added difficulties facing students who have English as a second language.

TABLE 5.1

Mean Facility Values for Tertiary Groups

	No. in Sample	Facility Values
University Students : English first language	(131)	91
" " : English second language	(11)	84
Technical College Students : English first language	(65)	90
" " " : English second language	(31)	80
Teachers in Training in Great Britain	(287)	89
Teachers in Training in West Indies	(55)	81

TABLE 5.2

University Students

Words which fewer than 80% of students got correct

(A) English First Language (% correct)

average	78	criteria	51	
converse	13	postulate	26	(5)
valid	63			

(B) English Second Language (% correct)

average	63	rate	72	
converse	18	spontaneous	72	
convert	72	valid	54	
efficient	72	criteria	72	
illustrate	72	postulate	36	(10)

TABLE 5.3

Technical College Students

Words which fewer than 80% of students got correct

(A) English First Language (% correct)

average	69	propagate	78	criteria	58	
converse	13	valid	41	postulate	38	(6)

(B) English Second Language (% correct)

associate	74	diversity	74	rate	77	hypothesis	64
average	77	effect	77	relevant	77	postulate	16
concept	70	efficient	61	simultaneous	77	substitute	77
contrast	70	factor	67	spontaneous	64	symmetrical	64
converge	74	illustrate	74	standard	64	theory	25
converse	41	incident	74	stimulate	77		
correspond	54	logic	77	valid	64		
disintegrate	67	probability	70	criteria	45		

(29)

TABLE 5.4

Teachers in Training

Words which fewer than 80% of students got correct

(A) In Great Britain (% correct)

average	76	criteria	74	incident	69	theory	77
converse	14	postulate	19	propagate	79	valid	58

(B) In West Indies (% correct)

average	72	factor	78	simultaneous	78
contrast	78	illustrate	78	spontaneous	65
converse	47	incident	63	valid	27
correspond	79	neglible	79	criteria	67
diversity	69	probability	56	postulate	21
effect	70	propagate	72	symmetrical	79
efficient	78	rate	74	theory	50

(21)

TABLE 5.5

Number of pupils taking each original test.

Test	Year 1	2	3	4	5	6	7
1	151	198	290	254	94	113	10
2		256	103	90	108	28	
3	121	287	303	164	132	37	25
4							
5	165	160	217	187	96	69	76
6	29	73	155	98			
7		59	173	36	44		
8	195	282	250	219	56	30	10
9	25	77	221	95	80	13	
10	53	55	71	42	13	7	
11	87	224	286	123	15	24	
12	371	389	209	180	53		
13				35			
14	153	159	82	88	39	3	
15		98	269	273	77	73	12
16	74	71	140	78		5	
17	160	246	196	126		12	
18	249	193	195	59		5	
19	186	150	129	66			
20			148	116	17	5	
21		78	82	69	58	45	
22		54	138	98	18	3	
23	107	145	237	59	107	8	
24	93	125	84	35			
25		42	131	77	75	14	11
26	31	79					
Total	2250	3500	4160	2667	1082	494	144

TOTAL: 14,297

Table 5.5 gives an indication of the large administrative problem. Some words were not tested by all the age range, some words were not tested at all, and some tests were conducted on one age group only. There would be difficulties in comparing British results with Australian results because if one school only was included in a test it may not have been typical of British schools. However, when tests involving large numbers of pupils in more than one school were considered, the British findings were similar to the Australian findings.

Table 5.6 shows a section of the results from Test 12, in which the British results are compared to the Australian results. The percentages correct are similar and P.L. Gardner's findings (see Appendix P) in the main may well be applicable to the British situation.

It is possible to pick out, within the administrative limitations, those words which cause pupils difficulty.

Tables 5.7 - 5.10 contain a large number of words, many of which we probably (erroneously) assume the pupil understands.

TABLE 5.6

Comparison: Australian and British Results

Word	Year 1	2	3	4	
Invert	88	90	95	93	Australian) Results
	91	94	97	100	British)
Instant	91	93	94	95	
	93	96	97	98	
Instantaneous	77	84	92	96	
	80	88	87	98	
Instrument	88	88	94	94	
	86	88	93	96	
Intake	71	82	85	92	
	75	78	87	97	
Intelligence	89	89	91	94	
	84	91	96	95	
Interfere	91	93	95	94	
	88	90	95	98	
Internal	79	86	93	94	
	77	82	91	97	
Interpret	56	67	77	83	
	55	61	79	91	

All figures are percentage correct.

TABLE 5.7

First Form List

Words which fewer than 70% of First Form pupils got correct.

abundant	diagnose	illustrate	positive	textbook
accumulate	diameter	incident	preparation	transform
action	disintegrate	incline	primitive	
adjacent	disperse	initial	probability	
adjust	displace	interpret	propagate	
agriculture	distinct	invert	proportion	
algebra	distribute	involuntary	random	
alternate	diversity	latitude	rate	
analysis	dominant	layer	recoil	
angle	effect	leaf	reference	
arid	efficient	leak	reflect	
ascend	enable	liberate	regulate	
audible	equivalent	limit	relative	
average	erect	linear	retard	
column	error	logic	revise	
complex	essential	lubricate	row	
composition	estimate	magnitude	section	
concept	evacuate	majority	simultaneous	
conception	exact	modify	spontaneous	
conical	exception	negative	stagnant	
constituent	excess	negligble	standard	
consume	excite	neutral	stimulate	
continent	exclude	omit	submerge	
contrast	exert	outline	substitute	
convection	external	partial	suckle	
converse	factor	percentage	summary	
correspond	film	permanent	switch	
crude	fog	perpendicular	symbol	
descendant	fundamental	phenomenon	system	
devise	generate	plot	tabulate	

(122)

TABLE 5.8

Second Form List

Words which fewer than 70% of Second Form pupils got correct.

abundant	disperse	liberate	reflect	
action	displace	limit	regulate	
arid	distribute	linear	revise	
ascend	diversity	logic	row	
audible	dominant	lubricate	section	
average	external	magnitude	simultaneous	
complex	factor	negative	spontaneous	
concept	film	negligible	stagnant	
conception	fog	neutral	standard	
constituent	fundamental	omit	stimulate	
continent	incident	outline	substitute	
contrast	incline	partial	tabulate	
convention	initial	percentage	transform	
converse	interpret	phenomenon		
correspond	invert	positive		
descendant	involuntary	probability		
devise	latitude	propagate		
diagnose	layer	random		(73)
diameter	leaf	rate		
disintegrate	leak	recoil		

TABLE 5.9

Third Form List

Words which fewer than 70% of Third Form pupils got correct.

audible	external	magnitude	standard	
average	factor	negative	stimulate	
concept	film	negligible	substitute	
conception	fundamental	omit	tabulate	
constituent	incline	propagate		
continent	invert	random		
convention	latitude	rate		
converse	layer	recoil		
correspond	leaf	regulate		
descendant	leak	revise		
diagnose	liberate	row		
disintegrate	limit	section		(49)
displace	linear	simultaneous		
distribute	logic	spontaneous		
diversity	lubricate	stagnant		

TABLE 5.10

Words which fewer than 70% of Fourth Form pupils got correct

converse
correspond
disintegrate
diversity
factor
latitude
layer
leaf
liberate
limit
linear
logic
lubricate
omit
rate
simultaneous
spontaneous
standard

(c) The Questions

One of the ideas behind the Chemical Society exercise was to involve people in designing their own questions to check word understanding. There may be difficulty in trying to put a precise percentage on the level of understanding of a word because the question itself may have an influence on the percentage correct.

Which words cause pupils difficulty irrespective of the question used? From the data received it was not easy to find examples of this. The three questions testing "fundamental" were one of the few examples. Even restricting the search to tests which involved large groups of pupils it was easier to find examples where the difficulty level altered because of the influence of connotation or context.

FUNDAMENTAL

Some students were studying the fundamental laws of physics

A. old

B. modern and newly discovered

C. difficult and hard to understand

D. easily explained

E. most important

	Form 1-2	Form 3-4
Number of pupils	108	113
Percentage correct	58	74

Iron is Fundamental to life:

A. iron can kill living things

B. iron stops living things from growing

C. all living things must have iron

D. life is difficult without iron

	Form 1-2	Form 3-4
Number of pupils	51	232
Percentage correct	49	65

The Fundamental property of a knife is that it:

A. is made of metal

B. is longer than a fork

C. can cut things

D. has a pointed end and a handle

	Form 1-2	Form 3-4
Number of pupils	51	84
Percentage correct	60	61

(i) Connotations

One word often has a number of connotations and it would be wrong to assume because a word is understood in one situation then it will be equally well understood in other situations. Consider the following examples based on the words "index", and "reverse" where large changes in the percentage correct have been found.

Index

Here is part of a science book:

This is called:

A. a text

B. a title

C. a dictionary

D. an index

E. the page numbers

Absorption, 221
Acids, 257
Action & Reaction, 84
Adaptive Features, 38
Adhesion, 94
Air, 151-154
Alkalis, 258
Anaerobic Respiration, 135
Animal Identification, 30
Ascent, of water, 62
Atomic Number, 62

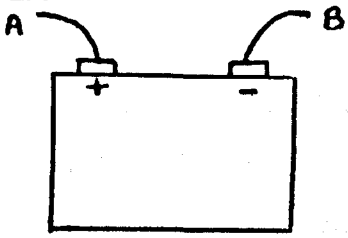
Bacteria, 223
Bases, 258
Berlese Funnel, 34

	Form 1-2	Form 3-4
Number of pupils	311	359
Percentage correct	90	93

Which of these is the Index finger?

	Form 1-2	Form 3-4
Number of pupils	108	112
Percentage correct	58	68

Reverse



	Form 1-2	Form 3-4
Number of pupils	126	110
Percentage correct	51	78

When a battery, as in the diagram, has its connections Reversed, you have to:

A. remove A from the + side and B from the - side
B. join B to the + side and A to the - side
C. join A to B
D. join + to -

When you reverse a car, you:

A. go in a circle
B. go faster
C. slow down and come to a stop
D. go backwards

	Form 1-2	Form 3-4
Number of pupils	336	193
Percentage correct	90	91

(ii) <u>Context/Precision</u>

From the data received, questions designed to test the same word with the same meaning produced different results. Part of the reason for this was the context in which the word was used related to the degree of discrimination or precision required of the pupil. Consider the following examples.

<u>Naked</u>

The lady was <u>naked</u>.

She:-

A. had no clothes on
B. was beautiful
C. was not clever
D. had only a few clothes
E. was absent

	Form 1-2	Form 3-4
Number of pupils	59	60
Percentage correct	95	100

A candle usually has a <u>naked</u> flame.

A. very weak
B. not covered
C. orange-coloured
D. slow burning

	Form 1-2	Form 3-4
Number of pupils	98	541
Percentage correct	75	78

<u>Law</u>

Lay down the <u>law</u> means:-

A. discuss
B. put the piece of paper down
C. argue
D. give orders

	Form 1-2	Form 3-4
Number of pupils	392	131
Percentage correct	74	80

Scientific <u>laws</u> are:-

A. laboratory rules
B. acts of Parliament
C. instructions on how to write up an experiment
D. facts we have learnt from experiments

	Form 1-2	Form 3-4
Number of pupils	221	161
Percentage correct	39	72

Standard

In England there is a metal bar which is called 1 yard long. All other 1 yard rulers in the world are supposed to be exactly equal to this length. The metal bar in England is:-

			Form 1-2	Form 3-4
A.	a factor of length			
B.	an estimate of length			
C.	a duplication of length	Number of pupils	51	246
D.	a standard of length	Percentage correct	48	60

A can of juice must contain at least 350 ml of liquid. Which can is not up to standard?

			Form 1-2	Form 3-4
A.	which contains 348 ml			
B.	which contains 350 ml			
C.	which contains 352 ml	Number of pupils	29	62
D.	which contains 363 ml	Percentage correct	90	93

Argument

A man is having an argument with his wife over which TV programme they should watch.
They had a:-

			Form 1-2	Form 3-4
A.	friendly chat			
B.	difference of ideas			
C.	quick check	Number of pupils	143	149
D.	long talk	Percentage correct	84	92

John explained his views by careful argument
He:-

			Form 1-2	Form 3-4
A.	shouted			
B.	provided evidence			
C.	made measurements	Number of pupils	201	106
D.	became annoyed	Percentage correct	50	59

5.5 The 1978-79 Investigation

In the light of the experience gained in the first year of the experiment, it was decided in the second year to test the most difficult words from the first year, in as many different situations as possible.

5.6 Administration

The 160 most difficult words from the first year of the investigation were divided into four tests each of 40 words and groups of teachers were invited (165) to prepare questions for these words and to test them with as many pupils as possible. There was an obvious advantage in organising this operation on an area basis so that a college with its "satellite" schools could share the burden of question writing and could organise even coverage of all age groups.

Interested participants were given in addition to a word list :

(a) an instruction sheet (Appendix Q)

(b) examples of types of questions (Appendix N)

(c) instructions for completing the response sheets (Appendix R)

Results were received from twenty-five working groups and included over 10,000 pupils.

5.7 Results and Discussion

The following tables, one for each test, list the scores (% correct) obtained from each participating group; they also show the mean of these scores; and the range of scores for each word.

The results are from Third Form pupils. These were chosen as a 'middle cut' in the whole population to reduce the length and complexity of this chapter.

TABLE 5.11

Test 1

Word	Percentage correct	Mean	Range
abundant	34, 57, 82, 83, 100	71	66
adjust	71, 74, 82, 91, 100	83	29
annual	66, 84, 91, 100	85	34
average	68, 70, 90, 100, 100, 100	88	32
capable	77, 77, 98, 98	87	21
classify	66, 66, 84, 100	79	34
complex	27, 57, 75, 88	61	61
conception	36, 65, 66	55	30
constituent	64, 70, 80	71	16
contrast	13, 77, 77, 91	64	64
converse	24, 42, 63, 74	50	50
crude	48, 64, 85, 86	70	38
descendant	67, 69, 86, 90, 92	80	25
disintegrate	22, 40, 40, 63, 85	50	63
diversity	33, 60, 78, 79, 98	69	65
emit	21, 47, 58, 58, 59, 79	53	58
estimate	66, 82, 83, 86, 91, 94	83	28
excite	65, 85, 89, 91, 95	85	30
external	44, 61, 84, 88, 94	74	50
film	70, 70, 85, 95, 98	83	28
grain	38, 89, 91, 95	78	57
illustrate	47, 54, 83, 86, 92	72	45
initial	42, 60, 72, 72, 87, 96	71	54
isolate	64, 74, 80, 82, 84, 91, 98	81	34
lubricate	51, 57, 75, 79, 84, 85, 96	75	45
maximum	55, 79, 80, 96	77	41
naked	72, 85, 90, 95, 97	87	25
obvious	71, 80, 81, 96, 100	85	29
percentage	56, 75, 86, 89, 94	80	38
plot	69, 75, 85, 88, 100, 100	86	31
probability	54, 60, 82, 93, 100, 100	81	46
random	45, 65, 72, 79, 81, 93	72	48
reflect	76, 77, 82, 93, 96, 100	87	24
repel	49, 74, 91, 96, 96	81	47
row	44, 65, 66, 68, 91	66	47
sequence	66, 70, 74, 100	77	34
stagnant	51, 66, 67, 72, 78	66	27
suspend	44, 54, 85, 87, 100	74	56
tabulate	30, 31, 41, 71, 79, 86	56	56
treatment	75, 83, 86	81	11

TABLE 5.12

Test 2

Word	Percentage correct	Mean	Range
action	78, 93, 95, 96, 98	92	20
alternate	65, 77, 80, 93, 97	82	32
appropriate	51, 91, 94, 98, 98, 100	88	49
associate	76, 83, 92, 95, 96, 96	89	20
characteristic	39, 61, 75, 75, 100	70	61
component	33, 63, 88, 89	68	56
consecutive	71, 77, 80, 80	77	9
continent	15, 63, 87, 99	66	84
convention	47, 52, 58, 68, 73	59	26
crest	45, 67, 70, 87, 94	72	49
deflect	84, 85, 88, 91, 92, 94	89	10
device	41, 75, 82, 86, 92, 94	78	53
diagnose	45, 68, 84, 91, 92, 93	78	48
displace	26, 35, 48, 67, 77, 89	57	63
effect	28, 77, 80, 87, 87, 92	75	64
erect	56, 63, 73, 79, 88, 94	75	38
exact	57, 85, 89, 91, 93, 95, 96	86	39
exert	47, 60, 63, 69, 73, 85, 90	69	43
fundamental	17, 59, 61, 66, 76	55	59
impact	47, 60, 69, 97	68	50
incline	8, 31, 69, 73, 78	51	70
limit	54, 73, 73, 86, 89, 91	77	37
linear	32, 37, 44, 69, 75, 79, 81	59	49
modify	66, 70, 76, 81, 85	75	19
negligible	20, 25, 27, 42, 54, 66	39	46
outline	78, 81, 83, 89, 95	85	17
perpendicular	36, 52, 70, 73, 75	61	39
previous	66, 71, 89, 90, 93, 96, 100	86	34
propagate	16, 41, 47, 50, 50, 59, 81	49	65
recoil	16, 40, 53, 61, 62, 96	54	80
relative	24, 74, 81, 83, 96	71	72
retard	9, 34, 50, 72, 83, 87	55	78
sense	71, 73, 92, 94, 94, 98	87	27
source	55, 63, 67, 85	67	30
standard	41, 55, 91, 94	70	53
submerge	48, 75, 86, 86, 100	79	52
symmetrical	36, 44, 56, 74, 79, 100	64	64
theory	52, 71, 73, 76, 85	71	33
vital	88, 91, 91, 100	92	12

TABLE 5.13

Test 3

Word	Percentage correct	Mean	Range
ability	89, 96, 100, 100	96	11
adjacent	77, 85, 89, 97	87	20
analysis	82, 88, 100, 100	92	18
audible	52, 55, 55, 76, 78, 100	69	48
calculate	85, 93, 93	90	8
column	67, 77, 78	74	11
concept	54, 61	57	7
consistent	65, 86	75	21
contract	17, 74, 85	58	68
converge	59, 68, 92, 93	78	34
criticise	40, 60, 90, 92	70	52
degree	59, 88, 96	81	37
diameter	74, 75, 88, 93	82	19
distinct	69, 78, 93, 98, 98	87	29
efficient	55, 58, 80, 85, 89, 89	76	34
essential	67, 75, 81, 91, 95	81	28
excess	29, 61, 77, 86, 95	69	66
expose	63, 90, 91, 100, 100	88	37
factor	32, 70, 80, 84, 100	73	68
function	73, 83, 98	84	25
generate	69, 72, 77, 96	78	27
illuminate	76, 79, 92, 96	85	20
influence	47, 86, 96	76	49
involuntary	42, 62, 81, 88, 93	73	51
magnitude	32, 47, 71	50	39
minimum	79, 81, 85, 100	84	27
negative	61, 77, 84, 97	79	36
omit	42, 52, 88, 92, 93	73	51
permanent	84, 88, 89, 96	89	12
preparation	60, 72, 85, 93, 96, 100	84	40
process	60, 88, 91, 93, 100, 100	88	40
rate	47, 65, 75, 95, 100	76	53
regulate	64, 79, 79, 93, 96	82	32
residue	60, 68, 77, 83, 86	74	26
section	66, 79, 93, 96, 98	86	32
simultaneous	42, 57, 84	61	42
stain	79, 95, 100	91	21
symbol	83, 90, 94, 96, 100	92	17
temporary	65, 88, 95, 99, 100	89	35
uniform	77, 85, 93	85	16

TABLE 5.14

Test 4

Word	Percentage correct	Mean	Range
accumulate	60, 72, 90, 100	80	40
agent	56, 86, 87, 96, 96	84	50
aperture	42, 43, 57, 85, 90	63	48
arid	30, 33, 51, 60, 71, 72, 98	59	68
coincide	38, 56, 67, 69, 100	66	62
composition	72, 76, 86, 95	82	23
conical	74, 75, 75, 86	77	12
consume	77, 77, 87, 91	83	14
contribute	87, 88, 90, 90, 96	90	9
correspond	31, 76, 84, 85, 89	73	68
decay	82, 85, 88, 92, 93, 94, 100	90	18
detect	46, 72, 75, 89, 93, 98, 100	81	54
devise	66, 71, 78, 86, 89, 97	81	3-
disperse	55, 75, 76, 79, 93, 94	78	39
dominant	57, 68, 71, 80, 84, 99	76	42
enable	69, 69, 70, 80, 80, 82, 98	78	29
evacuate	16, 54, 63, 80, 95, 95, 96	71	80
exclude	26, 81, 85, 88, 91, 92, 94	79	68
fog	77, 77, 77, 91, 94, 100	86	23
immerse	46, 48, 63, 78, 96	66	50
incident	23, 71, 81, 91, 94	72	71
interpret	53, 79, 88, 89	77	36
liberate	19, 37, 56, 67, 68, 71, 82	57	63
logic	63, 72, 73, 74, 90, 96	78	33
multiple	61, 80, 81, 85, 90, 97	82	36
neutral	76, 77, 79, 80, 87, 97	82	21
partial	68, 71, 85, 85, 87, 88	80	20
phenomenon	39, 64, 65, 69, 85, 86	68	57
primary	50, 60, 74, 86, 92, 100, 100	80	50
proportion	68, 75, 85, 85, 86, 91, 98	84	30
reférence	71, 72, 75, 75, 86, 88, 96	80	25
relevant	43, 61, 75, 84, 85, 87, 95	75	52
revise	9, 48, 66, 70, 88, 94	62	85
sensitive	49, 87, 90, 92, 92, 98	84	49
spontaneous	15, 42, 59, 61, 70	49	55
stimulate	37, 48, 54, 76, 92	61	55
substitute	42, 49, 86, 88, 91, 93	74	51
system	52, 69, 81, 90, 91, 93	79	41
thrust	59, 64, 77, 81, 85, 92	76	33
valid	42, 63, 76, 77, 88	69	46

TABLE 5.15

Range of Scores

Different Range (%)	Number of words in this category
0 - 10	5
11 - 20	19
21 - 30	29
31 - 40	33
41 - 50	28
51 - 60	19
61 - 70	20
71 - 80	5
81 - 90	2
91 - 100	0
0 - 100	160

The variation in the scores for each word in a test includes results from the first year of the exercise (i.e. every question designed to test a particular word has been included.)

The most striking feature of these four tables is the magnitude of the range of the scores for most of the words; very few of them having a range as small as ten per cent or less (see Table 5.15).

What reasons could there be for some of these large ranges of scores for questions testing the same word?

The possibility of factor analysis (166) on the possible variables in a question was considered but with the difficulty in deciding the factors that may be operating in any one question, it was decided that a more fruitful approach may be to consider each factor in turn and then look at questions in which each factor may be operating.

Three factors were considered :

1 Variation between the school populations tested

2 Type of question used (see Appendix N)

3 Difficulty of the question (i.e. the number of thinking stages and the degree of complexity of each stage in the question).

1 Type of School Population

In the 1978 exercise certain schools used identical questions and when small samples of fewer than thirty pupils were used gross differences sometimes appeared. When samples tested were larger the differences tended to be smaller. Three examples are shown in Table 5.16 where identical questions are tested on large samples from different schools.

TABLE 5.16

Identical Questions

Basic. Which is a basic thing that people do?

A. playing

B. eating

C. reading

D. swimming

E. seeing a film

		Form 1	2	3	4
School R	Sample size	167	183	79	74
	% correct	92	94	94	97
School S	Sample size	121	120	120	85
	% correct	96	100	100	100

Inhabited. The people inhabited the forest. They

A. lived there

B. hunted there sometimes

C. made it a habit to visit there

D. left the forest and went somewhere else

		Form 1	2	3	4
School P	Sample size	90	131	70	90
	% correct	88	89	94	98
School Q	Sample size	223	206	95	42
	% correct	88	96	96	98

Invert. The scientist inverted the beaker. He

A. looked inside it

B. drew a picture of it

C. turned it upside down

D. made it

E. put it inside something else

		Form 1	2	3	4
School T	Sample size	90	131	70	90
	% correct	40	53	68	76
School V	Sample size	223	206	95	42
	% correct	41	55	60	74

In the 1979 exercise although there were no questions which were identical, the word 'conical' in Test 4 was tested in a similar way. The four independently designed versions of the question are shown, together with the scores for third form pupils, in Table 5.17. The range is again not large.

If the school population was the major factor in causing the gross range of scores, then it could be a reasonable expectation that the results from a particular school would generally be poorer than those of another 'better' school.

In Table 5.18 the results from the third form of four different schools involved in Test 2 are listed. Although for each word there are some gross variations in the scores, it is not always the same school that has the lowest scores nor the same school with the highest scores. School L has the highest average score but in five out of the 24 words it has the lowest score. School M has the lowest average score but in seven out of the 24 words it has the highest score.

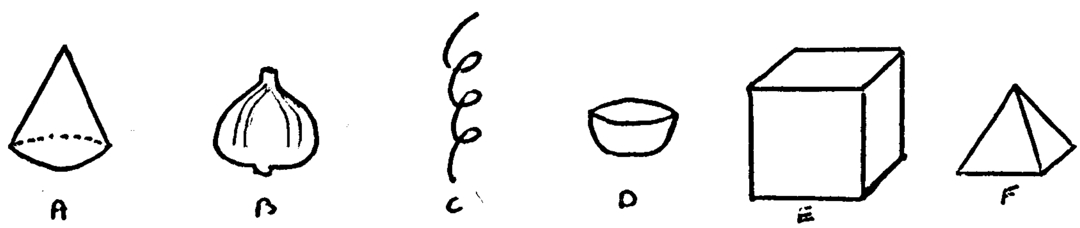
From the information from identical questions, similar questions, and a comparison of schools, the large ranges of scores for questions testing the same word cannot be substantially accounted for by differences in school population alone.

TABLE 5.17

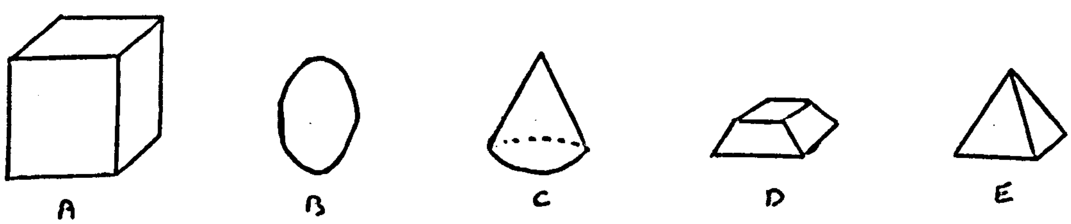
Similar Questions

	Version of Question	1	2	3	4
Third	Sample Size	215	179	505	95
Form	Percentage correct	75	86	75	74

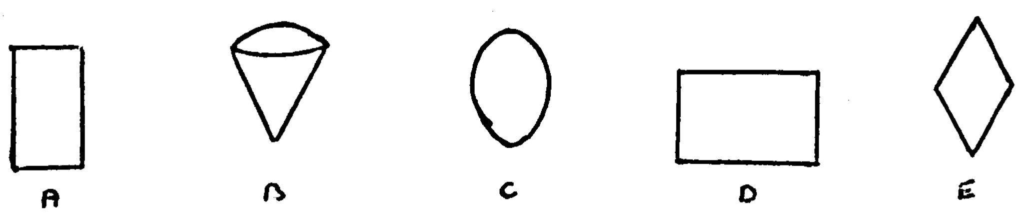
Version 1. Which one of the objects shown has a conical shape?



Version 2. Which one of these shapes could be described as conical?



Version 3. Which of the following is conical in shape?



Version 4. Which of the following shapes is conical?

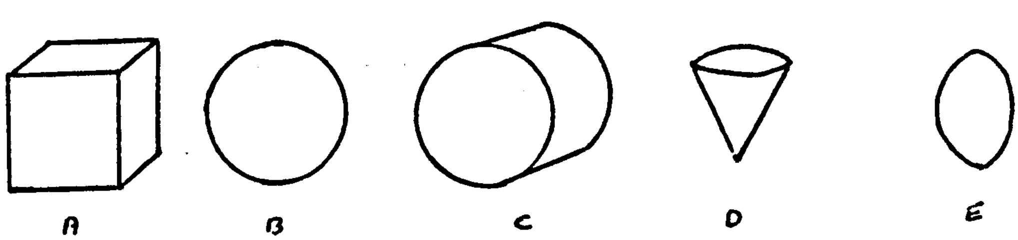


TABLE 5.18

Comparison of Schools

Word	School(s) L	M	N	O
Third Form Sample size	290	166	20	93
action	78	96	95	98
alternate	93	77	80	65
appropriate	94	98	51	98
associate	76	96	83	92
characteristic	61	39	75	75
component	88	33	89	63
consecutive	80	80	71	71
continent	15	99	87	63
convention	68	47	52	58
crest	87	45	70	67
deflect	94	85	92	84
device	82	41	86	94
diagnose	68	93	84	45
displace	67	35	26	48
effect	77	28	92	87
erect	94	88	63	79
exact	89	93	95	96
exert	90	47	60	63
fundamental	66	61	17	76
impact	97	47	69	60
incline	69	78	31	73
invert	65	36	42	54
limit	54	86	89	73
linear	37	69	44	32
Average score	74	67	68	71

2 <u>Type of Question Used</u>

In the information sent out to participating centres there are six types of question given as examples (see Appendix N)

A Recognising a Synonym

B Instance Recognition

C Diagram Recognition

D Content Usage

E Sentence Completion

F Gap Filling

It could be argued that the range of scores for individual words could be accounted for by the <u>type</u> of questions in which they were tested.

A selection of words which were tested in a variety of question types are shown in Table 5.19. The scores are those of third formers. There is a variation of score for a given word in a variety of question formats but no clear pattern emerges to suggest that any particular <u>type</u> of question poses special problems. Indeed the average scores for all types (except E, for which a few samples were available) are remarkably similar.

Although some of the range in the scores in Tables 5.11 to 5.14 can be accounted for by variations in schools and question type, these may not be the major factors. Other factors <u>within</u> the questions may be significant contributors.

TABLE 5.19

Type of Question

Word Tested	Type of Question					
	A	B	C	D	E	F
arid	71	51		60		72
coincide	67		100	56		69
contribute	90			90	87	
correspond	76			24	89	84
detect	100			72	98	89
devise	89			71		66
disperse	55			79	76	
dominant	71	80			84	
evacuate	63			95	54	
include	88	91		81		
fog	91	94		77		
immerse	96		46			
incident	91			94		75
logic	72				74	63
multiple	97	90		81		61
partial	87	88		68	85	71
phenomenon	39	69			64	85
primary	74	100		60	86	
proportion	91			85	75	85
spontaneous	15			59	42	
Percentage correct 'average'	76	82		72	76	75

3 <u>Difficulty of the Question</u>

(A) <u>Connotation</u> :

One word often has a number of connotations and it would be wrong to assume that because a word is understood in one situation it will be equally well understood in other situations. Consider the examples of 'grain', 'primary' and 'correspond', on the following pages. The differences in scores are large and perhaps in the 'correspond' examples the percentage correct in the last version is influenced not only by the connotation but also by the fact that it is a 'context usage' type of question and the difficulties may be cumulative. In other words the first version of the question testing 'correspond' is a sentence completion type. To arrive at the correct answer each response has had to be used in turn in the question and a decision made about which was the most appropriate. In the last version of the question on 'correspond' not only has the connotation of the word been changed to a less familiar use of the word but it is also in a 'context usage' type of question requiring each response to be read, understood, and compared with three other very different responses. It may be that this increase in the complexity of the thinking is responsible for the gross differences in the results.

GRAIN

Which of the following is a grain?

A. Peas
B. Beans
C. Oats
D. Turnips
E. Carrots

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	340	278	-
Percentage correct	85	88	-

The class talked about the grain of different rocks. They talked about :

A. the colours
B. the shapes
C. where the rocks had come from
D. how big the pieces in the rocks were
E. how old the rocks were

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	300	236	39
Percentage correct	49	52	52

The people decided that the town needed a primary school. It needed:

A. a school for young children

B. a school for older children

C. a new school

D. a modern school

	Year 1-2	Year 2-3	Year 5-6
Number of pupils	54	65	-
Percentage correct	100	100	-

Red, yellow and blue are the primary colours. This means that:

A. all colours can be made by mixing them

B. they are used in flags

C. they are used in American elections

D. they are only used in junior school

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	89	63	10
Percentage correct	75	100	100

The question was of primary importance

A. It was unimportant.

B. It was extremely important.

C. It was the first question asked.

D. Children were asked the question.

E. It was an examination question.

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	166	195	119
Percentage correct	24	41	55

CORRESPOND

If two people write to each other they are said to:

A. compete

B. deflect

C. dismiss

D. correspond

E. contradict

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	236	280	10
Percentage correct	85	90	100

When a product corresponds with a design

A. it is made exactly as designed

B. there are similarities between it and the design

C. there are letters written about it

D. it has been badly designed

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	191	252	166
Percentage correct	75	74	75

Which sentence uses the word
'correspond' correctly?

A. The fingers on the hand correspond to the toes on the feet.

B. The head corresponds to the neck.

C. The stomach corresponds to the mouth and intestines.

D. The feet correspond to the head.

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	101	232	-
Percentage correct	26	47	-

(B) <u>Context</u> :

The context in which the word is tested has an influence on the percentage correct.

Consider the examples on 'audible', 'recoil' and 'spontaneous'. The first version of 'audible' connects it with 'buzz' whereas in the second version there are no helpful connections in the stem of the question and the performance diminishes. That is a possible interpretation which could also be used in the 'recoil' versions.

In the first one 'recoil' is connected with a familiar object (a spring) and it is clearly not difficult to choose the correct response. However, in the second version the format is less helpful and the scores fall.

In the 'spontaneous' examples the explosion is a more familiar content than the buzzing and the structure of the questions suggest that the second version with larger responses and more information to handle makes the choice of the correct response more difficult. As previously suggested for variations in connotations it may be that variations in context also influence the internal processing necessary to arrive at the correct response, i.e. it may be that the increase in the complexity of the thinking is responsible for the gross differences in scores.

AUDIBLE

When the switch was pressed an audible 'buzz' was noted. It:

A. was noisy

B. was quiet

C. could be heard

D. was loud

E. could not be heard

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	201	116	68
Percentage correct	65	79	100

Which of the following is audible?

A. an oil painting

B. a distant star

C. a dictionary

D. a silent film

E. an explosion

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	758	747	352
Percentage correct	39	62	90

RECOIL

The boy let the spring recoil:

A. It returned to its original length.

B. It became longer.

C. It became tangled up.

D. It moved around.

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	177	122	-
Percentage correct	88	98	-

When a gun is fired, the bullet goes forward so fast that the gun jerks backwards. This jerking is called the:

A. recoil of the gun

B. back-spring of the gun

C. reverberation of the gun

D. back-play of the gun

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	176	132	54
Percentage correct	27	46	78

SPONTANEOUS

The explosion was spontaneous.
This means that it happened:

A. because of the bomb
B. suddenly on its own
C. with a loud bang
D. with a lot of smoke
E. inside a building

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	239	282	10
Percentage correct	56	65	100

When freshly cut grass is put in a pile there can be spontaneous burning

A. Burning will be very slow because the grass is green.
B. The sun can heat up the grass so much that it burns
C. Burning can only take place when the grass has dried out.
D. A fire can start without someone setting the grass alight.

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	149	234	21
Percentage correct	12	28	81

(c) Science Context :

If the score for a word tested in a non-science context is compared with the score for the same word tested in a science context, the science context appears to be more difficult.

Consider the examples on 'liberate', 'excess', 'preparation' and 'influence' on the following pages. The science context is perhaps less familiar. The connections in the non-science context between 'prisoners' and 'liberate'; 'parties' and 'food'; 'trainers' and 'preparation'; 'pupil' and 'bad influence' may be more within the framework of the pupils experience than the connections required within the science contexts where ideas and words may be less familiar. To think out the first version of 'liberate' may require fewer, easier thinking stages than are required in the second and third versions.

LIBERATE

The new ruler decided
to liberate the prisoners.
He was going to:

A. educate them

B. brainwash them

C. set them free

D. torture them

E. starve them

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	114	691	13
Percentage correct	60	60	92

Hydrogen gas was....when
magnesium was added to
the acid:

A. saved

B. evoked

C. reprieved

D. liberated

E. vibrated

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	166	195	119
Percentage correct	16	33	47

From the list of words
pick the one which best
completes the sentence.
We can......hydrogen gas
by putting zinc into
dilute sulphuric acid:

A. levitate

B. alleviate

C. elevate

D. illuminate

E. liberate

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	236	280	14
Percentage correct	16	25	100

EXCESS

After the party there was a lot of food left over.
There was:

A. an express of food

B. an excerpt of food

C. an excess of food

D. an access of food

E. a duress of food

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	758	724	349
Percentage correct	64	83	97

We used <u>excess</u> jam for our sandwich so we:

A. put too much on

B. did not put any on

C. did not put enough on

D. put just the right amount on

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	386	257	29
Percentage correct	50	75	100

The teacher tells you to make sure the acid used in the experiment is in excess.
You:

A. put the acid in a special container

B. add more water to the acid

C. make sure all the acid is used up

D. make sure some acid is left at the end

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	233	390	207
Percentage correct	37	57	70

PREPARATION

In preparation for the match, the team had a talk from their trainer.
What does preparation mean?

A. after
B. getting ready for
C. instead of
D. because of

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	192	75	-
Percentage correct	95	100	-

When dilute hydrochloric acid is added to marble chips a gas called carbon dioxide is produced. Thus hydrochloric acid and marble chips are used in the....of carbon dioxide.

A. collection
B. combustion
C. degradation
D. liquefaction
E. preparation

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	732	722	346
Percentage correct	41	46	85

INFLUENCE

The teacher said that John was a very bad.....on the rest of the class.

A. affluence
B. instance
C. confluence
D. immanence
E. influence

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	736	615	328
Percentage correct	76	90	91

Temperature influences the speed of chemical reactions.

A. affects
B. does not affect
C. increases
D. slows down

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	108	113	20
Percentage correct	45	61	100

(D) Confusion

If in the responses there is one which pupils can easily confuse with the correct response then this may account for differences in scores between questions. Confusion can arise from words which sound similar or which have the opposite meaning.

Consider the examples on 'simultaneous', 'emit', 'effect', and 'abundant' on the following papers. In the first version of 'simultaneous' response A is a good distractor. A large proportion of the pupils think that simultaneous means one after the other. This source of confusion is not present in the second version and the score increases. Similarly in the first version of 'emit' response C is a good distractor. A large percentage of the pupils have confused emit with the opposite meaning. When this option is not present in the second version the percentage correct increases. The confusion of the similar sounding words 'effect' and 'affect' may be a factor in explaining the gross differences between the two versions of the 'effect' question. The first version also has an extra twist in asking for <u>sensible</u>

statements. Similarly knowing that 'abundance' is to do with quantity is not sufficient if there is confusion as to which extreme it occupies, i.e.plentiful or in short supply. The second version did not offer this polarity. 'Abundance' was also involved in Chapter 3. In Table 3.8 the difficulty of interpreting 'least abundant' rather than 'most abundant' was described.

The connections and misconnections as suggested by Luria (81) between words/ideas may be influencing the thinking necessary to solve the question.

SIMULTANEOUS

Two experiments are carried out simultaneously.
They are:

A. carried out one after the other

B. carried out in different ways

C. carried out in different rooms

D. carried out at the same time

Percentage selecting

Year	A	B	C	D*	E
1-2	41	3	1	55	-
3-4	39	4	1	56	-
5-6	0	0	0	100	-

Two rockets are fired.
The explosions are simultaneous.
This means that the rockets:

A. missed their target

B. hit the same target

C. did a great deal of damage

D. exploded loudly

E. exploded at the same time

Percentage selecting

Year	A	B	C	D	E*
1-2	4	13	5	8	70
3-4	3	5	3	3	86
5-6	-	-	-	-	100

EMIT

Certain materials can <u>emit</u>
radiation.
Does this mean that materials:

A. give out radiation

B. transfer radiation to other countries

C. take in radiation

D. connect radiation to another form

	Percentage selecting				
Year	A*	B	C	D	E
1-2	48	4	45	3	-
3-4	59	3	35	3	-
5-6	100	0	0	0	-

A lamp which will <u>emit</u> blue light

A. gives out blue light

B. cannot give out blue light

C. uses up blue light

D. reflects blue light

	Percentage selecting				
Year	A*	B	C	D	E
1-2	59	22	7	12	-
3-4	85	6	4	5	-
5-6	91	3	3	3	-

EFFECT

Which of the following sentences is sensible and uses <u>effect</u> correctly?

A. Smiling will effect everyone else.

B. He could not effect the work of the rest of the group.

C. There is little effect on the trees when the temperature rises in spring.

D. The boy's laziness could effect the rest of his career.

E. The effect of heating water with a bunsen burner is that it boils.

Percentage selecting

Year	A	B	C	D	E*
1-2	0	3	12	41	44
3-4	1	5	27	31	36
5-6	0	0	28	23	49

Your teacher told you to find the effect of adding acid to a metal, so you tried to find:

A. what happened

B. the quantity of acid used

C. the reason for adding acid

D. how long it took

Percentage selecting

Year	A*	B	C	D	E
1-2	88	2	7	3	-
3-4	94	1	4	1	-
5-6	98	0	1	1	-

ABUNDANT

Which statement explains the meaning of the word abundant in the sentence:
"There was an abundant supply of splints for the class to use?

A. There was a shortage of splints.

B. The splints were not suitable.

C. The supply of splints was just enough.

D. No splints were available.

E. There were plenty of splints.

Percentage selecting

Year	A	B	C	D	E*
1-2	23	6	18	9	44
3-4	13	3	15	8	61
5-6	0	0	0	0	100

Apples were abundant last year.
Does this mean apples were:

A. larger than usual

B. deeper in colour

C. in plentiful supply

D. ready for picking earlier

Percentage selecting

Year	A	B	C*	D	E
1-2	13	5	66	16	-
3-4	4	4	85	7	-
5-6	0	0	100	-	-

(E) Combination of Words

The combination of words may result in an expression of precise meaning that is not readily understood by pupils.

This may be just a variation of connotation/ context. Consider the examples on 'external' and 'linear' on the following pages. 'External skeleton' and 'linear relationship' seem to be more difficult to understand than 'external aerial', 'external symptom' and 'linear', respectively.

The combination of words may influence the thinking necessary to solve questions.

EXTERNAL

Some animals have an <u>external</u> skeleton

A. hard

B. soft

C. inside

D. outside

E. large

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	108	113	20
Percentage correct	40	70	100

Which of the following sentences has the meaning nearest to the underlined sentence?

<u>Insects have an external skeleton</u>.

A. The skeleton is on the outside of the body.

B. The skeleton sticks out through the skin.

C. They have an invisible skeleton.

D. The skeleton is made of bone.

E. They have a skeleton which bends.

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	326	278	-
Percentage correct	32	50	-

The.......symptoms of illness are flushed face, hot forehead, swollen glands, sickness and fainting.

A. external

B. expanded

C. extended

D. exported

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	51	84	15
Percentage correct	78	96	100

Which sentence uses the word <u>external</u> correctly?

A. The external TV aerial was placed on the roof.

B. The Greek Gods are external.

C. The heart, lungs etc. are the external organs.

D. The external TV aerial was inside the set.

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	205	135	75
Percentage correct	91	99	100

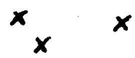
LINEAR

Look at the three crosses.
Which form a <u>linear</u> line?

A. 

B. 

C. 

D. 

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	390	135	16
Percentage correct	83	81	87

Which one of the following lines is <u>linear</u>?

A. 

B. 

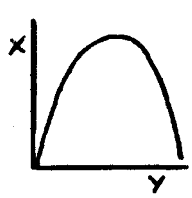
C. 

D. 

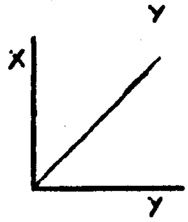
	Year 1-2	Year 3-4	Year 5-6
Number of pupils	388	136	15
Percentage correct	74	80	86

In which diagram (graph) is there
a <u>linear</u> relation between X and Y?

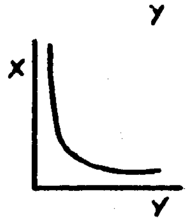
	Year 1-2	Year 3-4	Year 5-6
Number of pupils	135	141	-
Percentage correct	41	45	-



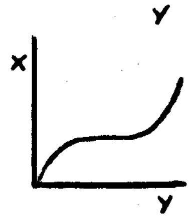
A



B



C



D

(F) Precision and Discrimination

The degree of precision of understanding of the word tested and the degree of discrimination of the responses testing this understanding influences the percentage correct. This is similar to the ideas of Vygotsky (82) already discussed in Section 3.5.

Consider the examples on 'immerse' and 'diagnose' on the following pages. In the first version of 'immerse', if the pupil knows that 'immerse' is a word involving liquid, then the correct response is easy to get. However, to get the correct response in the second version it is not enough to know that 'immerse' is a word involving liquid. To be able to discriminate between the responses the pupil had to be more precise in his understanding of the term. Similarly in the first version of 'diagnose', if the pupil knows the connection between diagnose and illness (or sees the connection in the stem), it is easy to pick out the correct response. In the second version it is more difficult to discriminate between the responses because of the more precise understanding required. It may be that the increase in the precision of the thinking is responsible for the gross difference in the results.

IMMERSE

If we immerse an object, we have

A. heated it

B. measured its length

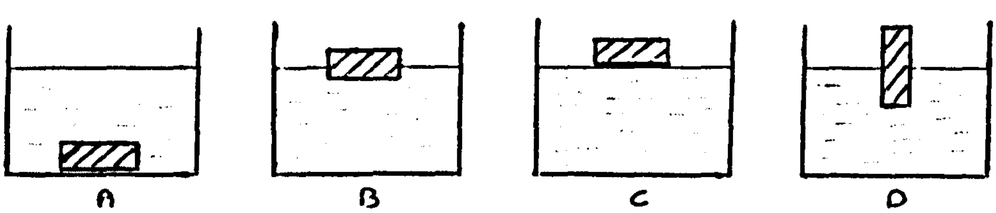
C. covered it with a liquid

D. weighed it

E. rubbed it

	Percentage selecting				
Year	A	B	C*	D	E
1-2	7	2	84	1	6
3-4	1	1	96	1	1
5-6	0	0	100	0	0

In which of these drawings is the block of wood immersed?



	Percentage selecting				
Year	A*	B	C	D	E
1-2	39	16	28	17	-
3-4	64	12	14	10	-
5-6	100	0	0	0	-

DIAGNOSE

The doctor <u>diagnosed</u> the man's illness.
He:

A. found out what the illness was

B. gave him some medicine

C. looked up the illness in a book

D. made him better

E. said he could not cure him

Percentage selecting

Year	A*	B	C	D	E
1-2	-	-	-	-	-
3-4	93	3	2	2	0
5-6	95	5	0	0	0

Which sentence used the word <u>diagnosed</u> correctly?

A. The nurse saw what was wrong and diagnosed some medicine.

B. The doctor examined the patient and diagnosed tonsilitis.

C. The nurse diagnosed the patient's temperature.

D. The chemist diagnosed the prescription.

Percentage selecting

Year	A	B*	C	D	E
1-2	33	23	20	24	-
3-4	29	56	7	8	-
5-6	9	77	7	7	-

(G) Thinking

By examining all the words with gross differences and then looking at the questions for any common factor in them which could be causing this difference it was possible to divide them into groups in which the main factors seemed to be Connotation; Context; Science Context; Confusion; Combination of Words; Precision and Discrimination.

The question now arises - Is there something even more fundamental underlying all of these or are we in such a tangle that no useful, workable pattern can emerge?

A common factor has emerged time after time under each of the groupings mentioned above. In the examples we have studied, the most difficult questions are those demanding most thinking or interpretation steps. In moving from a non-science to a science situation we are taking the student on to less familiar ground where perhaps the interpretation of a whole new context is necessary to find a meaning for the word. In a scientific context words may have a more precise meaning than in more general situations and this extra precision and discrimination demands more effort and thought. The distinction between "heating" and "burning" or "melting" and "dissolving" are elementary examples of this. In support of this tentative idea that the most difficult questions are those demanding most complex thinking or interpretation steps the reader is asked to consider the following examples of the words 'revise', 'invert', 'coincide', 'agent', 'appropriate' and 'detect' where there are gross differences in the percentage correct.

REVISE

The pupils were told to revise their work.
They had to:

A. complete it
B. put it into a folder
C. put it into paragraphs
D. punctuate
E. read it again to learn it

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	238	283	10
Percentage correct	96	94	100

If you revise something you:

A. write a summary of it
B. change or alter it
C. read it quickly
D. copy it out

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	316	144	-
Percentage correct	5	9	-

INVERT

To start one of those egg-timers with sand in them, you have to <u>invert</u> it.
You have to:

A. shake it

B. turn it upside down

C. lay it on its side

D. put more sand in it

	Year	Year	Year
	1-2	3-4	5-6
Number of pupils	228	205	39
Percentage correct	100	100	100

To <u>invert</u> an object means:

A. to turn the object upside down

B. to make an object that no-one else has made

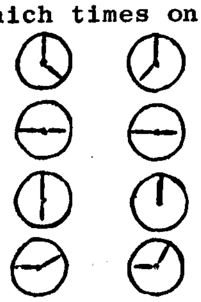
C. to turn the object on its side

D. to decorate the object

	Year	Year	Year
	1-2	3-4	5-6
Number of pupils	177	132	54
Percentage correct	51	60	87

COINCIDE

Which times on the clock coincide?



A

B

C

D

	Year	Year	Year
	1-2	3-4	5-6
Number of pupils	240	205	93
Percentage correct	100	100	100

Two events are found to <u>coincide</u>

A. The events happened to different people.

B. They occurred at the same time.

C. One event followed closely after the other.

D. One event occurred the day following the other.

E. One event caused the other to occur.

	Year	Year	Year
	1-2	3-4	5-6
Number of pupils	236	280	14
Percentage correct	64	71	93

When two things coincide

A. they are related

B. they are the same

C. they are different

D. they change places

E. they are joined together

	Year	Year	Year
	1-2	3-4	5-6
Number of pupuls	167	261	101
Percentage correct	20	43	58

AGENT

Mrs. Smith applied to the firm to become an.....to sell cosmetics

A. agent
B. agile
C. active
D. avenue

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	115	668	-
Percentage correct	98	96	-

An agent of change is something which:

A. is changed itself
B. stops a change
C. is not changed at all
D. an enemy of change
E. brings about the change

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	236	280	14
Percentage correct	48	61	100

APPROPRIATE

The payment should be appropriate for the work done. The payment shall be

A. high
B. prompt
C. suitable
D. an estimate
E. offered

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	201	116	68
Percentage correct	80	85	97

Which one of the following sentences uses the word appropriate properly?

A. The appropriate number of sodium is 11.
B. An appropriate way of collecting ethene would be over water.
C. Using 96,500 coulombs to represent the Faraday is only appropriate.
D. I appropriate the work done by Rutherford.

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	135	141	-
Percentage correct	27	38	-

DETECT

Jim said he could hear a noise.
The other children said they could not hear it.
Jim could

A. affect the noise

B. inspect the noise

C. reject the noise

D. detect the noise

E. contact the noise

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	159	199	44
Percentage correct	95	98	97

If I detect something I will

A. find it out

B. write it down

C. throw it away

D. leave it behind

E. cancel it out

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	236	280	14
Percentage correct	90	91	100

The use of a flame allows hydrogen gas to be

A. displaced

B. distorted

C. decomposed

D. detected

E. dehydrated

	Year 1-2	Year 3-4	Year 5-6
Number of pupils	114	654	29
Percentage correct	40	47	79

5.8 Conclusions

From the results of the first year of the investigation it was possible to produce lists indicating words that may be causing pupils and students difficulties at various stages (Tables 5.1, 5.2, 5.3, 5.4, 5.7, 5.8, 5.9, 5.10) and there is an indication (Table 5.6) that Gardner's findings are in the main applicable to Britain. As suggested in the Scottish and JMB experiments, performance in multiple choice questions is not controlled by regional factors but may be determined by the thinking processes necessary to solve the question. From the results of the Australian exercise and this investigation the vocabulary of pupils does seem to improve as they move through the secondary school and in Chapter 6 some suggestions will be made that may enhance this improvement.

This work goes beyond Gardner's work and particularly in the second year of the investigation the following conclusions become more established.

(a) The meaning of a word may not be absolute but varies from a general meaning to a more precise meaning (Section 5.7 3F).

(b) A combination of words can result in an expression with a difficult meaning (Section 5.7 3E).

(c) The meaning of a word may depend on its connotation and on its context (Section 5.7 3A and B).

(d) A word in a scientific context may be harder to understand than the same word in a non-scientific context (Section 5.7 3C).

In the examples studied (Section 5.7) where there have been gross differences between questions testing understanding of the same word, the differences seem to reflect on the response of the internalisation aspect of the language to the language of the question. It seems to be the internal connections and mis-connections between words and ideas that is influencing the thinking necessary to solve multiple choice questions.

CHAPTER 6

Conclusions and Recommendations

6.1 The influence of language on performance in matched pairs of multiple choice questions

In the Scottish and JMB Experiments the procedures that were adopted from the evidence of the common control questions seems to have resulted in closely matched samples of pupils who attempted the various paired tests and it is assumed that differential performances are due to the changes made in the question and not to the characteristics of the pupil.

From the JMB Experiment there was clear evidence :

(a) that ability to respond correctly to multiple choice chemistry questions is associated strongly with measured verbal ability.

(b) that simplification of items materially helped the less able as well as girls without impairing the general efficiency of the test as a measuring instrument.

(c) that higher social class groups achieve higher facility values in chemistry questions than lower social class groups. This may reflect the reported influence of social class on language development (167)(168)(169)(170).

In addition to these personal factors, performance in multiple choice chemistry questions seems to be influenced by :-

1 <u>Words</u> :

If a non-technical word that needs to be understood to answer the question (a key word) is replaced by a word that is more easily understood then there is an improvement in performance.

If any word is capable of being misinterpreted, then this influences performance.

In addition to the key words, the other words in the question may also have an influence on performance and compressed formal language (pompous) may depress performance.

2 <u>Expressions of quantity or order</u>

If incompatible expressions like 'least abundant', 'least concentrated' are replaced by more compatible expressions like 'most abundant', 'most concentrated', then there is an improvement in performance.

3 <u>Negatives</u>

If a negative expression is removed, there can be an improvement in performance.

4 'Bits' of Information

If extraneous bits of information are removed, performance improves, but if bits of information are removed to such an extent that the question becomes more abstract, then performance deteriorates.

If the lists of information are arranged in simple sentences instead of larger sentences with embedded clauses, then performance improves.

If the item consists of information and a question, performance seems to be improved by not separating the question from the responses by the insertion of information.

Performance in multiple choice chemistry does not seem to be influenced by minor changes in parts of speech nor by changing the passive voice into the active voice.

6.2 Information on aspects of language from individual multiple choice questions

From the Scottish Experiment these tentative conclusions are suggested :

(a) Technical vocabulary that is introduced early in the secondary school may not be recalled by O grade chemistry candidates.

(b) From the vocabulary questions certain non-technical words including logical connectives may be a barrier to the learning of chemistry.

(c) The language of the text book may not be the language with which the pupil is most comfortable.

(d) In learning definitions of technical expressions certain cues or trigger words may play an important role.

From the Chemical Society Experiment on the understanding of non-technical words, it is possible to make the following conclusions :

(a) The meaning of a word is not absolute but varies from a general meaning to a more precise meaning.

(b) A combination of words can result in an expression with a difficult meaning.

(c) The meaning of a word depends on its connotation and on its context.

(d) A word in a scientific context is harder to understand than the same word in a non-scientific context.

6.3 Multiple Choice Questions and Pupil Answers

This interest in language developed from listening to individual pupils mentally stumble through questions like this (171).

Example 1

9. Which of the following statements is true for the four carbonates?

sodium carbonate

silver carbonate

lead carbonate

magnesium carbonate

*A they neutralise dilute acids

B they react with dilute alkalis producing carbon dioxide

C they decompose on heating to form the metal oxide and carbon dioxide

D they are insoluble in water

Example 2

31. Coal is formed from decayed plants which grew millions of years ago. The energy which is released when coal burns was trapped in these plants by a chemical process called :

*A photosynthesis

B nitrogen fixation

C respiration

D destructive distillation

* correct response

In Example 1 the apparent difficulty was removed when in discussion 'neutralise' in response A was replaced by 'reacts'. In Example 2 the apparent difficulty was removed when the question was read omitting the embedded clause 'which is released when coal burns'. In teaching pupils it has been my experience that there have been so many examples of a language modification leading to an improved response that it seemed to point to the close relationship between language and the processing necessary to solve the question.

This was substantiated by the consideration of questions released by the Scottish Certificate of Education Examination Board (172).

No. 239102 Ability : Co Key D

Syllabus section I2 Percentage Correct : 28%

When zinc displaces copper from copper (II) sulphate solution which of the following occurs?

A Zinc is reduced and copper is oxidised.

B Zinc is oxidised and copper is reduced.

C Zinc is reduced and copper ions are oxidised.

D Zinc is oxidised and copper ions are reduced.

No. 239101 Ability : Co Key C

Syllabus section I2 Percentage Correct : 53%

If magnesium is placed in iron (III) chloride solution then

A magnesium is oxidised and the chloride ion reduced.

B magnesium is reduced and the chloride ion oxidised.

C magnesium is oxidised and the iron ion reduced

D magnesium is reduced and the iron ion oxidised.

Both questions are testing the same syllabus section (159).

Both questions are testing the same ability co-comprehension (173), based on an adaptation of Bloom's (174) classification of objectives.

The questions are apparently very similar but the percentage correct are very different. The main reason is that in No. 239102 there is a precise distinction between responses that does not exist in No. 239101. The distinction is between responses B and D. D contains the word 'ions' and B does not. In reading and processing the answer the pupils have to be able to distinguish between these two very similar answers - such is the subtlety that language can bring to the thinking necessary to solve a question.

6.4 Reading, Processing and Performing

In Section 2.2 there is a diagram Figure 2.1 on the relationship between reading, processing and performing, which was influenced by Fig. 1.3 Model of Cognitive Processes - White (105). By examining performance it was suggested that it would be possible to infer about the complicated interrelationship between reading and processing. The conclusions for each of the experiments have already been listed in this chapter but by laying some of these against some of the theoretical background and research described in Chapters 1 and 2 it may be possible to make some very tentative interpretations on these conclusions which may give some indication of how the superficial language of the multiple choice question is related to the necessary internal thinking processes.

1 <u>Words</u> :

Replacing key words in multiple choice chemistry questions and reducing the amount of compressed formal language may make the questions easier because it makes the meaning more accessible. The most important factor in determining readability is word difficulty (139)(140)(141) and this may be being substantiated by this work.

2/3 <u>Expressions of quantity or order/Negatives</u>

Alterations to these terms in multiple choice chemistry questions seem to influence performance. The difficulty with expressions of quantity seem to mirror the reported difficulties (131)(132)(133)(134) in young children with terms like 'more' or 'less'. The difficulty with negatives seems to confirm the finding of various works (126)(127)(128)(129) that negatives are conceptually more difficult than affirmatives. Slavin (130) suggests that this type of grammatical feature takes up more space in the short term memory and consequently reduces its facility to process information.

4 Bits of Information :

Various organisational changes seem to influence performance in multiple choice questions. This may reflect Slobin's conclusion (111) that putting material into an order makes it easier to understand. For example it is more difficult to understand information in which other information has been embedded (151). In processing information in addition to the number of bits of information there is a need to put the bits in a meaningful working order. Both the number and the ordering may occupy space in the short term memory and since there is a restriction on the number of 'chunks' (142)(122)(121) with which the short term memory can cope, if the organisational changes reduce some of these items it could release more space in the short term memory for processing the information and consequently improve performance.

In the vocabulary questions from the Chemical Society Experiment, in which there are gross differences, between questions testing understanding of the same word, it seems to be the internal connections and misconnections (81)(82) between words and ideas that is influencing the thinking processes.

In the multiple choice questions in the Scottish Experiment, the JMB Experiment, the Chemical Society Experiment and the earlier Australian investigation the same feature seems to come across. It is the meaning that is important. Changes to parts of speech of words in multiple choice questions and the removal of the passive voice do not seem to influence performance perhaps because neither of these alterations alter the underlying meaning of the question. The meaning is crucial and is derived by an active internal interpretation process that is language dependent in two interrelated senses :

(a) the language of the question is being processed, i.e. words, expressions, and bits of information are moving into the memory units

(b) language could be being used for the processing, e.g. advance organisers (109), cognitive bridges (110), linking (116), cues (135) may be being used to manipulate, store and recall information within the memory units.

The superficial language of the question is responsible for (a) and will have an impact on (b), and both (a) and (b) together contribute to the active interpretative process. Thus the superficial language of the question is closely related to the necessary internal thinking process.

6.5 Recommendations :

From these experiments and particularly from the Chemical Society Experiment, there may be an apparent suggestion of prohibiting certain words but that is not the case. In chemistry as in other subjects in the secondary school there is a need to consciously build on pupils vocabulary.

The following suggestions are offered to try to improve pupils understanding of words and hopefully improve their science. These suggestions are based on a consideration of some of the possible reasons in the Chemical Society Experiment for the gross differences in the scores between question testing understanding of the same word.

Connotation : when appropriate discuss the various connotations of a word

Context : explain words in context. The word used in a technical sense should be linked with, or distinguished from its more general use.

Confusion : similar sounding words to the new word should be discussed. Words opposite in meaning to it could also be discussed where appropriate.

Precision and Discrimination : Different grammatical forms of the new word should be pointed out, e.g. filter, filtration. Words of similar meaning could be discussed where appropriate. The learning of set definitions may have an important role to play in this. Pupils should be encouraged to express the meaning of new words in words of their own so that the teacher can be sure that they are understood. Only then should he encourage the use of a new word.

The implications of these suggestions are that new words have to be consciously connected to existing vocabulary before any new word will become part of the pupil. It has been suggested by Ausubel (109) and Novak (110) that meaningful learning occurs only if new information is linked to existing relevant concepts. This may also apply to new words. Teachers may be able to help pupils to make connections between new vocabulary and their existing vocabulary and by the quality of these connections, it may be possible to help the pupils to move from a vague meaning of a word to a more complete understanding of its meaning.

In the wider context of the total learning experience pupils are often inundated with new skills, concepts and language in an amazingly concentrated fashion. It is a sobering exercise to listen in to a short lesson and to list the new skills (of head and hand), ideas and words which wash over pupils. This almost certainly results in an information overload which militates against meaningful learning. If it is possible to reduce the information overload in teaching by using more efficient linguistic strategies then science teaching will improve.

In this wider area of meaning it would be good to be able to make recommendations.

1 To authors : In text books include glossaries of all technical terms and non-technical terms where they differ from normal usage.

2 To examiners : Avoid negative expressions

appearing in both the stem and the responses of multiple choice questions

3 To teachers : Avoid compressed formal language when introducing new ideas

4 To all three groups :

(a) Be wary of using phrases that may be ambiguous

(b) Try to present information in succinct simple sentences without recourse to embedded information

(c) Communicate in a form that is appropriate to the expected audience,

but it is not as easy as that! Authors, examiners and teachers are aware of the need for chemical accuracy and what I feel needs to be added to this is to heighten their awareness of the importance of communicating meaning clearly. This implies being sensitive to the difficulties of the pupil and appreciating the complex interrelationship of language, thinking and learning. Language can be both an aid and a barrier to learning. Be it pupil talk, teacher questions, worksheets, text books, notes or whatever the only way a pupil is going to take hold of chemistry is through language and making the language part of themselves is learning.

It is my hope that this research will make a contribution to increasing awareness.

CHAPTER 7

Consequences

Under the University regulations, a thesis should make a useful contribution to knowledge. Whether this thesis complies with this still remains to be seen. The preparation of it has however, added greatly to my knowledge. In addition I feel that research in education, if it is useful research, should have an impact on education. An impact on education is difficult to measure but there have been a number of consequences to this research that may suggest that it is having some influence.

1 A number of organisations throughout Britain have invited me to talk on this research at various conferences and meetings.

The Chemical Society, July '77; September '78, February '80

The Association of Science Education, February '80

Renfrew Primary Teachers : February '80

Strathclyde Science Teachers : May '79 and June '79

West Midland Science Teachers : July '79

National Course Language across the Curriculum (Aberdeen) : September '79

Scottish Remedial Teachers Conference :

October '79

Scottish Religious Education Conference :

May '80

Strathclyde Management for Senior Promoted

Staff in Secondary School :

January '80, June '80.

2 A number of sources have asked for articles to be written. The following have been published :

J.R.T. Cassels and A.H. Johnstone : Language in Chemistry : Bulletin of the Scottish Centre for Maths, Science and Technical Education II : 1977: p19-24

J.R.T. Cassels and A.H. Johnstone : Language in Chemistry : Report of Education Division Conference : Research for the Classroom and Beyond : p48-54 The Chemical Society : London : July 1977

J.R.T. Cassels and A.H. Johnstone : What's in a Word? : New Scientist 18th May 1978 p 432-434

J.R.T. Cassels and A.H. Johnstone : The Understanding of Non-technical Words in Science in a report of a research exercise : The Chemical Society. London, February 1980

In addition two articles with the title 'Language and Learning - a Chemists View' are due to appear in the autumn of 1980, one in the Scottish Education Department Inspectorate Bulletin and the other in the Scottish Curriculum Development Centre Bulletin - Teaching English.

3 My interest led to an invitation to become a member of theChemistry Panel of the Scottish Certificate of Education Examination Board and I presented a paper on my research work to this panel which after due consultation led to the formation of a Joint Working Party of the Scottish Central Committee on Science and the Scottish Certificate of Education Examination Board. This Joint Working Party of which I am a member, has produced a package with the title 'Language in Chemistry'. The package consists of seven units: Introduction; Talking to learn; Listening and understanding; Teacher and pupil talk; Reading and learning; Writing and learning; and Languageand assessment. They are intended to focus attention on the use of language in teaching and assessing chemistry throughout the secondary school by encouraging teachers not just to read the units but to

become actively engaged in the suggested activities and get involved in a professional exchange of ideas with their colleagues.

Initially in the autumn of 1980 a free copy of the package will be sent by the Scottish Curriculum Development Service - Dundee Centre to all Principal Teachers of Chemistry in Scotland.

In Chapter 1 Section 1.2, it is stated that it is through my concern for chemistry pupils that this research has been initiated and it is my hope that this work will make some contribution towards the real need identified in the Bullock report (17).

> 'We must convince the teacher of history or of science, for example, that he has to understand the process by which his pupils take possession of the historical or scientific information that is offered them; and that such an understanding involves his paying particular attention to the part language plays in learning?'

This research and its consequences may just be beginning on this.

Information Sheet (1977 & 1978)

The following test is one of several to try to find out how the language used in Chemistry may affect pupil understanding. Your name will not be needed and your mark will certainly not affect your future although answers from you and pupils in other parts of Scotland may help to shine some light on this problem.

Thank you for your co-operation.

Please follow instructions carefully:-

1. Your teacher will give you - (i) your school number
   (ii) your year number, and
   (iii) your own number.

   Note them.

2. If your number is even you should have - (i) the Pink E Test and
   (ii) a pink answer card.

   If your number is odd you should have - (i) the Yellow O Test and
   (ii) the yellow answer card.

   Check this.

3. Fill in the answer card in pencil as instructed.

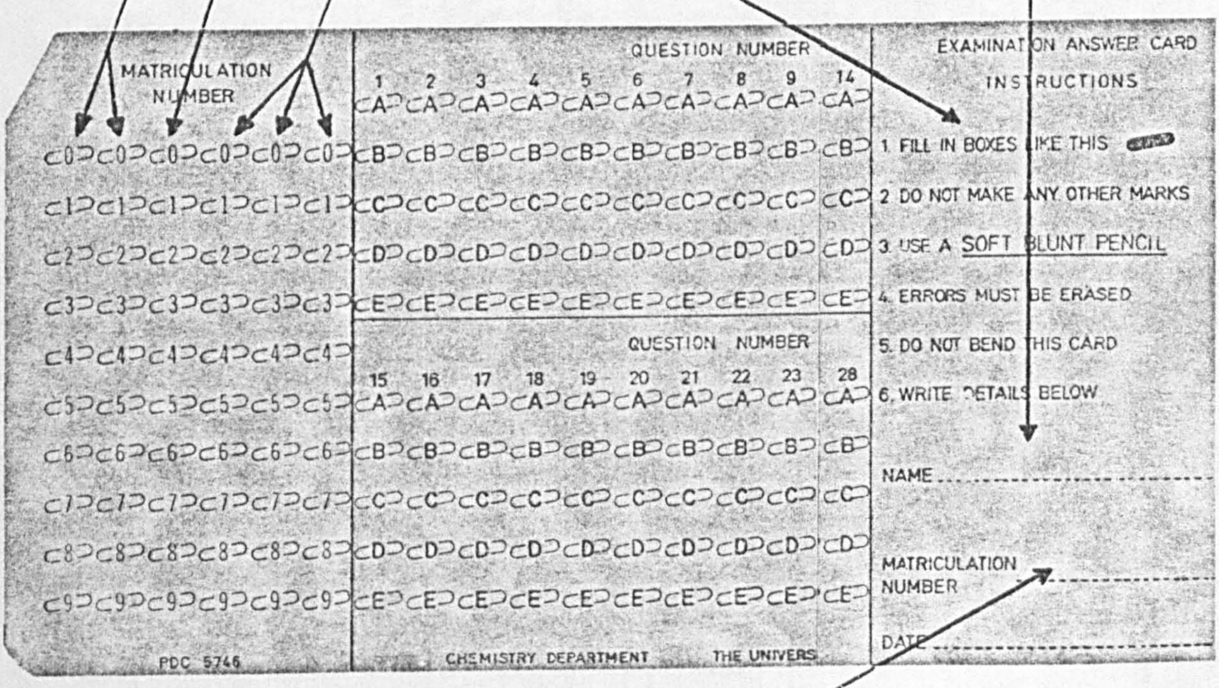
Column for school number

Year number

Your own number

Please put M if you are male or F if you are female.

Instructions



Your Father or Guardian's Occupation

4. Only one oval should be shaded in any one column. If you want to change your answer rub out the shading with an ordinary rubber and shade another oval instead.

5. Tackle all the questions in the test and mark your answers with heavy shading - the heavier and blacker your shading the better - on the answer card.

Information Sheet (1979)

The following test is one of several to try to find out how the language used in Chemistry may affect pupil understanding. Your name will not be needed and your mark will certainly not affect your future although answers from you and pupils in other parts of Scotland may help to shine some light on this problem.

Thank you for your co-operation.

Please follow instructions carefully:-

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   (ii) your year number, and
   (iii) your own number.

   Note them.

2. If your number is even you should have - (i) the Pink E Test and
   (ii) an answer card.

   If your number is odd you should have - (i) the Yellow O Test and
   (ii) an answer card.

   Check this.

3. Fill in the answer card in pencil as instructed.

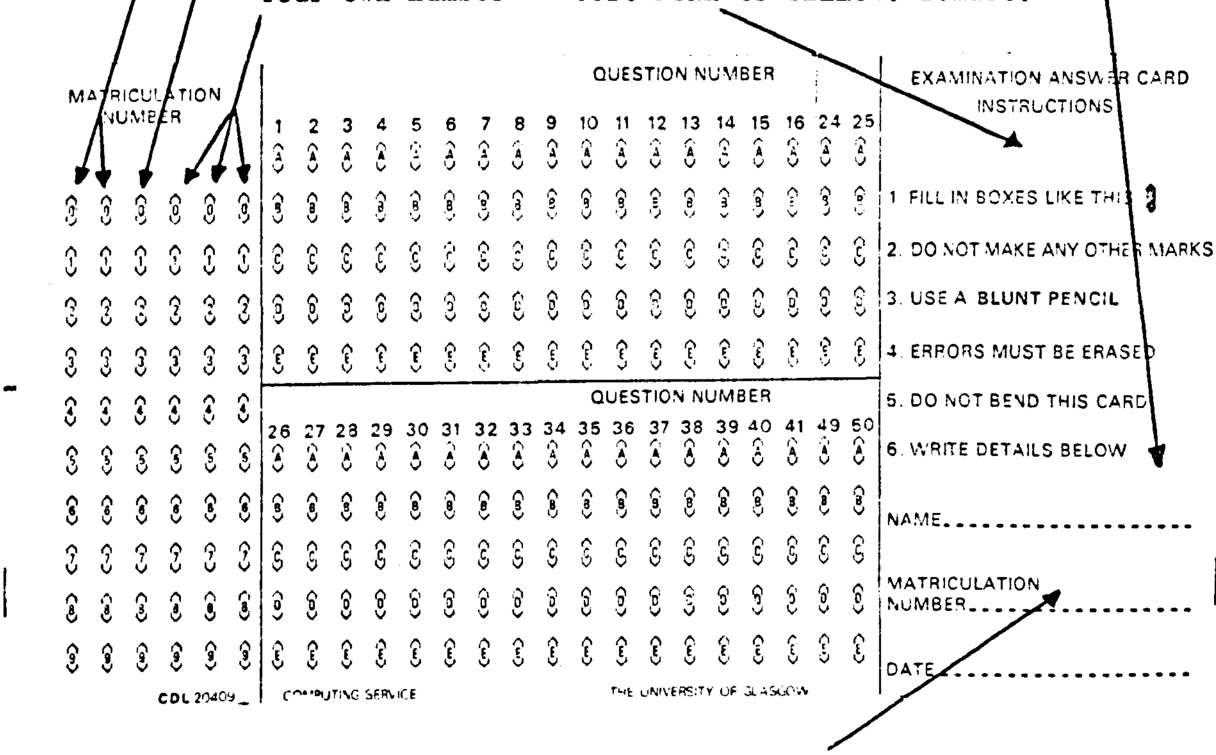
Column for school number

Year number

Your own number

Please put the colour of the test PINK or YELLOW.

Please put M if you are male or F if you are female.



Your Father or Guardian's Occupation.

4. Only one oval should be shaded in any one column. If you want to change your answer rub out the shading with an ordinary rubber and shade another oval instead.

5. Tackle all the questions in the test and mark your ansers in pencil with firm shading - using an HB pencil if possible. Please shade in the oval completely.

UNIVERSITY OF GLASGOW - SCIENCE EDUCATION GROUP

LANGUAGE IN CHEMISTRY

YELLOW 'O' TEST (3)

1. When meat is boiled for too long, it <u>disintegrates</u>.
It:

A. changes colour.
B. breaks into small pieces.
C. dries out.
D. disappears.

2. One half of something written as a <u>percentage</u> is:

A. $\frac{1}{2}$.
B. 5/10.
C. 50.
D. 0.5.

3. The doctor saw a man with a disease that had never been seen before.
The doctor thought that the disease might have been caused by the food the man had eaten.
The doctor's idea could be called

A. a fact.
B. an observation.
C. a result.
D. a theory.

4. Which of the following groups of objects has the most <u>diversity</u>?

A. □ □ O Δ O.
B. ▭ Δ O ▭.
C. O O □ O Δ Δ.
D. Δ Δ Δ Δ Δ Δ Δ Δ.

5. Some students are studying the <u>fundamental</u> laws of physics.
What does fundamental mean?

A. Modern and newly discovered.
B. Difficult and hard to understand.
C. Easily explained.
D. Most important.

6. If two things happen <u>simultaneously</u>, they happen

A. at the same time.
B. quickly.
C. one after the other.
D. once a year.

7. Which of the following could have the highest <u>probability</u>?

A. A man throws a coin and it shows 'heads'.
B. A man wins a million dollars in a competition.
C. A woman has six children, all born together.
D. A man grows to a height of 7 feet.

8. When a solid is dissolved in a liquid, that solid is called

A. the solution.
B. the residue.
C. the solute.
D. the solvent.

9. Which one of the following requires a liquid other than water to dissolve it ?

A. Salt.
B. Sugar.
C. Sodium nitrate.
D. Sulphur.

0. Elements in the same column of the Periodic Table have the same number of

A. protons.
B. electron shells.
C. neutrons.
D. outer electrons.

1. Which one of the following is a choking gas?

A. Carbon dioxide.
B. Nitrogen.
C. Sulphur dioxide.
D. Methane.

When a concentrated aqueous solution of sodium bromide is electrolysed, the product at the positive electrode is

A. bromine.
B. hydrogen.
C. oxygen.
D. sodium.

Which one of the following sulphides is easiest to break down to its elements?

A. Lead sulphide.
B. Sodium sulphide.
C. Calcium sulphide.
D. Zinc sulphide.

A melted compound conducts electricity but when solid does not conduct. This suggests the bonding in the compound is

A. covalent.
B. polar covalent.
C. metallic.
D. ionic.

To tell the difference between nitrogen and helium you could use:

A. a burning taper.
B. a large balloon.
C. a glowing splint.
D. bromine water.

16. Which element would form the same number of bonds as nitrogen?

A. Hydrogen.
B. Beryllium.
C. Boron.
D. Oxygen.

17. W, X, Y and Z are four elements in order, one after the other, in the Periodic Table. Y is a noble gas. Which formula is likely to be correct?

A. WX.
B. Z_2W.
C. Z_2X.
D. ZW_2.

18. A sample of element X contains the following types of atom:

$^{13}_{7}X$ $^{15}_{7}X$ $^{16}_{7}X$

The electronic configuration of the element is

A. 2,4.
B. 2,5.
C. 2,6.
D. 2,7.

19. An isotope of aluminium has an atomic number of 13 and a mass number of 27. An atom of this isotope will contain

A. 14 protons and 13 neutrons.
B. 13 protons and 14 neutrons.
C. 14 protons and 13 electrons.
D. 13 protons and 14 electrons.

20. Some atoms of an element are heavier than other atoms of the same element. This is because they have different numbers of

A. neutrons.
B. nuclei.
C. protons.
D. electrons.

21. Which of the following statements is true of sea water?

A. It has a lower electrical conductivity than tap water.
B. It contains no dissolved gold salts.
C. There are no ions present.
D. It freezes below $0^\circ C$.

22. Which of these statements is correct? The elements of column 4 of the Periodic Table

A. are all metals.
B. do not form dioxides.
C. all form the same number of bonds.
D. dissolve readily in water.

23. A sample of copper (II) sulphate containing copper (II) oxide was powdered and mixed with a large volume of water. The mixture was then filtered. Which one of the following statements is true?

A. The copper (II) oxide would dissolve in the water.
B. The copper (II) sulphate would be left on the filter paper.
C. One compound dissolves in the water and the other does not.
D. The filtrate would be colourless.

24. Three metals Z, T and Y were added to separate solutions containing metal X ions. Z precipitates X; T had no effect; and with Y a gas was given off from the solution.
Which one shows the metals in the correct order of activity (the most reactive first)?

A. Y Z X T.
B. Y X T Z.
C. Z X T Y.
D. T X Y Z.

25. Why are the atomic weights of naturally occurring elements not whole numbers?

A. The number of protons and neutrons in each element varies.
B. Naturally occurring elements are mixtures of isotopes.
C. Chemical methods of atomic weight determination are inaccurate.
D. It is difficult to isolate the elements in the pure state.

26. If X is the symbol for an element, which position is used for the atomic number?

$$\begin{array}{ccc} A & & B \\ & X & \\ D & & C \end{array}$$

27. ${}^{35}_{17}Cl^{-}$ and ${}^{40}_{20}Ca^{2+}$ have the same number of

A. protons.
B. electrons.
C. charges.
D. neutrons.

28. Calcium is a metal which burns in oxygen to form an oxide which when added to water gives a solution whose pH value is

A. between 2 and 5.
B. between 5 and 7.
C. 7.
D. above 7.

UNIVERSITY OF GLASGOW - SCIENCE EDUCATION GROUP

LANGUAGE IN CHEMISTRY

PINK 'E' TEST (3)

1. When meat is boiled for too long, it <u>disintegrates</u>.
It:

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   B. breaks into small pieces.
   C. dries out.
   D. disappears.

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   A. $\frac{1}{2}$.
   B. 5/10.
   C. 50.
   D. 0.5.

3. The doctor saw a man with a disease that had never been seen before.
The doctor thought that the disease might have been caused by the food the man had eaten.
The doctor's idea could be called

   A. a fact.
   B. an observation.
   C. a result.
   D. a theory.

4. Which of the following groups of objects has the most <u>diversity</u>?

   A. □ □ ○ △ ○.
   B. ▭ △ ○ ▭.
   C. ○ ○ □ ○ △ △.
   D △ △ △ △ △ △ △ △.

5. Some students are studying the <u>fundamental</u> laws of physics.
What does fundamental mean?

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   C. A woman has six children, all born together.
   D. A man grows to a height of 7 feet.

8. When a solid is dissolved in a liquid, that solid is called

A. the solution.
B. the residue.
C. the solute.
D. the solvent.

9. Which one of the following requires a non-aqueous solvent to dissolve it?

A. Salt.
B. Sugar.
C. Sodium nitrate.
D. Sulphur.

0. Elements in the same group of the Periodic Table have the same number of

A. protons.
B. electron shells.
C. neutrons.
D. outer electrons.

1. Which one of the following is a pungent gas?

A. Carbon dioxide.
B. Nitrogen.
C. Sulphur dioxide.
D. Methane.

2. When a concentrated aqueous solution of sodium bromide is electrolysed, the product at the anode is

A. bromine.
B. hydrogen.
C. oxygen.
D. sodium.

3. Which is the least stable sulphide among the following?

A. Lead sulphide.
B. Sodium sulphide.
C. Calcium sulphide.
D. Zinc sulphide.

4. A fused compound conducts electricity but when solid does not conduct. This suggests the bonding in the compound is

A. covalent.
B. polar covalent.
C. metallic.
D. ionic.

5. To distinguish between nitrogen and helium you could use:

A. a burning taper.
B. a large balloon.
C. a glowing splint.
D. bromine water.

16. The valency of nitrogen is the same as that of

    A. hydrogen.
    B. beryllium.
    C. boron.
    D. oxygen.

17. W, X, Y and Z are four consecutive elements in the Periodic Table. Y is a noble gas. Which formula is likely to be correct?

    A. WX.
    B. Z_2W.
    C. Z_2X.
    D. ZW_2.

18. A sample of element X contains the following types of atom:

$$^{13}_{7}X \qquad ^{15}_{7}X \qquad ^{16}_{7}X$$

The electronic configuration of the element is

    A. 2,4.
    B. 2,5.
    C. 2,6.
    D. 2,7.

19. An isotope of aluminium has an atomic number of 13 and a mass number of 27. An atom of this isotope will contain

    A. 14 protons and 13 neutrons.
    B. 13 protons and 14 neutrons.
    C. 14 protons and 13 electrons.
    D. 13 protons and 14 electrons.

20. Some atoms of an element are heavier than other atoms of the same element. This is because they have different numbers of

    A. neutrons.
    B. nuclei.
    C. protons.
    D. electrons.

21. Which of the following statements is not true of sea water?

    A. It has a higher electrical conductivity than tap water.
    B. It contains dissolved gold salts.
    C. It contains a variety of positive ions and negative ions.
    D. It freezes at 0°C.

22. Which of these statements is incorrect? The elements of column 4 of the Periodic Table

    A. all form the same number of bonds.
    B. all form dioxides.
    C. are all metals.
    D. do not dissolve readily in water.

23. A sample of copper (II) sulphate containing copper (II) oxide was powdered and mixed with a large volume of water. The mixture was then filtered. Which one of the following statements is not true?

A. The copper (II) sulphate would dissolve in the water.
B. The copper (II) oxide would be left in the filter paper.
C. Both compounds would be left on the filter paper.
D. The filtrate would be a blue solution.

24. When a metal Z was added to the sulphate of a metal X, the metal X was precipitated and there was no effervescence. When the test was repeated using the metal T in place of Z no reaction occurred. When a metal Y was added to a solution of the sulphate of X, a brisk effervescence occurred. Which one of the following is the correct order of decreasing activity (i.e. the most reactive first) of the four metals?

A. Y Z X T.
B. Y X T Z.
C. Z X T Y
D. T X Y Z.

25. Which of the following is the best explanation of the fact that the atomic weights of most of the naturally occurring elements are not whole numbers?

A. The number of protons and neutrons in each element varies.
B. Naturally occurring elements are mixtures of isotopes.
C. Chemical methods of atomic weight determination are inaccurate.
D. It is difficult to isolate the elements in the pure state.

26. Around the symbol for an element there are four positions where further information may be given. Which of these positions is used to indicate the atomic number?

A. Top left.
B. Top right.
C. Bottom right.
D. Bottom left.

27. Which statement is true about the ions $^{35}_{17}Cl^{-}$ and $^{40}_{20}Ca^{2+}$?

A. Their atoms contain the same number of protons.
B. They contain the same number of electrons.
C. They will combine with the same number of F^{-} ions.
D. They contain the same number of neutrons.

28. What would be the pH of the solution formed when calcium oxide dissolves in water?

A. Between 2 and 5.
B. Between 5 and 7.
C. 7.
D. Above 7.

UNIVERSITY OF GLASGOW - SCIENCE EDUCATION GROUP

LANGUAGE IN CHEMISTRY

YELLOW 'O' TEST (78)

1. Which one of the following compounds is predominantly covalent?

   A. Potassium bromide.
   B. Carbon tetrachloride.
   C. Silver iodide.
   D. Aluminium chloride.

2. Which one of the following solutions would conduct electricity appreciably?

   A. A glucose solution.
   B. A salt solution.
   C. A sugar solution.
   D. A starch solution.

3. When calcium is added to water which of the following are produced?

   A. An acid and oxygen.
   B. An acid and hydrogen.
   C. An alkali and oxygen.
   D. An alkali and hydrogen.

4. An unknown metal X was found to be more reactive than sodium. Predict which one of the following is most likely to be correct.

   A. It will oxidise readily in air.
   B. It should be stored under water.
   C. Its compounds will be unstable.
   D. It will be obtained from its oxide by reduction with carbon.

5. Which one of the following will be a non-conductor of electricity when it is a solid, but a conductor when it is a liquid?

   A. Sulphur.
   B. Hydrogen chloride.
   C. Potassium bromide.
   D. Carbon tetrachloride.

6. What is the product at the positive electrode when a concentrated aqueous solution of potassium iodide is electrolysed?

   A. Hydrogen.
   B. Oxygen.
   C. Potassium.
   D. Iodine.

7. A sample of element X contains the following types of atom:

$$^{13}_{7}X \qquad ^{15}_{7}X \qquad ^{16}_{7}X$$

The electronic configuration of the element is

   A. 2,4.
   B. 2,5.
   C. 2,6.
   D. 2,7.

8. An isotope of aluminium has an atomic number of 13 and a mass number of 27. An atom of this isotope will contain

A. 14 protons and 13 neutrons.
B. 13 protons and 14 neutrons.
C. 14 protons and 13 electrons.
D. 13 protons and 14 electrons.

9. Some atoms of an element are heavier than other atoms of the same element. This is because they have different numbers of

A. neutrons.
B. nuclei.
C. protons.
D. electrons.

10. A saturated solution of a substance is one

A. in which 1g of the substance is dissolved.
B. which is made by dissolving the substance in boiling water.
C. in which no more of the substance will dissolve at a given temperature.
D. in which the substance is dissolved without stirring at a given temperature.

11. Crude oil is refined by:

A. filtration.
B. sublimation.
C. distillation.
D. condensation.

12. When a solid dissolves in a liquid, the liquid part is called:

A. solute.
B. soluble.
C. solution.
D. solvent.

13. What do we call the change when water turns into a gas?

A. Freezing.
B. Condensing.
C. Evaporation.
D. Melting.

14. Which of these is an emulsion?

A. Bleach.
B. Ink.
C. Sugar dissolved in water.
D. Milk.

In the following questions all the answers are correct but we would like to find out which <u>one</u> you prefer.

15. If you were asked to explain the meaning of the word ELEMENT which <u>ONE</u> of the following statements would you prefer to use?

A. An element is a substance which is made of only one type of atom.
B. An element is composed of atoms all of which have the same atomic number.
C. Elements are substances where atoms all contain the same number of protons in the nucleus.

16. If you were asked to explain the meaning of the word ISOTOPES which <u>ONE</u> of the following statements would you prefer to use?

A. Isotopes of an element are composed of atoms that have the same atomic number but different mass numbers.
B. Isotopes are atoms of the same element with different numbers of neutrons.
C. Isotopes are atoms of an element with different mass numbers.
D. Isotopes are atoms with the same atomic number but different mass numbers.

17. If you were asked to explain the meaning of the words ATOMIC MASS which <u>ONE</u> of the following statements would you prefer to use?

A. The Atomic Mass of an element is the weighted mean of the isotopic masses on the scale in which an atom of ^{12}C is taken as 12 exactly.
B. The Atomic Mass of an element is the average mass of one atom of an element on a scale where the carbon 12 isotope $^{12}_{6}C$ has a mass of 12.00000a.m.u.
C. The Atomic Mass of an element is the average mass of an atom of the element, taking into account the proportion of each isotope present.
D. The Atomic Mass of an element is the average mass of the isotopes of the element in their proportion.

18. If you were asked to explain the meaning of the words MASS NUMBER which <u>ONE</u> of the following statements would you prefer to use?

A. The total number of protons and neutrons in an atom is called the Mass Number.
B. The Mass Number of an atom is the number of protons plus the number of neutrons in its nucleus.
C. The Mass Number of an atom is the sum of the number of protons and neutrons in that atom.
D. The Mass Number of an isotope of an element is the number of protons and neutrons in the nucleus of an atom of the isotope.

19. If you were asked to explain the meaning of the words ATOMIC NUMBER which <u>ONE</u> of the following statements would you prefer to use?

A. The Atomic Number of an element is the number of protons in the nucleus of an atom of an element.
B. The Atomic Number of an atom is the number of protons in the nucleus of that atom.
C. The Atomic Number of an element is the number of protons in an atom of the element.
D. The Atomic Number of an element is the number of protons in the nucleus of one of its atoms.

In the following questions you have to choose the answer to fill in the blank space. There may be more than one answer that is correct. I would like you to choose the ONE answer which you prefer to use.

20. The energy is ——— as light.

A. discharged.
B. released.
C. emitted.
D. given out.

21. We have already ——— charged atoms.

A. met.
B. come across.
C. encountered.
D. confronted.

22. Atoms cannot lose electrons easily because this ——— pulling a negative particle (the electron) away from the attraction of the positive nucleus.

A. means.
B. involves.
C. entails.
D. signifies.

23. In electrovalent compounds each ——— ion is attracted to all its neighbours.

A. no word is needed.
B. individual.
C. separate.
D. constituent.

24. Does this ——— anything about the colour of the dichromate ions?

A. suggest.
B. signify.
C. tell us.
D. indicate.

One of the main differences which we found between (25) and compounds was the fact that the (26) of the components in a mixture could be varied while the (27) of a (28) were in a fixed proportion.

25. A. mixtures.
B. components.
C. proportions.

26. A. compounds.
B. mixtures.
C. proportions.

27. A. proportions.
B. components.
C. compounds.

28. A. compound.
B. mixture.
C. component.

Thank you for your help.

UNIVERSITY OF GLASGOW - SCIENCE EDUCATION GROUP

LANGUAGE IN CHEMISTRY

P I N K 'E' T E S T (78)

1. In which one of the following compounds does covalency predominate?

   A. Potassium bromide.
   B. Carbon tetrachloride.
   C. Silver iodide.
   D. Aluminium chloride.

2. Which one of the following solutions would have an appreciable electrical conductivity?

   A. A glucose solution.
   B. A salt solution.
   C. A sugar solution.
   D. A starch solution.

3. When calcium is added to water which of the following are the products?

   A. An acid and oxygen.
   B. An acid and hydrogen.
   C. An alkali and oxygen.
   D. an alkali and hydrogen.

4. An unknown metal X was found to be more reactive than sodium. Which one of the following predictions is most likely to be correct?

   A. It will oxidise readily in air.
   B. It should be stored under water.
   C. Its compounds will be unstable.
   D. It will be obtained from its oxide by reduction with carbon.

5. Which one of the following does not conduct electricity when it is a solid but does conduct electricity when it is a liquid?

   A. Sulphur.
   B. Hydrogen chloride.
   C. Potassium bromide.
   D. Carbon tetrachloride.

6. When a concentrated aqueous solution of potassium iodide is electrolysed the product at the positive electrode is:

   A. hydrogen.
   B. oxygen.
   C. potassium.
   D. iodine.

7. A sample of element X contains the following types of atom:

   $^{13}_{7}X$ $\quad$ $^{15}_{7}X$ $\quad$ $^{16}_{7}X$

   The electronic configuration of the element is

   A. 2,4.
   B. 2,5.
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8. An isotope of aluminium has an atomic number of 13 and a mass number of 27. An atom of this isotope will contain

    A. 14 protons and 13 neutrons.
    B. 13 protons and 14 neutrons.
    C. 14 protons and 13 electrons.
    D. 13 protons and 14 electrons.

9. Some atoms of an element are heavier than other atoms of the same element. This is because they have different numbers of

    A. neutrons.
    B. nuclei.
    C. protons.
    D. electrons.

10. When a gas dissolves in a liquid, the mixture of the gas and the liquid is called a:

    A. bubble.
    B. solute.
    C. solution.
    D. solvent.

11. When making water fit to drink, mud is removed from pond water by:

    A. chlorination.
    B. distillation.
    C. filtration.
    D. precipitation.

12. When a solid dissolves in a liquid, the solid part is called:

    A. Solvent.
    B. Solution.
    C. Residue.
    D. Solute.

13. Which one of the following is a non aqueous solvent?

    A. Water.
    B. Starch.
    C. Petrol.
    D. None of these.

14. Particles in a colloid:

    A. can be seen without a microscope.
    B. will not go through filter paper.
    C. settle to the bottom of their container in time.
    D. can reflect light and make a beam.

In the following questions all the answers are correct but we would like to find out which <u>one</u> you prefer.

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    C. Elements are substances where atoms all contain the same number of protons in the nucleus.

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D. Isotopes are atoms with the same atomic number but different mass numbers.

17. If you were asked to explain the meaning of the words ATOMIC MASS which <u>ONE</u> of the following statements would you prefer to use?

A. The Atomic Mass of an element is the weighted mean of the isotopic masses on the scale in which an atom of ^{12}C is taken as 12 exactly.
B. The Atomic Mass of an element is the average mass of one atom of an element on a scale where the carbon 12 isotope $^{12}_{6}C$ has a mass of 12.00000a.m.u.
C. The Atomic Mass of an element is the average mass of an atom of the element, taking into account the proportion of each isotope present.
D. The Atomic Mass of an element is the average mass of the isotopes of the element in their proportion.

18. If you were asked to explain the meaning of the words MASS NUMBER which <u>ONE</u> of the following statements would you prefer to use?

A. The total number of protons and neutrons in an atom is called the Mass Number.
B. The Mass Number of an atom is the number of protons plus the number of neutrons in its nucleus.
C. The Mass Number of an atom is the sum of the number of protons and neutrons in that atom.
D. The Mass Number of an isotope of an element is the number of protons and neutrons in the nucleus of an atom of the isotope.

19. If you were asked to explain the meaning of the words ATOMIC NUMBER which <u>ONE</u> of the following statements would you prefer to use?

A. The Atomic Number of an element is the number of protons in the nucleus of an atom of an element.
B. The Atomic Number of an atom is the number of protons in the nucleus of that atom.
C. The Atomic Number of an element is the number of protons in an atom of the element.
D. The Atomic Number of an element is the number of protons in the nucleus of one of its atoms.

In the following questions you have to choose the answer to fill in the blank space. There may be more than one answer that is correct. I would like you to choose the ONE answer which you would prefer to use.

20. We learned that the nucleus of an atom is ——— in the heart of the atom.

A. found.
B. concentrated.
C. focussed.
D. situated.

21. ——— the Periodic Table at the front of the book and remind yourself of the names of the noble gases.

A. Look at.
B. Examine.
C. Refer to.
D. Peruse.

22. The gas which you are able to smell at the onode during the electrolysis of copper chloride ——— molecules of chlorine.

A. was made up of.
B. was composed of.
C. consisted of.
D. comprised of.

23. In electrovalent compounds each ——— ion is attracted to all its neighbours.

A. no word is needed.
B. individual.
C. separate.
D. constituent.

24. Different colours ——— to different amounts of energy.

A. accord.
B. relate.
C. mean.
D. correspond.

One of the main differences which we found between (25) and compounds was the fact that the (26) of the components in a mixture could be varied while the (27) of a (28) were in a fixed proportion.

25. A. mixtures.
B. components.
C. proportions.

26. A. compounds.
B. mixtures.
C. proportions.

27. A. proportions.
B. components.
C. compounds.

28. A. compound.
B. mixture.
C. component.

Thank you for your help.

UNIVERSITY OF GLASGOW

SCIENCE EDUCATION GROUP

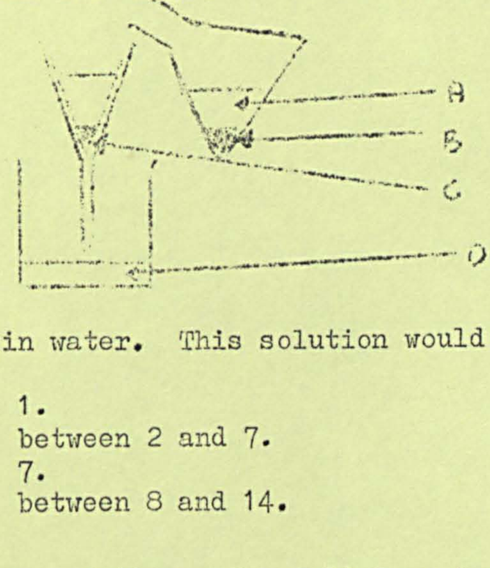
Language in Chemistry

Yellow 'O' Test (1979)

In each of these questions choose the substance that is a compound

Question	Answers			
	A	B	C	D
1.	Rust	Air	Lead	Tin
2.	Iron	Milk	Sulphur	Salt
3.	Copper	Ice	Silver	Sulphur

4. Which of the substances in the diagram below could be called the filtrate?



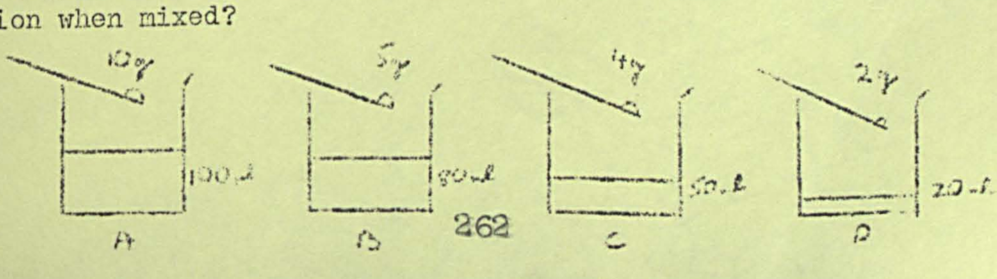
5. Calcium oxide dissolves in water. This solution would have a pH of

A 1.
B between 2 and 7.
C 7.
D between 8 and 14.

6. Which one of the following solutions of a salt in water is the least concentrated?

A 11g of salt dissolved in 15cm^3 of water.
B 9g of salt dissolved in 10cm^3 of water.
C 7g of salt dissolved in 15cm^3 of water.
D 5g of salt dissolved in 10cm^3 of water.

7. Which beaker of water and spatula of salt would make the most dilute solution when mixed?



8. Copper when heated in air turns black. Copper heated in the absence of air does not turn black. Which one of the following statements is true about copper?

When heated:
A in the absence of air it loses weight.
B in air it stays the same weight.
C in the absence of air it stays the same weight.
D in the absence of air it gains weight.

9. A brass contains 75 per cent copper, 22 per cent zinc, 2 per cent aluminium and 1 per cent lead.

What is the most abundant element in this brass?

A Aluminium.
B Copper.
C Lead.
D Zinc.

10. To tell ethene and propanol apart, just by looking at them, you would have to know that

A the molecules of propanol are larger than those of ethene.
B ethene molecules contain a double bond whereas propanol molecules do not.
C ethene is a gas and propanol is a liquid.
D propanol is an alcohol and ethene is not.

11. A sample of element X contains the following types of atom:

$^{13}_{7}X$ $^{15}_{7}X$ $^{16}_{7}X$

The electronic configuration of the element is

A 2,4.
B 2,5.
C 2,6.
D 2,7.

12. An isotope of aluminium has an atomic number of 13 and a mass number of 27. An atom of this isotope will contain

A 14 protons and 13 neutrons.
B 13 protons and 14 neutrons.
C 14 protons and 13 electrons.
D 13 protons and 14 electrons.

13. Some atoms of an element are heavier than other atoms of the same element. This is because they have different numbers of

A neutrons.
B nuclei.
C protons.
D electrons.

14. Which one of the following pairs of particles would contain equal numbers of protons?

A Na and Na^+.
B Na^+ and Ne.
C Cl^- and Ar.
D K^+ and Ca^{2+}.

15. Which one of the following particles has the same number of electrons as a calcium ion?

A A potassium atom.
B A potassium ion.
C A magnesium ion.
D A chlorine atom.

16. Which statement is not true?

A The proton does not have the same mass as an electron.
B The hydrogen molecule contains two atoms.
C Isotopes of chlorine do not have different numbers of protons in their atoms.
D The element with Atomic Number 13 is a non metal.

17. In which of the following elements do most of the atoms contain equal numbers of protons and neutrons?

A Fluorine.
B Oxygen.
C Chlorine.
D Hydrogen.

18. A compound with the general formula XY_3 would be likely to be formed from which of the following pairs of elements?

A Phosphorus and hydrogen.
B Hydrogen and sulphur.
C Sulphur and chlorine.
D Chlorine and carbon.

19. Atoms of X have two electrons in the outer shell.
Atoms of Y have seven electrons in the outer shell.
Atoms of X and Y combine.
Which one of the following statements is true?

A The compound formed has the formula XY_2.
B X^+ ions are formed.
C Y^{2-} ions are formed.
D The compound formed is covalent.

20. Which of the following compounds has a formula of the type X_2Y where both ions have the same electronic arrangement as argon (2,8,8) ?

A Potassium sulphide.
B Calcium chloride.
C Sodium fluoride.
D Potassium oxide.

21. An analysis of 24g of antimony oxide showed that 20g were antimony and 4g were oxygen. Knowing that the atomic weight of antimony was 120 and that of oxygen was 16, which of the following formulae would correctly represent antimony oxide?

A SbO.
B SbO_2.
C SbO_3.
D Sb_2O_3.

22. A solution of a salt is electrolysed. At the negative electrode a brown deposit forms and at the positive electrode a yellowish green gas is evolved. Which of the following could have been the salt?

A Potassium bromide.
B Lead chloride.
C Copper chloride.
D Calcium iodide.

23. Which one of these compounds is covalent?

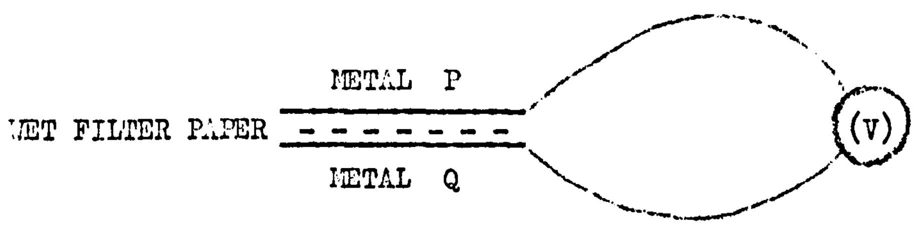
A Calcium fluoride.
B Sulphur chloride.
C Sodium bromide.
D Potassium iodide.

24. To make an exactly 0.1 Molar solution of sodium chloride (formula weight = 58.5) what would you do?

A Dissolve 5.85g of sodium chloride in 100ml of water.
B Dissolve 5.85g of sodium chloride in water and make up with water to 1 litre of solution.
C Add 100ml of a molar solution of sodium chloride to 1 litre of water.
D Add 5.85g of sodium chloride to 1 litre of water and shake until dissolved.

25. In which one of the following are the metals arranged in decreasing order of activity?

A Iron, calcium, sodium.
B Calcium, iron, sodium.
C Iron, sodium, calcium.
D Sodium, calcium, iron.



26. Which pair of metals would give the lowest reading on the voltmeter?

	METAL P	METAL Q
A	Zinc	Copper
B	Magnesium	Silver
C	Iron	Tin
D	Lead	Platinum

27. Carbon reduces iron(II) oxide at high temperature but does not reduce magnesium oxide. Which of the following statements is a correct deduction from these facts?

A Magnesium ions accept electrons less easily than do iron(II) ions.
B Iron is a more active metal than magnesium.
C Oxides of metals are stable compounds.
D Iron(II) oxide forms iron(II) carbonate with hot carbon.

28. Which pair of compounds would both decompose when heated separately with a bunsen burner?

A Sodium nitrate, calcium oxide.
B Zinc oxide, lithium nitrate.
C Copper carbonate, mercury oxide.
D Potassium carbonate, silver oxide.

In the following questions you have to choose the answer to fill in the blank space. There may be more than one answer that is correct. I would like you to choose the ONE answer which you would prefer to use.

29. When lithium is added to the water you can see ________

A efflorescence. B bubbles. C effervescence. D frothing.

30. Substances which conduct electricity when dissolved in water or when molten are called electrolytes. These substances are ________ by electricity.

A separated. B decomposed. C broken down. D resolved.

31. Sodium chloride solution conducts electricity ________.

A no word necessary. B sufficiently. C greatly. D appreciably.

In the following questions choose the word or phrase which you feel fits best into the blank space.

32. Carborunden and diamond are both made of giant molecules. All substances made of giant molecules have melting points above 1000°C. Silicon is also made of giant molecules. ________, silicon has a melting point above 1000°C.

A However
B Yet
C Namely
D Therefore

33. Ionic salts dissolve in water to form solutions which conduct electricity. Sodium chloride and potassium chloride are both ionic salts. ________ solutions of both salts will conduct electricity.

A On the other hand
B Consequently
C Conversely
D However

In the following questions more than one answer may be correct but we would like to find out which one you prefer.

34. If you were asked to explain the meaning of the word element which ONE of the following statements would you prefer to use?

A An element is a substance which is made of only one type of neutron.
B An element is composed of atoms all of which have the same mass number.
C Elements are substances where atoms all contain the same number of protons in the nucleus.
D An element is made of only one type of atom.

35. If you were asked to explain the meaning of the word isotopes which ONE of the following statements would you prefer to use?

A Isotopes of an element are composed of atoms that have the same atomic number.
B Isotopes are atoms of the same element with different numbers of protons.
C Isotopes are atoms of an element with different mass numbers.
D Isotopes are atoms with the same atomic number but different mass numbers.

36. If you were asked to explain the meaning of the words Mass Number which ONE of the following statements would you prefer to use?

A The total number of protons and electrons in an atom is called the mass number.
B The mass number of an atom is the number of protons plus the number of electrons in its nucleus.
C The mass number of an atom is the sum of the number of protons and neutrons in that atom.
D The mass number of an isotope of an element is the number of protons and neutrons in the nucleus of an atom of the isotope.

UNIVERSITY OF GLASGOW

SCIENCE EDUCATION GROUP

Language in Chemistry

Pink 'E' Test (1979)

In each of these questions choose the substance that is an element

Question	Answers			
	A	B	C	D
1.	Chlorine	Salt	Sugar	Water
2.	Alcohol	Milk	Solder	Tin
3.	Acid	Iron	Litmus	Rust

4. Which method would be best for separating a mixture of an insoluble solid and a liquid?

 A Crystallisation
 B Distillation
 C Evaporation
 D Filtration

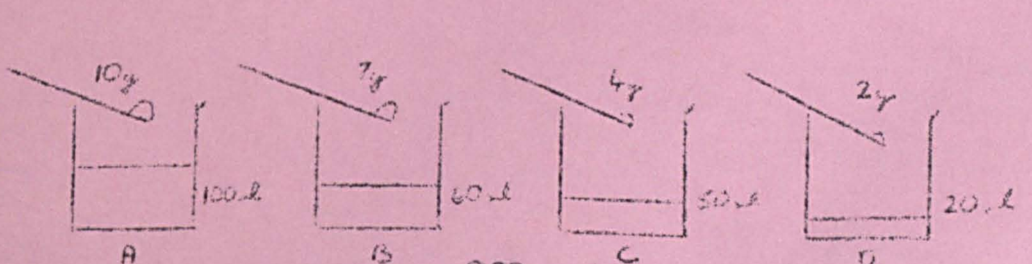
5. The burning of calcium in oxygen produces an oxide which, when it is added to water, gives a solution whose pH value is

 A 1.
 B between 2 and 7.
 C 7.
 D between 8 and 14.

6. Which one of the following solutions of a salt in water is the most concentrated?

 A 11g of salt dissolved in 10cm^3 of water.
 B 9g of salt dissolved in 10cm^3 of water.
 C 7g of salt dissolved in 5cm^3 of water.
 D 5g of salt dissolved in 5cm^3 of water.

7. Which beaker of water and spatula of salt would make the most concentrated solution when mixed?



8. A piece of copper, when heated directly in the bunsen flame, turns black but when heated in a hard glass tube from which all air has been removed it does not turn black. Which one of the following statements is true about copper?

When heated: A in the tube it loses weight.
B in air it stays the same weight.
C in the tube it stays the same weight.
D in the tube it gains weight.

9. A brass contains 75 per cent copper, 22 per cent zinc, 2 per cent aluminium and 1 per cent lead.

What is the least abundant element in this brass?

A Zinc.
B Lead.
C Copper.
D Aluminium.

10. To distinguish visually between ethene and propanol, one would have to know that

A the molecules of propanol are larger than those of ethene.
B ethene molecules contain a double bond whereas propanol molecules do not.
C ethene is a gas and propanol is a liquid.
D propanol is an alcohol and ethene is not.

11. A sample of element X contains the following types of atom:

$$^{13}_{7}X \qquad ^{15}_{7}X \qquad ^{16}_{7}X$$

The electronic configuration of the element is

A 2,4.
B 2,5.
C 2,6.
D 2,7.

12. An isotope of aluminium has an atomic number of 13 and a mass number of 27. An atom of this isotope will contain

A 14 protons and 13 neutrons.
B 13 protons and 14 neutrons.
C 14 protons and 13 electrons.
D 13 protons and 14 electrons.

13. Some atoms of an element are heavier than other atoms of the same element. This is because they have different numbers of

A neutrons.
B nuclei.
C protons.
D electrons.

14. Equal numbers of protons would be contained in which one of the following pairs of particles?

A Na and Na^+
B Na^+ and Ne
C Cl^- and Ar
D K^+ and Ca^{2+}

15. Which one of the following particles does <u>not</u> have the same number of electrons as a calcium ion?

A A potassium ion.
B A potassium atom.
C An argon atom.
D A chlorine atom.

16. Which statement is true?

A The proton has the same mass as an electron.
B The hydrogen molecule contains three atoms.
C Isotopes of chlorine have different numbers of protons in their atoms.
D The element with Atomic Number 13 is a metal.

17. In which of the following elements do most of the atoms contain unequal numbers of protons and neutrons?

A Carbon.
B Fluorine.
C Nitrogen.
D Oxygen.

18. Which of the following pairs of elements are likely to form a compound with the general formula XY_3 ?

A Phosphorus and hydrogen.
B Hydrogen and sulphur.
C Sulphur and chlorine.
D. Chlorine and carbon.

19. Atoms of element X, which have two electrons in the outer shell, combine with atoms of element Y, which have seven electrons in the outer shell. Which one of the following statements is true?

A The compound formed has the formula XY_2.
B X^+ ions are formed.
C Y^{2-} ions are formed.
D The compound formed is covalent.

20. A compound, where both ions have the same electronic arrangement as argon (2, 8, 8), has a formula of the type X_2Y. Which of these compounds is it?

A Potassium sulphide.
B Calcium chloride.
C Sodium fluoride.
D Potassium oxide.

21. From an analysis of 24g of antimony oxide, which showed that 20g were antimony and 4g were oxygen, which of the following formulae would correctly represent antimony oxide, knowing that the atomic weight of antimony was 120 and that of oxygen was 16 ?

A SbO
B SbO_2
C SbO_3
D Sb_2O_3

22. Which of the following could be a salt which, when a solution is electrolysed, gives a brown deposit at the negative electrode and evolves a yellowish green gas at the positive electrode?

A Potassium bromide.
B Lead chloride.
C Copper chloride.
D Calcium iodide.

23. In which one of the following compounds is there a tendency for covalency to predominate?

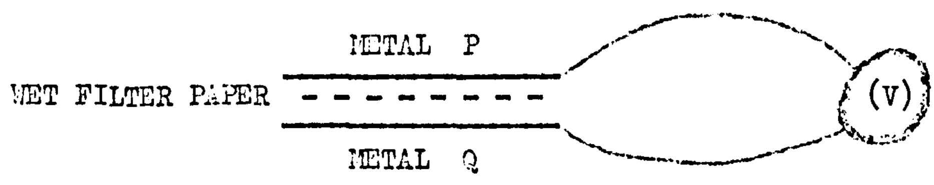
A Calcium fluoride.
B Sulphur chloride.
C Sodium bromide.
D Potassium iodide.

24. Which of the following procedures would be expected to produce an exactly 0.1 Molar solution of sodium chloride (formula weight = 58.5) ?

A Dissolving 5.85g of sodium chloride in 100 ml of water.
B Dissolving 5.85g of sodium chloride in water and making up with water to 1 litre of solution.
C Adding 100ml of a molar solution of sodium chloride to 1 litre of water.
D Adding 5.85g of sodium chloride to 1 litre of water and shaking until dissolved.

25. In which one of the following are the metals arranged in increasing order of activity?

A Sodium, calcium, iron.
B Calcium, iron, sodium.
C Iron, sodium, calcium.
D Iron, calcium, sodium.



26. Which pair of metals would give the highest reading on the voltmeter ?

	METAL P	METAL Q
A	Zinc	Copper
B	Iron	Tin
C	Magnesium	Silver
D	Lead	Platinum

27. Iron(II) oxide is reduced when it is heated with carbon, but magnesium oxide is unaffected by this treatment. Which of the following statements is a correct deduction from these facts?

A Magnesium ions accept electrons less easily than do iron(II) ions.
B Iron is a more active metal than magnesium.
C Oxides of metals are stable compounds.
D Iron(II) oxide forms iron(II) carbonate with hot carbon.

28. In which of the following would both compounds not have been decomposed when heated separately with a bunsen burner?

A Sodium nitrate, silver oxide.
B Mercury oxide, zinc nitrate.
C Potassium carbonate, calcium oxide.
D Copper carbonate, lithium nitrate.

In the following questions you have to choose the answer to fill in the blank space. There may be more than one answer that is correct. I would like you to choose the ONE answer which you would prefer to use.

29. Two elements have the electronic arrangement 2, 8 and 2, 8, 8. These elements are particularly ____________ .

A unreactive. B inert. C stable. D inactive.

30. Place a small crystal of blue copper(II) sulphate in the water at one side of the dish and a small crystal of potassium ferrocyanide at the other. These should give evidence for the ____________ of the ions.

A movement. B diffusion. C spreading. D dispersion.

31. The copper coloured wires which you have been using in your electrolysis are ____________ not composed of blue copper ions!

A plainly. B obviously. C manifestly. D evidently.

In the following questions choose the word or phrase which you feel fits best into the blank space.

32. The formula of carbon dioxide is CO_2; ____________ a carbon dioxide molecule contains one carbon atom and two oxygen atoms.

A for example.
B such as
C conversely
D that is

33. Students shall not taste acids and bases; ____________ they should not taste any dangerous chemicals.

A nevertheless
B indeed
C although
D consequently

In the following questions more than one answer may be correct but we would like to find out which one you prefer.

34. If you were asked to explain the meaning of the word element which ONE of the following statements would you prefer to use?

A An element is a substance which is made of only one type of neutron.
B An element is composed of atoms all of which have the same mass number.
C Elements are substances where atoms all contain the same number of protons in the nucleus.
D An element is made of only one type of atom.

35. If you were asked to explain the meaning of the word isotopes which ONE of the following statements would you prefer to use?

A Isotopes of an element are composed of atoms that have the same atomic number.
B Isotopes are atoms of the same element with different numbers of protons.
C Isotopes are atoms of an element with different mass numbers.
D Isotopes are atoms with the same atomic number but different mass numbers.

36. If you were asked to explain the meaning of the words Mass Number which ONE of the following statements would you prefer to use?

A The total number of protons and electrons in an atom is called the mass number.
B The mass number of an atom is the number of protons plus the number of electrons in its nucleus.
C The mass number of an atom is the sum of the number of protons and neutrons in that atom.
D The mass number of an isotope of an element is the number of protons and neutrons in the nucleus of an atom of the isotope.

Joint Matriculation Board

General Ability Test (Verbal)

DO NOT TURN OVER THE PAGE UNTIL YOU ARE TOLD TO DO SO.

The time allowed for this test is 30 minutes.

ANSWER ALL THE QUESTIONS.

Answers to questions must be entered in pencil on the special answer-sheet provided. Do NOT use a ball-point pen. The method of recording your answers is shown on the answer-sheet. Erase completely any mark you wish to change.

If you need to do any rough work you should use the question booklet and NOT the answer-sheet.

The questions in this test are numbered from 1 to 40. Your answers should be marked on the section of the answer-sheet which is referred to as Part I.

DO NOT REMOVE THE QUESTION BOOKLET OR ANSWER-SHEET FROM THE ROOM.

Each of the following five sentences (1 to 5) has a "twin" among the answers list (lettered A to E) i.e. a sentence with a similar meaning. Find the "twin" of each numbered sentence and mark the space for its letter on your answer sheet.

1. Empty vessels make the most sound.
2. Don't count your chickens until they are hatched.
3. Patience wears out stones.
4. Imitation is the sincerest form of flattery.
5. It never rains but it pours.

Answers

A) Troubles seldom come singly.
B) He that persists, succeeds.
C) We copy only those we admire.
D) There's many a slip 'twixt cup and lip.
E) Much cry, little wool.

In each sentence in questions 6 to 8 there is a hidden word in one of the sections. Mark the space for the section on your answer sheet.

6. FIND THE ANIMAL OR FRUIT

The long	lost riches	of the Incas	will never	be found.
A	B	C	D	E

7. FIND THE ANIMAL OR FRUIT

They	tried hard	not to	drop lumps	of wax.
A	B	C	D	E

8. FIND THE WORD THAT GOES BEST WITH CHAR AND BURN

One of the most	direct routes	to America	is across	the Atlantic Ocean.
A	B	C	D	E

In questions 9 to 11, choose the best word to complete the sentence.

9. Lung is to breathe as heart is to:

A) blood
B) valve
C) pump
D) life
E) mind

10. Square is to circle as cube is to:

A) arc
B) cylinder
C) cone
D) pyramid
E) sphere

11. Mechanic is to machine as physician is to:

A) hospital
B) medicine
C) gymnasium
D) patient
E) laboratory

PLEASE GO ON TO THE NEXT PAGE

In questions 12 to 14 choose one word which means the opposite of the word in capital letters.

12. The opposite of AMIABLE is:
A) hostile
B) discontented
C) disillusioned
D) unwanted
E) abominable

13. The opposite of DURABLE is:
A) ephemeral
B) dogged
C) patient
D) imponderable
E) tolerable

14. The opposite of OPAQUE is:
A) crystal
B) transparent
C) vague
D) void
E) legible

In questions 15 and 16 choose one word which means the same as the word in capital letters.

15. HARMONY means the same as:
A) tune
B) consent
C) entirety
D) duet
E) agreement

16. EVOLVE means the same as:
A) spin
B) include
C) develop
D) dance
E) avoid

17. The one word which is most like PRAYER, REQUEST and DEMAND is:
A) investigation
B) entreaty
C) discussion
D) question
E) examination

A, B, C, D, and E give examples of classes of things.

A. orange, ham, beer B. oak, elm, beech C. desk, carpet, window D. cat, sparrow, fly E. nail, leg, eye.

On your answer sheet, mark the letter of the class to which the following things (questions 18-22) best belong.

Example: Teak belongs best in class B.

18. human
19. peanut
20. paw
21. vine
22. light

276

PLEASE GO ON TO THE NEXT PAGE

The following five words (A – E) can each have several different meanings. For each of the questions 23 to 29, mark on your answer sheet the letter of the word which goes best or most often with the word in question.

For example: hand, chair and weapon could all go with ARM.

A) TENDER B) SACK C) FAIR D) GRAVE E) FAST

23. engine
24. plunder
25. bid
26. secure
27. serious
28. green
29. share

30. RENOUNCE means the same as:
A) declare
B) dismiss
C) repeat
D) defect
E) disclaim

31. OBNOXIOUS means the same as:
A) offensive
B) oblivious
C) troublesome
D) poisonous
E) officious

32. RELINQUISH means the same as:
A) abandon
B) transfer
C) refrain
D) dismiss
E) cancel

33. The earth is to the sun as the moon is to the:
A) earth
B) stars
C) night
D) planets
E) universe

34. Thermometer is to barometer as temperature is to:
A) weather
B) pressure
C) atmosphere
D) forecast
E) climate

PLEASE GO ON TO THE NEXT PAGE

277

35. The opposite of DEGENERATE is:

A) generate
B) generous
C) charge
D) upstanding
E) autocratic

36. The opposite of COMPETE is:

A) co-operate
B) renovate
C) surfeit
D) defeat
E) replete

37. The opposite of HAMPER is:

A) empower
B) unshackle
C) unburden
D) facilitate
E) precede

In a new language:

It is cold = ist el sup
He was wet = rist els supi
She is cold and wet = ist ler rist elis sup

38. The words for SHE IS WET are:

A) ist elis sup
B) ler el supi
C) rist elis sup
D) rist els supi
E) None of these

39. The words for HE IS are:

A) ist el
B) rist els
C) ist elis
D) els sup
E) ist ler

40. The words for AND SHE WAS are:

A) ist els sup
B) ler rist sup
C) rist els sup
D) ler elis supi
E) None of these

IF YOU HAVE TIME, PLEASE CHECK THAT YOU HAVE ANSWERED EVERY QUESTION.

Test Y (Yellow)

DO NOT TURN OVER THE PAGE UNTIL YOU ARE TOLD TO DO SO.

The time allowed for this test is 40 minutes.

ANSWER ALL THE QUESTIONS.

Answers to questions must be entered in pencil on the special answer-sheet provided. Do NOT use a ball-point pen. The method of recording your answers is shown on the answer-sheet. Erase completely any mark you wish to change.

If you need to do any rough work you should use the question booklet and NOT the answer-sheet.

The questions in this test are numbered from 41 to 70. Your answers should be marked on the section of the answer-sheet which is referred to as Part II.

The colour of your question booklet is EITHER PINK OR YELLOW. Please indicate, in the space provided on the answer-sheet, which colour your question paper is.

DO NOT REMOVE THE QUESTION BOOKLET OR ANSWER-SHEET FROM THE ROOM.

41. The temperature of the acid was $0^{\circ}C$. The temperature of the powder was $25^{\circ}C$. The metal had a negative temperature.

A. The temperature of the metal was between the acid and the powder.
B. The metal was colder than $0^{\circ}C$.
C. The metal was warmer than the acid and the powder.
D. The temperature of the metal had not been measured.

42. Which sentence uses the word correspond correctly?

A. The fingers on the hand correspond to the toes on the feet.
B. The head corresponds to the neck.
C. The stomach corresponds to the mouth and intestines.
D. The feet correspond to the head.

43. Which sentence uses the word efficient correctly?

A. Children need to eat efficient food to grow strong and healthy.
B. Large brooms are more efficient than small brushes for sweeping the school yeard.
C. The sick boy did not eat enough green vegetables and was efficient in vitamins as a result.
D. The girl did not stay at the school for an efficient time to learn English properly.

44. "If it is an acid, then it will turn litmus red." The converse of this statement is:-

A. If it is not an acid, then it will not turn litmus red.
B. If it is an alkali, then it will turn litmus blue.
C. If it turns litmus red, then it is an acid.
D. It will only turn litmus red if it dissolves in water.

45. Jim said something which was valid. He was

A. correct.
B. hard to understand.
C. telling a lie.
D. saying something new.

46. Which one of the following is not a choking gas?

A. Sulphur dioxide
B. Hydrogen chloride
C. Chlorine
D. Oxygen

47. Which gas has two atoms in every molecule?

A. Carbon dioxide
B. Oxygen
C. Argon
D. Hydrogen sulphide

48. An atom of element Y can be represented as $^{16}_{8}Y$. How many bonds would element Y form?

A. 0
B. 2
C. 6
D. 8

49. An element has an atomic number of 4. Another element in the same column of the Periodic Table would have an atomic number of

A. 14
B. 12
C. 10
D. 8

50. Which one of the following when heated would give a metal?

A. Silver oxide
B. Magnesium chloride
C. Copper(II) oxide
D. Aluminium oxide

51. A melted compound conducts electricity but when solid does not conduct. This suggests the bonding in the compound is

A. covalent.
B. polar covalent.
C. metallic.
D. ionic.

52. A sample of element X contains the following types of atom.

$^{13}_{7}X$ $^{15}_{7}X$ $^{16}_{7}X$

The electronic configuration of the element is

A. 2,4
B. 2,5
C. 2,6
D. 2,7

53. An isotope of aluminium has an atomic number of 13 and a mass number of 27. An atom of this isotope will contain

A. 14 protons and 13 neutrons.
B. 13 protons and 14 neutrons.
C. 14 protons and 13 electrons.
D. 13 protons and 14 electrons.

54. Some atoms of an element are heavier than other atoms of the same element. This is because they have different numbers of

A. neutrons.
B. nuclei.
C. protons.
D. electrons.

55. An element X of atomic number 13, forms a chloride. Which one of the following would be the formula of the chloride?

A. XCl_4
B. XCl_3
C. XCl_2
D. XCl

56. An element has only three isotopes of mass numbers 14, 16 and 17. Which one of the following could be the atomic weight of the element?

A. 19.9
B. 11.7
C. 17.2
D. 15.1

57. A sample of copper(II) sulphate containing copper(II) oxide was powdered and mixed with a large volume of water. The mixture was then filtered. Which one of the following statements is true?

A. The copper(II) oxide would dissolve in the water.
B. The copper(II) sulphate would be left in the filter paper.
C. One compound dissolves in the water and the other does not.
D. The filtrate would be colourless.

58. In which one of the following equations is the first species oxidised?

A. $2Fe^{3+} + 2Cl^{-} \longrightarrow 2Fe^{2+} + Cl_2$
B. $Cl_2 + H_2S \longrightarrow 2HCl + S$
C. $Sn^{2+} + 2Fe^{3+} \longrightarrow Sn^{4+} + 2Fe^{2+}$
D. $2Cl^{-} + Pb^{2+} \longrightarrow Pb^{2+}(Cl^{-})_2$

59. ${}^{8}_{3}Li^{+}$ and ${}^{8}_{4}Be^{2+}$ have the same number of

A. neutrons.
B. protons.
C. charges.
D. electrons.

60. Which one of these particles A to D would be a positively charged ion?

	Protons	Neutrons	Electrons
A.	4	5	4
B.	8	8	10
C.	12	12	10
D.	17	20	17

61. When marble chips react with hydrochloric acid, carbon dioxide is given off. Which one of the following would increase the volume of carbon dioxide given off?

$CaCO_3 + 2HCl \longrightarrow CaCl_2 + CO_2 + H_2O$

(1 mole of $CaCO_3$ is 100 g)

2.5g of marble chips were allowed to react completely with $100cm^3$ 2.0 M (2.0 N) hydrochloric acid. The volume of carbon dioxide could be increased by

A. powdering the marble chips
B. making the acid more concentrated
C. using more acid
D. using more marble chips

62. Three metals Z, T and Y were added to separate solutions containing metal X ions. Z precipitates X; T had no effect; and with Y a gas was given off from the solution. Which one of the following shows the metals in the correct order of activity (the most active first)?

A. YZXT
B. YXTZ
C. XYZT
D. TXYZ

63. Dry air contains nitrogen and oxygen. Which one of the following statements is also correct?

There is in the air

A. a large percentage of hydrogen and a little carbon dioxide.
B. a large percentage of hydrogen, about 1% carbon dioxide and a little argon.
C. about 1% argon and a little carbon dioxide.
D. about 1% carbon dioxide and a little argon.

64. Why are the atomic weights of naturally occurring elements not whole numbers?

A. The number of protons and neutrons in each element varies.
B. It is difficult to isolate the elements in the pure state.
C. Chemical methods of atomic weight determination are inaccurate.
D. Naturally occurring elements are mixtures of isotopes.

65. What oxide is least soluble in water?

A. Magnesium oxide.
B. Phosphorus(V) oxide.
C. Silicon(IV) oxide.
D. Sulphur dioxide.

66. What would be the pH of the solution formed when calcium oxide dissolves in water?

A. Between 2 and 5
B. Between 5 and 7
C. 7
D. Above 7

67. Which metal nitrate would give off only oxygen when heated?

A. Copper(II) nitrate
B. Lead(II) nitrate
C. Silver nitrate
D. Sodium nitrate

68. Tritium has mass number 3. Helium can also have a mass number of 3. These two are not considered to be atoms of the same substance because

A. they are isotopes.
B. they have the same number of neutrons.
C. the weight of the electrons makes an appreciable difference here.
D. they have different numbers of protons.

69. When powdered copper and sulphur are heated gently together, the mass glows red hot and the product is black. Which of the following conclusions can be correctly drawn from these observations alone?

A. The copper and sulphur have combined to form copper(II) sulphide.
B. The copper and sulphur have combined to form only one compound.
C. A mixture of copper and sulphur remains.
D. The copper has reacted with the sulphur.

70. Element X has two electrons in the outer shell. Element Y has seven electrons in the outer shell. Which one of the following statements about a compound of X and Y is true?

A. The formula is XY_2.
B. X^+ ions are present.
C. Y^{2-} ions are present.
D. The compound is covalent.

Joint Matriculation Board

Test X (Pink)

DO NOT TURN OVER THE PAGE UNTIL YOU ARE TOLD TO DO SO.

The time allowed for this test is 40 minutes.

ANSWER ALL THE QUESTIONS.

Answers to questions must be entered in pencil on the special answer-sheet provided. Do NOT use a ball-point pen. The method of recording your answers is shown on the answer-sheet. Erase completely any mark you wish to change.

If you need to do any rough work you should use the question booklet and NOT the answer-sheet.

The questions in this test are numbered from 41 to 70. Your answers should be marked on the section of the answer-sheet which is referred to as Part II.

The colour of your question booklet is EITHER PINK OR YELLOW. Please indicate, in the space provided on the answer-sheet, which colour your question paper is.

DO NOT REMOVE THE QUESTION BOOKLET OR ANSWER-SHEET FROM THE ROOM.

41. The temperature of the acid was $0^{\circ}C$. The temperature of the powder was $25^{\circ}C$. The metal had a negative temperature.

A. The temperature of the metal was between the acid and the powder.
B. The metal was colder than $0^{\circ}C$.
C. The metal was warmer than the acid and the powder.
D. The temperature of the metal had not been measured.

42. Which sentence uses the word correspond correctly?

A. The fingers on the hand correspond to the toes on the feet.
B. The head corresponds to the neck.
C. The stomach corresponds to the mouth and intestines.
D. The feet correspond to the head.

43. Which sentence uses the word efficient correctly?

A. Children need to eat efficient food to grow strong and healthy.
B. Large brooms are more efficient than small brushes for sweeping the school yard.
C. The sick boy did not eat enough green vegetables and was efficient in vitamins as a result.
D. The girl did not stay at the school for an efficient time to learn English properly.

44. "If it is an acid, then it will turn litmus red." The converse of this statement is:-

A. If it is not an acid, then it will not turn litmus red.
B. If it is an alkali, then it will turn litmus blue.
C. If it turns litmus red, then it is an acid.
D. It will only turn litmus red if it dissolves in water.

45. Jim said something which was valid. He was

A. correct.
B. hard to understand.
C. telling a lie.
D. saying something new.

46. Which one of the following is not a pungent gas?

A. Sulphur dioxide
B. Hydrogen chloride
C. Chlorine
D. Oxygen

47. Which gas has diatomic molecules?

A. Carbon dioxide
B. Oxygen
C. Argon
D. Hydrogen sulphide

48. An atom of element Y can be represented as $^{16}_{8}Y$. What is the valency number of element Y?

A. 0
B. 2
C. 6
D. 8

49. An element has an atomic number of 4. Another element in the same group of elements in the Periodic Table would have an atomic number of

A. 14
B. 12
C. 10
D. 8

50. Which one of the following when heated would leave a metallic residue?

A. Silver oxide
B. Magnesium chloride
C. Copper(II) oxide
D. Aluminium oxide

51. A fused compound conducts electricity but when solid does not conduct. This suggests the bonding in the compound is

A. covalent.
B. polar covalent.
C. metallic.
D. ionic.

52. A sample of element X contains the following types of atom.

$^{13}_{7}X$ $^{15}_{7}X$ $^{16}_{7}X$

The electronic configuration of the element is

A. 2,4
B. 2,5
C. 2,6
D. 2,7

53. An isotope of aluminium has an atomic number of 13 and a mass number of 27. An atom of this isotope will contain

A. 14 protons and 13 neutrons.
B. 13 protons and 14 neutrons.
C. 14 protons and 13 electrons.
D. 13 protons and 14 electrons.

54. Some atoms of an element are heavier than other atoms of the same element. This is because they have different numbers of

   A. neutrons.
   B. nuclei.
   C. protons.
   D. electrons.

55. An element X of atomic number 13, forms a chloride. Which one of the following would be the formula of the chloride?

   A. XCl_4
   B. XCl_3
   C. XCl_2
   D. XCl

56. An element has only three isotopes of mass numbers 14, 16 and 17. Which one of the following could not be the atomic weight of the element?

   A. 14.2
   B. 15.4
   C. 16.3
   D. 17.1

57. A sample of copper(II) sulphate containing copper(II) oxide was powdered and mixed with a large volume of water. The mixture was then filtered. Which one of the following statements is not true?

   A. The copper(II) sulphate would dissolve in the water.
   B. The copper(II) oxide would be left in the filter paper.
   C. The copper(II) sulphate and the copper(II) oxide would be left in the filter paper.
   D. The filtrate would be a blue solution.

58. In which one of the following equations is the first species not oxidised?

   A. $2Fe^{2+} + Cl_2 \longrightarrow 2Fe^{3+} + 2Cl^-$
   B. $H_2S + Cl_2 \longrightarrow 2HCl + S$
   C. $2Cl^- + Pb^{2+} \longrightarrow Pb^{2+}(Cl^-)_2$
   D. $Sn^{2+} + 2Fe^{3+} \longrightarrow Sn^{4+} + 2Fe^{2+}$

59. Which statement is true about the ions $^{8}_{3}Li^{+}$ and $^{8}_{4}Be^{2+}$?

   A. They contain the same number of neutrons.
   B. Their atoms contain the same number of protons.
   C. They will combine with the same number of F^- ions.
   D. They contain the same number of electrons.

60. The numbers of electrons, protons and neutrons in four particles A to D are listed below. Which one of them represents a positively charged ion?

	Protons	Neutrons	Electrons
A.	4	5	4
B.	8	8	10
C.	12	12	10
D.	17	20	17

61. $CaCO_3 + 2HCl \longrightarrow CaCl_2 + CO_2 + H_2O$

(1 mole of $CaCO_3$ is 100g)

2.5g of marble chips were allowed to react completely with 100cm^3 2.0 M (2.0 N) hydrochloric acid. The volume of carbon dioxide evolved could be increased by

A. powdering the marble chips.
B. making the acid more concentrated.
C. using more acid of the same concentration.
D. using a greater mass of marble chips.

62. When a metal Z was added to the sulphate of a metal X, the metal X was precipitated and there was no effervescence. When the test was repeated using the metal T in place of Z, no reaction occurred. When a metal Y was added to a solution of the sulphate of X, a brisk effervescence occurred. Which one of the following is the correct order of decreasing activity (i.e. the most reactive first) of the four metals?

A. YZXT
B. YXTZ
C. XYZT
D. TXYZ

63. Dry air contains about 20% of oxygen. Which one of the following correctly describes the approximate composition of the remaining 80%?

A. Mainly nitrogen and hydrogen with a little carbon dioxide
B. Mainly nitrogen and hydrogen with about 1% carbon dioxide and a little argon
C. Mainly nitrogen with about 1% argon and a little carbon dioxide
D. Mainly nitrogen with about 1% carbon dioxide and a little argon

64. The atomic weights of most of the naturally occurring elements are not whole numbers. Which of the following is the best explanation of this fact?

A. The number of protons and neutrons in each element varies.
B. It is difficult to isolate the elements in the pure state.
C. Chemical methods of atomic weight determination are inaccurate.
D. Naturally occurring elements are mixtures of isotopes.

65. From among the following, select the element with the oxide which is least soluble in water.

A. Magnesium
B. Phosphorus
C. Silicon
D. Sulphur

66 . Calcium is a metal which burns in oxygen to form an oxide which when added to water gives a solution whose pH value is

A. between 2 and 5.
B. between 5 and 7.
C. 7.
D. above 7.

67. A metal forms a nitrate which, on heating, gives oxygen as the only gaseous product. The metal is

A. copper.
B. lead.
C. silver.
D. sodium.

68. Why are atoms with the same mass number not necessarily atoms of the same element?

It is because

A. they could be isotopes.
B. they need to have the same number of neutrons.
C. the weight of electrons could be the same.
D. they could have different numbers of protons.

69. When powdered copper and sulphur are heated gently together, the mass glows red hot and the product is black. Which of the following conclusions can be correctly drawn <u>from these observations alone</u>?

A. The copper and sulphur have combined to form copper(II) sulphide.
B. The copper and sulphur have combined to form a compound.
C. A mixture of copper and sulphur remains.
D. The copper has reacted with the sulphur.

70. Atoms of element X, having two electrons in the outer shell, come into contact with atoms of element Y with seven electrons in the outer shell. Which one of the following statements is probably <u>not</u> true?

A. The compound formed has the formula X_2Y.
B. X^{2+} ions are formed.
C. Y^- ions are formed.
D. The compound formed is ionic.

Appendix G

Joint Matriculation Board

Investigation into Language Barriers in Chemistry (Ordinary)

SURNAME ______________________ OTHER NAMES ______________________

SCHOOL ______________________

OCCUPATION OF FATHER AND/OR MOTHER ______________________

For each question make a thick pencil stroke through the appropriate letter joining the two dots as in this example. Erase completely any mark you wish to change.
Do not use ink or ball-point pen.

PUPIL INFORMATION Boy Girl

PART I

Please refer to the white question booklet and answer the 40 questions in the spaces numbered 1 - 40 below.

1	14	27
2	15	28
3	16	29
4	17	30
5	18	31
6	19	32
7	20	33
8	21	34
9	22	35
10	23	36
11	24	37
12	25	38
13	26	39
		40

PART II

You will have been provided with either a pink or a yellow question booklet. Please indicate in the box below the colour of the booklet you have been given.

Pink Yellow

The booklet contains 30 questions which are numbered 41 - 70. Please answer the questions in the spaces numbered 41 - 70 below.

41	51	61
42	52	62
43	53	63
44	54	64
45	55	65
46	56	66
47	57	67
48	58	68
49	59	69
50	60	70

FOR OFFICIAL USE ONLY

Investigation into Language Barriers in Chemistry (Ordinary) being carried out in association with the Science Education Group, University of Glasgow

Instructions to Supervisors

A. Introduction

These instructions are for the guidance of teachers administering the General Ability Test (Verbal) and the 'Language in Chemistry' test. (There are two forms of the 'Language in Chemistry' test: Test X (Pink) and Test Y (Yellow)).

The aim of the 'Language in Chemistry' test is to investigate the effects of language difficulties of candidates in Chemistry (Ordinary) in terms of key word positions, syntax and sentence length. Although some questions appear in exactly the same form in both tests, the majority of questions in Test X appear in Test Y in a modified form of language.

The aim of conducting the General Ability Test (Verbal) is to obtain an indication of the general (verbal) ability of those candidates who are being tested.

B. The Tests

The General Ability Test (Verbal) contains 40 questions (numbered from 1 to 40) and is of 30 minutes duration. Answers to questions for this test should be made in Part I of the special (combined) answer-sheet.

The 'Language in Chemistry' test appears in two different forms. Test X (Pink) and Test Y (Yellow) should be distributed to the candidates alternately i.e. the first candidate receives Text X, the second candidate receives Test Y, the third candidate receives Test X, etc. Test X and Test Y each contains 30 questions (numbered from 41 to 70): 40 minutes is to be allowed for pupils to complete the test. Answers to questions for this test should be made in Part II of the answer-sheet. Each pupil should complete the General Ability Test (Verbal) and either Test X or Test Y.

C. General Preparation

The following materials are required for each pupil on each occasion (see Section D):

1. One General Ability Test (Verbal) booklet OR one Test X (Pink) booklet OR one Test Y (Yellow) booklet,

2. One combined answer-sheet,

3. Paper for rough work,

4. Two sharpened pencils (HB) and an india rubber.

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The test supervisor will also require:

1. A supply of spare pencils and india rubbers,

2. A stop-watch or other suitable timing device.

D. Candidate identity

The General Ability Test (Verbal) and the 'Language in Chemistry' test may be administered on the same occasion or on different occasions. If the tests are administered on the same occasion and the results of individual candidates are required by the school, the candidates' answer-sheets must carry their names or be marked in some other way so that the candidates can be identified.

If the tests are set on different occasions each candidate's answer-sheet must carry his/her identity because he/she must complete the same answer-sheet on which he/she recorded the answers to the first test.

Each candidate is requested to indicate the occupation of either his/her father or mother or both. In addition each candidate is requested to indicate in the appropriate box whether he/she is a boy or a girl.

E. Procedure for General Ability Test (Verbal)

1. Pupils should first be told to fill in the information section at the top of the answer-sheet. Note that the school may or may not require the candidates to be identified on their answer-sheets (see Section D above).

2. The supervisor must make sure at this stage that all pupils understand how to fill in the answer-sheet correctly.

3. The supervisor should then announce:

   "When you are told to start the test, try to answer each problem in turn. Work carefully and quickly. Do not waste time over any question you cannot do, but go on to the next one. If you are not quite sure of the answer to any problem, mark what seems to be the best answer. Remember to record your answers on the answer-sheet only. Rub out any answer you wish to change and mark clearly the answer you think is correct. Answer-sheets should be kept flat at all times. No rough work should be done on the answer-sheets. If you should need another pencil during the test, raise your hand. Always check to be sure that each answer you mark belongs to the question you have just attempted".

4. When candidates are clear about the procedure the supervisor should say:

   "Turn to page one. Begin".

5. The supervisor should write down the exact time at which he says "Begin" and what the time will be after 20 minutes, 25 minutes and 30 minutes.

   After 20 minutes the supervisor should announce:

   "You have 10 minutes more",

   and after 25 minutes,

   "You have 5 minutes more",

   and after 30 minutes,

   "Stop writing".

6. Immediately after the test has been completed all test booklets must be collected. Unless the second session of testing is to follow immediately the answer-sheets should also be collected.

F. <u>Procedure for Test X (Pink) and Test Y (Yellow)</u>

1. Each candidate should indicate on his/her answer-sheet, in the space provided, the colour of the paper on which his/her test booklet is printed. This is most important.

2. The supervisor must make sure at this stage that all pupils understand how to fill in the answer-sheet correctly.

3. As for Section E, paragraph 3 (if this session of testing follows immediately after the General Ability Test (Verbal) then this may be omitted).

4. When there are no further questions the supervisor should say:

   "Turn to page one. Begin".

5. The supervisor should write down the exact time at which he says "Begin" and what the time will be after 20 minutes, 30 minutes and 40 minutes.

   After 20 minutes the supervisor should announce:

   "You have 20 minutes more",

   and after 30 minutes,

   "You have 10 minutes more",

   and after 40 minutes,

   "Stop writing".

6. Immediately after the test has been completed all test booklets and answer-sheets must be collected.

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G. Return of test material

All answer-sheets and test booklets, whether used or unused, should be returned to the Research Unit, Joint Matriculation Board, Manchester M15 6EU as soon as both tests have been completed. Before returning test material, please separate answer-sheets of candidates entered for the JMB GCE Chemistry (Ordinary) examination from those of other pupils.

The box(es) in which the tests were sent to the school may be used for their return. Labels for this purpose have been provided. Postage costs will be refunded.

Appendix I

Chemistry questions in original (Text X) and simplified (Test Y) form together with appropriate item statistics

(The correct response is indicated by *)

(a) Questions in which there has been a change of words in key positions

Original Question (X)

46. Which one of the following is not a pungent gas?

A. Sulphur dioxide
B. Hydrogen chloride
C. Chlorine
*D. Oxygen

Simplified Question (Y)

Which one of the following is not a choking gas?

A. Sulphur dioxide
B. Hydrogen chloride
C. Chlorine
*D. Oxygen

Original Question (X)

47. Which gas has diatomic molecules?

A. Carbon dioxide
*B. Oxygen
C. Argon
D. Hydrogen sulphide

Simplified Question (Y)

Which gas has two atoms in every molecule?

A. Carbon dioxide
*B. Oxygen
C. Argon
D. Hydrogen sulphide

From Table VI it may be seen that the simplification of these items leads to significantly higher facility values in all sub-groups except Ability Group 1 for item no.46. It should be noted that no.46 was an extremely easy item (Tables IV and V).

There is no difference in the pattern of responses to the incorrect options in these items.

Original Question (X)

48. At atom of element Y can be represented as $^{16}_{8}Y$. What is the valency number of element Y?

A. 0
*B. 2
C. 6
D. 8

Simplified Question (Y)

An atom of element Y can be represented as $^{16}_{8}Y$. How many bonds would element Y form?

A. 0
*B. 2
C. 6
D. 8

The only significant change in this item shows as a sex difference in favour of the girls.

	Original Question (X)	Simplified Question (Y)
49.	An element has an atomic number of 4. Another element in the same group of elements in the Periodic Table would have an atomic number of	An element has an atomic number of 4. Another element in the same column of the Periodic Table would have an atomic number of
	A. 14 *B. 12 C. 10 D. 8	A. 14 *B. 12 C. 10 D. 8

There were no significant differences within any sub-group of pupils between the two forms of this question.

	Original Question (X)	Simplified Question (Y)
50.	Which one of the following when heated would leave a metallic residue?	Which one of the following when heated would give a metal?
	*A. Silver oxide B. Magnesium chloride C. Copper (II) oxide D. Aluminium oxide	*A. Silver oxide B. Magnesium chloride C. Copper (II) oxide D. Aluminium oxide

Table VI shows a clear trend that simplification leads to lower facility values in sub-groups of pupils. The facility values are low but the word 'metal' would seem to be harder to understand than 'metallic residue' perhaps because in the practical situation the result of this experiment is so rarely like a metal, being more like the less specific 'metallic residue'.

	Original Question (X)	Simplified Question (Y)
51.	A fused compound conducts electricity but when solid does not conduct. This suggests the bonding in the compound is	A melted compound conducts electricity but when solid does not conduct. This suggests the bonding in the compound is
	A. covalent. B. polar covalent. C. metallic. *D. ionic.	A. covalent. B. polar covalent. C. metallic. *D. ionic.

Table VI shows that for all sub-groups there was a rise in the facility values on simplification although three only were statistically significant. The facility value rose from 55 for all Test X pupils to 61 for all Test Y pupils; option A proved to be very popular with both samples.

(b) Questions in which the change of wording removes a negative.

	Original Question (X)	Simplified Question (Y)
56.	An element has only three isotopes of mass numbers 14, 16 and 17. Which one of the following could not be the atomic weight of the element?	An element has only three isotopes of mass numbers 14, 16 and 17. Which one of the following could be the atomic weight of the element?
	A. 14.2 B. 15.4 C. 16.3 *D. 17.1	A. 19.9 B. 11.7 C. 17.2 *D. 15.1

For every sub-group (except non-GCE candidates) the removal of the negative leads to a statistically significant rise in facility values (Table VI).

	Original Question (X)	Simplified Question (Y)
57.	A sample of copper(11) sulphate containing copper (11) oxide was powdered and mixed with a large volume of water. The mixture was then filtered. Which one of the following statements is not true?	A sample of copper(11) sulphate containing copper(11) oxide was powdered and mixed with a large volume of water. The mixture was then filtered. Which one of the following statements is true?
	A. The copper(11) sulphate would dissolve in the water. B. The copper(11) oxide would be left in the filter paper. *C. The copper(11) sulphate and the copper(11) oxide would be left in the filter paper. D. The filtrate would be a blue solution.	A. The copper(11) would dissolve in the water. B. The copper(11) sulphate would be left in the filter paper. *C. One compound dissolves in the water and the other does not. D. The filtrate would be colourless.

There were no significant changes for this item as a result of the removal of the negative.

Original Question (X)

58. In which one of the following equations is the first species not exidised?

A. $2Fe^{2+} + Cl_2 \rightarrow 2Fe^{3+} + 2Cl^-$

B. $H_2S + Cl_2 \rightarrow 2HCl + S$

*C. $2Cl^- + P_b^{2+} \rightarrow Pb^{2+}(Cl^-)_2$

D. $Sn^{2+} + 2Fe^{3+} \rightarrow Sn^{4+} + 2Fe^{2+}$

Simplified Question (Y)

In which one of the following equations is the first species oxidised?

A. $2Fe^{3+} + 2Cl^- \rightarrow 2Fe^{2+} + Cl_2$

B. $Cl_2 + H_2S \rightarrow 2HCl + S$

*C. $Sn^{2+} + 2Fe^{3+} \rightarrow Sn^{4+} + 2Fe^{2+}$

D. $2Cl^- + Pb^{2+} \rightarrow Pb^{2+}(Cl^-)2$

As Table VI indicates there was a definite trend for pupils in sub-groups to find that the removal of the negative made the item more difficult. Whereas in its original form options A and B attracted 8 and 31 per cent of the pupils overall, when simplified these options attracted 32 and 18 per cent respectively.

(c) Questions in which the numbers of words have been reduced.

Original Question (X)

59. Which statement is true about the ions $^{8}_{3}Li^{+}$ and $^{8}_{4}Be^{2+}$?

A. They contain the same number of neutrons.
B. Their atoms contain the same number of protons.
C. They will combine with the same number of F^- ions.
*D. They contain the same number of electrons.

Simplified Question (Y)

$^{8}_{3}Li^{+}$ and $^{8}_{4}Be^{2+}$ have the same number of

A. neutrons.
B. protons.
C. charges.
*D. electrons.

There is apparently no effect on facility values resulting from the simplification of this difficult item. In the simple version option C was considerably less attractive to pupils than it was originally.

Original Question (X)

60. The numbers of electrons, protons and neutrons in four particles A to D are listed below. Which one of them represents a positively charged ion?

	Protons	Neutrons	Electrons
A.	4	5	4
B.	8	8	10
*C.	12	12	10
D.	17	20	17

Simplified Question (Y)

Which one of these particles A to D would be a positively charged ion?

	Protons	Neutrons	Electrons
A.	4	5	4
B.	8	8	10
*C.	12	12	10
D.	17	20	17

Although the pattern of responses to incorrect options did not change greatly as a result of simplification the trend shown in Table VI is for the reduction of words to produce lower facility values.

Original Question (X)	Simplified Question (Y)
62. When a metal Z was added to the sulphate of a metal X, the metal X was precipitated and there was no effervescence. When the test was repeated using the metal T in place of Z, no reaction occurred. When a metal Y was added to a solution of the sulphate of X, a brisk effervescence occurred. Which one of the following is the correct order of decreasing activity (i.e. the most reactive first) of the four metals?	Three metals Z, T and Y were added to separate solutions containing metal X ions. Z precipitates X; T had no effect; and with Y a gas was given off from the solution. Which one of the following shows the metals in the correct order of activity (the most active first)?
*A. YZXT B. YXTZ C. XYZT D. TXYZ	*A. YZXT B. YXTZ C. XYZT D. TXYZ

The removal of words brings about some gains in performance.

Original Question (X)	Simplified Question (Y)
63. Dry air contains about 20% of oxygen. Which one of the following correctly describes the approximate composition of the remaining 80%?	Dry air contains nitrogen and oxygen. Which one of the following statements is also correct? There is in the air
A. Mainly nitrogen and hydrogen with a little carbon dioxide. B. Mainly nitrogen and hydrogen with about 1% carbon dioxide and a little argon. *C. Mainly nitrogen with about 1% argon and a little carbon dioxide. D. Mainly nitrogen with about 1% carbon dioxide and a little argon.	A. a large percentage of hydrogen and a little carbon dioxide. B. a large percentage of hydrogen, about 1% carbon dioxide and a little argon. *C. about 1% argon and a little carbon dioxide. D. about 1% carbon dioxide and a little argon.

Although, from Table VI, it may be seen that some sub-groups found the item easier when revised, more pupils found option D attractive than they did the key in both versions of this, the most difficult of all items used in the experiment.

	Original Question (X)	Simplified Question (Y)
64.	The atomic weights of most of the naturally occuring elements are not whole numbers. Which of the following is the best explanation of this fact?	Why are the atomic weights of naturally occuring elements not whole numbers?
	A. The number of protons and neutrons in each element varies.	A. The number of protons and neutrons in each element varies.
	B. It is difficult to isolate the elements in the pure state.	B. It is difficult to isolate the elements in the pure state.
	C. Chemical methods of atomic weight determination are inaccurate.	C. Chemical methods of atomic weight determination are inaccurate.
	*D. Naturally occuring elements are mixtures of isotopes.	*D. Naturally occuring elements are mixtures of isotopes.

Changes in this item had no apparent effects.

	Original Question (X)	Simplified Question (Y)
65.	From among the following, select the element with the oxide which is least soluble in water.	What oxide is least soluble in water?
	A. Magnesium	A. Magnesium oxide
	B. Phosphorus	B. Phosphorus(V) oxide
	*C. Silicon	*C. Silicon(IV) oxide
	D. Sulphur	D. Sulphur dioxide

Changes in this item tended to make it more difficult for some sub-groups

	Original Question (X)	Simplified Question (Y)
67.	A metal forms a nitrate which, on heating, gives oxygen as the only gaseous product. The metal is.	Which metal nitrate would give off only oxygen when heated?
	A. copper.	A. Copper(11) nitrate
	B. lead.	B. Lead(11) nitrate
	C. silver.	C. Silver nitrate
	*D. sodium.	*D. Sodium nitrate

There were no statistically significant differences resulting from the changes made to this item (Table VI). Pupils found option C to be attractive in both forms.

Original Question (X)	Simplified Question (Y)
68. Why are atoms with the same mass number not necessarily atoms of the same element? It is because	Tritium has mass number 3. Helium can also have a mass number of 3. These two are not considered to be atoms of the same substance because
A. they could be isotopes.	A. they are isotopes.
B. they need to have the same number of neutrons.	B. they have the same number of neutrons.
C. the weight of electrons could be the same.	C. the weight of the electrons makes an appreciable difference here.
*D. they could have different numbers of protons.	*D. they have different numbers of protons.

It should be noted that the verbal changes in this item, although simplifying it by making it more specific, actually increased the number of words in the stem. Changes to this item lead to significant rises in facility values for most sub-groups. There is evidence that pupils switched from option B to option C as a result of the simplification.

(d) Question in which a possible ambiguity has been removed.

Original Question (X)	Simplified Question (Y)
69. When powdered copper and sulphur are heated gently together, the mass glows red hot and the product is black. Which of the following conclusions can be drawn from these observations alone?	When powdered copper and sulphur are heated gently together, the mass glows red hot and the product is black. Which of the following conclusions can be drawn from these observations alone?
A. The copper and sulphur have combined to form copper (II) sulphide.	A. the copper and sulphur have combined to form copper (II) sulphide.
B. The copper and sulphur have combined to form a compound.	B. The copper and sulphur have combined to form only one compound.
C. A mixture of copper and sulphur remains.	C. A mixture of copper and sulphur remains.
*D. The copper has reacted with the sylphur.	*D. The copper has reacted with the sulphur.

This question, in its original version, appeared in a recent SCEEB Ordinary grade examination. In option B 'a compound' could mean at least one unspecified compound or one and only one compound. The simplified version removed the ambiguity and resulted in an improvement in performance (Table VI).

(e) Questions in which there has been a re-organisation in terms of the number of clauses.

	Original Question (X)	Simplified Question (Y)
66.	Calcium is a metal which burns in oxygen to form an oxide which when added to water gives a solution whose pH value is	What would be the pH value of the solution formed when calcium oxide dissolves in water?
	A. between 2 and 5. B. between 5 and 7. C. 7. • D. above 7.	A. between 2 and 5. B. between 5 and 7. C. 7. • D. above 7.

No statistically significant differences were found between the two versions.

	Original Question (X)	Simplified Question (Y)
70.	Atoms of element X, having two electrons in the outer shell, come into contact with atoms of element Y with seven electrons in the outer shell. Which one of the following statements is probably <u>not</u> true?	Element X has two electrons in the outer shell. Element Y has seven electrons in the outer shell. Which one of the following statements about a compound of X and Y is true?
	•A. The compound formed has the formula X_2Y. B. X^{2+} ions are formed. C. Y^- ions are formed. D. The compound formed is ionic.	•A. The formula is XY_2. B. X^+ ions are present. C. Y^{2-} ions are present. D. The compound is covalent.

As well as a reduction in the number of clauses in the stem of this item, a negative was also removed. Despite these changes no sub-group found the revised version significantly easier. Indeed the only statistically significant difference was in the opposite direction although this was for the non-GCE sub-group of pupils.

41. A sample of element X contains the following types of atom:

$^{13}_{7}X \quad ^{15}_{7}X \quad ^{16}_{7}X$

B

The electronic configuration of the element is

A. 2,4.
B. 2,5.
C. 2,6.
D. 2,7.

42. An isotope of aluminium has an atomic number of 13 and a mass number of 27. An atom of this isotope will contain

A. 14 protons and 13 neutrons.
B. 13 protons and 14 neutrons.
C. 14 protons and 13 electrons.
D. 13 protons and 14 electrons.

B

43. Some atoms of an element are heavier than other atoms of the same element. This is because they have different numbers of

A. neutrons.
B. nuclei.
C. protons.
D. electrons.

A

44. Which of the following particles has the same number of electrons as a calcium ion?

A. A potassium atom
B. A potassium ion
C. A magnesium ion
D. A chlorine atom

B

45. Which statement is true?

A. The proton has the same mass as an electron.
B. The hydrogen molecule contains one atom.
C. Isotopes of chlorine have different numbers of protons in their atoms.
D. The element with atomic number 13 is a metal.

D

46. Which one of the following pairs of particles contains equal numbers of protons?

A. Na and Na^+
B. Na^+ and Ne
C. Cl^- and Ar
D. K^+ and Ca^{2+}

A

47. Which of the following compounds has a formula of the type X_2Y where both ions have the same electronic arrangement as argon (2,8,8)?

A. Potassium sulphide
B. Aluminium chloride
C. Sodium fluoride
D. Potassium oxide

A

48. An element X of atomic number 13 forms a chloride. Which one of the following is the formula of the chloride?

A. XCl_5
B. XCl_4
C. XCl_3
D. XCl_2

C

49. Which of the following pairs of elements are likely to form a compound with the formula XY_3?

A. Phosphorus and hydrogen
B. Hydrogen and sulphur
C. Sulphur and chlorine
D. Chlorine and carbon

A

50. Which pair of compounds would both decompose when heated separately with a bunsen burner?

A. sodium nitrate, calcium oxide
B. zinc oxide, lithium nitrate
C. copper carbonate, mercury oxide
D. potassium carbonate, silver oxide

C

51. Calcium oxide dissolves in water. The solution would have a pH of

A. 1.
B. between 2 and 7.
C. 7.
D. between 8 and 14.

D

52. Copper when heated in air turns black. Copper when heated in the absence of air does not turn black. Which one of the following statements is true about copper?

When heated

A. in the absence of air it loses weight.
B. in air it stays the same weight.
C. in the absence of air it stays the same weight.
D. in the absence of air it gains weight.

C

53. Fluorine is more active than chlorine
Chlorine is more active than bromine
Bromine is more active than iodine

A

From this it can be deduced that in solution

A. chlorine displaces both iodine from potassium iodide and bromine from potassium bromide.
B. iodine displaces bromine from potassium bromide.
C. bromine displaces chlorine from potassium chloride.
D. bromine displaces both iodine from potassium iodide and fluorine from potassium fluoride.

54. The spread of colour from a crystal through still water is called

A. dilution.
B. dissolving.
C. diffusion.
D. melting.

C

55. The table below shows some of the properties of elements represented by the letters A - D. Which one of the elements shows typical metallic properties?

Element	Conductivity of electricity when solid	Type of oxide
A	insulator	basic
B	conductor	acidic
C	insulator	acidic
D	conductor	basic

D

56. In which one of the following are the metals arranged in decreasing order of activity?

A. Iron, calcium, sodium
B. Calcium, iron, sodium
C. Iron, sodium, calcium
D. Sodium, calcium, iron

D

57. Which one of the following solutions of a salt in water is most concentrated?

A. 10g of salt dissolved in 100 ml of water
B. 7g of salt dissolved in 60 ml of water
C. 4g of salt dissolved in 50 ml of water
D. 2g of salt dissolved in 20 ml of water

B

58. Which one of these compounds is covalent?

A. Calcium fluoride
B. Sulphur chloride
C. Sodium bromide
D. Potassium iodide

B

59. To make an exactly 0.1 molar solution of sodium chloride (formula weight = 58.5) what would you do?

A. Dissolve 5.85g of sodium chloride in 100 ml of water
B. Dissolve 5.85g of sodium chloride in water and make up with water to 1 litre of solution
C. Add 100 ml of a molar solution of sodium chloride to 1 litre of water
D. Add 5.85g of sodium chloride to 1 litre of water and shake until dissolved

B

60. Which one of these is a test for carbon dioxide?

A. Relights a glowing splint
B. Bleaches damp litmus
C. Forms a white precipitate when passed through a solution of calcium hydroxide
D. Forms a white precipitate when passed through a solution of sodium hydroxide

C

61. Hydrated copper(II) sulphate is obtained from a dilute solution of copper(II) sulphate by

A. filtration.
B. precipitation.
C. neutralisation.
D. crystallisation.

D

62. When a metal atom changes to an ion it

A. loses electrons.
B. changes the structure of its nucleus.
C. gains protons.
D. is reduced.

A

63. If air is passed through sodium hydroxide solution and then over heated copper, the gas collected contains nitrogen and

A. oxygen.
B. carbon dioxide.
C. noble gases.
D. nitrogen dioxide.

C

64. An analysis of 24g of antimony oxide showed that 20g were antimony and 4g were oxygen. Knowing that the atomic weight (relative atomic mass) of antimony was 120 and that of oxygen was 16, which of the following formulae would correctly represent antimony oxide?

A. SbO
B. SbO_2
C. Sb_2O_5
D. Sb_2O_3

D

65. A solution of a salt is electrolysed. At the negative electrode a brown deposit forms and at the positive electrode a yellowish green gas is evolved. Which of the following could the salt have been?

A. Potassium bromide
B. Lead chloride
C. Copper(II) chloride
D. Calcium iodide

C

66. Given this equation

$$H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$$

Which of these solutions would exactly neutralise $20cm^3$ of 2M sulphuric acid?

A. $20cm^3$ of 2M potassium hydroxide
B. $40cm^3$ of 2M potassium hydroxide
C. $10cm^3$ of 2M potassium hydroxide
D. $40cm^3$ of M potassium hydroxide

B

67. The volume of ammonia measured at room temperature and atmospheric pressure needed to produce 1 mole of nitrogen molecules is

A. 2 litres.
B. 4 litres.
C. 24 litres.
D. 48 litres.

D

68. Solid sodium chloride does not conduct electricity but sodium chloride does conduct when molten. The reason is

A. solid sodium chloride contains no ions.
B. the passage of electric current forms ions in molten sodium chloride but not in the solid form.
C. melting sodium chloride produces sodium ions and chloride ions.
D. ions present in solid sodium chloride are not free to migrate but can do so when the substance is molten.

D

69. Which one of these statements about carbon dioxide is correct?

- A. It is not the only product formed by the action of hydrochloric acid on marble chips.
- B. It does not give a white precipitate when passed into lime water.
- C. It is a basic oxide.
- D. Its molecule is made up from two carbon atoms and one oxygen atom linked covalently.

A

70. Which one of the following statements is true of the elements in the Periodic Table?

- A. Elements with similar properties are arranged in vertical columns.
- B. The elements in group I become less reactive with increasing atomic mass.
- C. The elements in group VII become more reactive with increasing atomic mass.
- D. All the elements in group IV have five electrons in the outer shell of their atoms.

A

71. Assume that air contains nitrogen and oxygen only. Remember that the boiling point of nitrogen is lower than that of oxygen. If 100cm^3 of air is liquefied and then allowed to warm up, which one of the following will result?

- A. 20cm^3 of oxygen will come off first and then 80cm^3 of nitrogen.
- B. 80cm^3 of oxygen will come off first and then 20cm^3 of nitrogen.
- C. 20cm^3 of nitrogen will come off first and then 80cm^3 of oxygen.
- D. 80cm^3 of nitrogen will come off first and then 20cm^3 of oxygen.

D

72. The formation of potassium bromide is similar to the formation of sodium chloride in that each metal atom loses one electron to each non-metal atom. Which one of the following best describes the composition of a crystal of potassium bromide?

- A. A lattice containing equal numbers of potassium atoms and bromine atoms arranged in a definite pattern.
- B. A lattice containing equal numbers of potassium ions and bromide ions arranged in a definite pattern.
- C. A lattice containing equal numbers of potassium ions and bromide ions arranged in no definite pattern.
- D. Many separate molecules each made up of one potassium atom and one bromine atom.

B

73. Which one of the following is the order in which water is purified for use in towns and cities?

- A. chlorination, storage, filtration, distribution
- B. collection, distribution, filtration, storage
- C. extraction, sterilisation, distillation, storage
- D. collection, filtration, chlorination, distribution

D

41. A sample of element X contains the following types of atom:

$^{13}_{7}X$ $^{15}_{7}X$ $^{16}_{7}X$

The electronic configuration of the element is B

A. 2,4.
B. 2,5.
C. 2,6.
D. 2,7.

42. An isotope of aluminium has an atomic number of 13 and a mass number of 27. An atom of this isotope will contain

A. 14 protons and 13 neutrons.
B. 13 protons and 14 neutrons. B
C. 14 protons and 13 electrons.
D. 13 protons and 14 electrons.

43. Some atoms of an element are heavier than other atoms of the same element. This is because they have different numbers of

A. neutrons.
B. nuclei. A
C. protons.
D. electrons.

44. Which of the following particles does not have the same number of electrons as a calcium ion?

A. A potassium ion
B. A potassium atom
C. An argon atom B
D. A chloride ion

45. Which statement is not true?

A. The proton does not have the same mass as an electron.
B. The hydrogen molecule contains two atoms.
C. Isotopes of chlorine do not have different numbers of protons in their atoms. D
D. The element with atomic number 13 is a non-metal.

46. Equal numbers of protons are contain in which one of the following pairs of particles?

A. Na and Na^+
B. Na^+ and Ne A
C. Cl^- and Ar
D. K^+ and Ca^{2+}

47. A compound, where both ions have the same electronic arrangement as argon (2,8,8) has a formula of the type X_2Y. Which of these compounds is it?

A. Potassium sulphide
B. Aluminium chloride
C. Sodium fluoride
D. Potassium oxide

A

48. An element X of atomic number 13 forms a chloride. Which one of the following is the formula of the chloride?

A. XCl_5
B. XCl_4
C. XCl_3
D. XCl_2

C

49. A compound with the formula XY_3 would be likely to be formed from which of the following pairs of elements?

A. Phosphorus and hydrogen
B. Hydrogen and sulphur
C. Sulphur and chlorine
D. Chlorine and carbon

A

50. In which of the following would both compounds not have been decomposed when heated separately with a bunsen burner?

A. sodium nitrate, silver oxide
B. mercury oxide, zinc nitrate
C. potassium carbonate, calcium oxide
D. copper carbonate, lithium nitrate

C

51. The burning of calcium in oxygen produces an oxide which, when it is added to water, gives a solution whose pH value is

A. 1.
B. between 2 and 7.
C. 7.
D. between 8 and 14.

D

52. A piece of copper, when heated directly in the bunsen flame, turns black but when heated in a hard glass tube from which all air has been removed it does not turn black. Which one of the following statements is true about copper?

When heated

A. in the tube it loses weight.
B. in air it stays the same weight.
C. in the tube it stays the same weight.
D. in the tube it gains weight.

C

53. The order of increasing chemical reactivity (least reactive first) of four halogen elements is

iodine, bromine, chlorine, fluorine.

From this information it can be deduced that

A. chlorine displaces both iodine from potassium iodide solution and bromine from potassium bromide solution.
B. iodine displaces bromine from potassium bromide solution.
C. bromine displaces chlorine from potassium chloride solution.
D. bromine displaces both iodine from potassium iodide solution and fluorine from potassium fluoride solution.

A

54. If a crystal of hydrated copper(II) sulphate is placed carefully at the bottom of a beaker of water to stand for several days, a blue colour gradually spreads through the liquid. The best way to describe the spread of colour is

A. dilution.
B. dissolving.
C. diffusion.
D. melting.

C

55. The table below shows some of the properties of elements represented by the letters A - D. Which one of the elements shows four typical metallic properties?

Element	State at $0^{\circ}C$	State at $1000^{\circ}C$	Conductivity of electricity when solid	Type of oxide
A	liquid	gas	insulator	basic
B	solid	solid	conductor	acidic
C	liquid	gas	insulator	acidic
D	solid	solid	conductor	basic

D

56. In which one of the following are the metals arranged in increasing order of activity?

A. Sodium, calcium, iron
B. Calcium, iron, sodium
C. Iron, sodium, calcium
D. Iron, calcium, sodium

D

57. Which one of the following solutions of a salt in water is most dilute?

A. 10g of salt dissolved in 100 ml of water
B. 5g of salt dissolved in 80 ml of water
C. 4g of salt dissolved in 50 ml of water
D. 2g of salt dissolved in 20 ml of water

B

58. In which one of the following compounds is there a tendency for covalency to predominate?

A. Calcium fluoride
B. Sulphur chloride
C. Sodium bromide
D. Potassium iodide

B

59. Which of the following procedures would be expected to produce an exactly 0.1 molar solution of sodium chloride (formula weight = 58.5)?

A. Dissolving 5.85g of sodium chloride in 100 ml of water
B. Dissolving 5.85g of sodium chloride in water and making up with water to 1 litre of solution
C. Adding 100 ml of a molar solution of sodium chloride to 1 litre of water
D. Adding 5.85g of sodium chloride to 1 litre of water and shaking until dissolved

B

60. Which one of the following observations is used to detect the presence of carbon dioxide?

A. Relights a glowing splint
B. Bleaches damp litmus
C. Forms a white precipitate when passed through a solution of calcium hydroxide
D. Forms a white precipitate when passed through a solution of sodium hydroxide

C

61. The process used to obtain hydrated copper(II) sulphate from a dilute solution of copper(II) sulphate is called

A. filtration.
B. precipitation.
C. neutralisation.
D. crystallisation.

D

62. When an atom of a metallic element ionises it

A. loses electrons.
B. changes the structure of its nucleus.
C. gains protons.
D. is reduced.

A

63. The laboratory preparation of nitrogen by passing air through sodium hydroxide solution and then over heated copper produces nitrogen which contains

A. oxygen.
B. carbon dioxide.
C. noble gases.
D. nitrogen dioxide.

C

64. From an analysis of 24g of antimony oxide, which showed that 20g were antimony and 4g were oxygen, which of the following formulae would correctly represent antimony oxide, knowing that the atomic weight (relative atomic mass) of antimony was 120 and that of oxygen was 16?

A. SbO
B. SbO_2
C. Sb_2O_5
D. Sb_2O_3

D

65. Which of the following could be a salt which, when a solution is electrolysed, gives a brown deposit at the negative electrode and evolves a yellowish green gas at the positive electrode?

A. Potassium bromide
B. Lead chloride
C. Copper(II) chloride
D. Calcium iodide

C

66. Which one of the following solutions when added to $20cm^3$ of 2M sulphuric acid would form a neutral solution?

The equation for the reaction is

$$H_2SO_4 + 2KOH \longrightarrow K_2SO_4 + 2H_2O$$

A. $20cm^3$ of 2M potassium hydroxide
B. $40cm^3$ of 2M potassium hydroxide
C. $10cm^3$ of 2M potassium hydroxide
D. $40cm^3$ of M potassium hydroxide

B

67. The volume of dry ammonia gas measured at one atmosphere pressure and at room temperature needed to produce 1 mole of gaseous nitrogen molecules is

A. 2 litres.
B. 4 litres.
C. 24 litres.
D. 48 litres.

D

68. Crystalline sodium chloride does not conduct electricity but fused sodium chloride has an appreciable electrical conductivity. The reason for this observation is that

A. solid sodium chloride contains no ions.
B. the passage of electric current forms ions in molten sodium chloride but not in the solid form.
C. melting sodium chloride produces sodium ions and chloride ions.
D. ions present in solid sodium chloride are not free to migrate but can do so when the substance is molten.

D

69. Which one of these statements about carbon dioxide is incorrect?

A. It is the only product formed by the action of hydrochloric acid on marble chips.
B. It gives a white precipitate when passed into lime water.
C. It is an acidic oxide.
D. Its molecule is made up from two oxygen atoms and one carbon atom, linked covalently.

A

70. Which one of the following statements is NOT true of the elements in the Periodic Table?

A. Elements with similar properties are arranged in horizontal rows.
B. The elements in group I become more reactive with increasing atomic mass.
C. The elements in group VII become less reactive with increasing atomic mass.
D. All the elements in group IV have four electrons in the outer shell of their atoms.

A

71. Assume that air contains nitrogen and oxygen only and the boiling point of nitrogen is lower than that of oxygen. If $100cm^3$ of air is liquefied and then allowed to warm up, which one of the following will result?

A. $20cm^3$ of oxygen will come off first and then $80cm^3$ of nitrogen.
B. $80cm^3$ of oxygen will come off first and then $20cm^3$ of nitrogen.
C. $20cm^3$ of nitrogen will come off first and then $80cm^3$ of oxygen.
D. $80cm^3$ of nitrogen will come off first and then $20cm^3$ of oxygen.

D

72. Use your knowledge of the structure of sodium chloride and the knowledge that the formation of potassium bromide involves the transfer of one electron from each potassium atom to each bromine atom to predict which one of the following statements best describes the composition of a crystal of potassium bromide?

A. A lattice containing equal numbers of potassium atoms and bromine atoms arranged in a definite pattern.
B. A lattice containing equal numbers of potassium ions and bromide ions arranged in a definite pattern.
C. A lattice containing equal numbers of potassium ions and bromide ions arranged in no definite pattern.
D. Many separate molecules each made up of one potassium atom and one bromine atom.

B

73. The sequential stages involved in the large scale purification of water supplies for use in towns and cities are

A. chlorination, storage, filtration, distribution.
B. collection, distribution, filtration, storage.
C. extraction, sterilisation, distillation, storage.
D. collection, filtration, chlorination, distribution.

D

1979 Investigation into Language Barriers in Chemistry being carried out in association with the Science Education Group, University of Glasgow

Instructions to Supervisors

A. Introduction

These instructions are for the guidance of teachers administering the General Ability Test (Verbal) and the 'Language in Chemistry' test. (There are two forms of the 'Language in Chemistry' test: Test X (Pink) and Test Y (Yellow)).

The aim of the 'Language in Chemistry' test is to investigate the effects of language difficulties of candidates in Chemistry (Ordinary) in terms of key word positions, syntax and sentence length. Although some questions appear in exactly the same form in both tests, the majority of questions in Test X appear in Test Y in a modified form of language.

The aim of conducting the General Ability Test (Verbal) is to obtain an indication of the general (verbal) ability of those candidates who are being tested.

B. The Tests

The General Ability Test (Verbal) contains 40 questions (numbered from 1 to 40) and is of 30 minutes duration. Answers to questions for this test should be made in Part I of the special (combined) answer-sheet.

The 'Language in Chemistry' test appears in two different forms. Test X (Pink) and Test Y (Yellow) should be distributed to the candidates alternately i.e. the first candidate receives Text X, the second candidate receives Test Y, the third candidate receives Test X, etc. Test X and Test Y each contains 33 questions (numbered from 41 to 73): 40 minutes is to be allowed for pupils to complete the test. Answers to questions for this test should be made in Part II of the answer-sheet. Each pupil should complete the General Ability Test (Verbal) and *either* Test X *or* Test Y.

C. General Preparation

The following materials are required for each pupil on each occasion (see Section D):

1. One General Ability Test (Verbal) booklet OR one Test X (Pink) booklet OR one Test Y (Yellow) booklet,

2. One combined answer-sheet,

3. Paper for rough work,

4. Two sharpened pencils (HB) and an india-rubber.

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The test supervisor will also require:

1. A supply of spare pencils and india-rubbers,

2. A stop-watch or other suitable timing device.

D. Candidate identity

The General Ability Test (Verbal) and the 'Language in Chemistry' test may be administered on the same occasion or on different occasions. If the tests are administered on the same occasion and the results of individual candidates are required by the school, the candidates' answer-sheets must carry their names or be marked in some other way so that the candidates can be identified.

If the tests are set on different occasions each candidate's answer-sheet must carry his/her identity because he/she must complete the same answer-sheet on which he/she recorded the answers to the first test.

Each candidate is requested to indicate in the appropriate box whether he/she is a boy or a girl.

E. Procedure for General Ability Test (Verbal)

1. Pupils should first be told to fill in the information section at the top of the answer-sheet. Note that the school may or may not require the candidates to be identified on their answer-sheets (see Section D above).

2. The supervisor must make sure at this stage that all pupils understand how to fill in the answer-sheet correctly.

3. The supervisor should then announce:

   "When you are told to start the test, try to answer each problem in turn. Work carefully and quickly. Do not waste time over any question you cannot do, but go on to the next one. If you are not quite sure of the answer to any problem, mark what seems to be the best answer. Remember to record your answers on the answer-sheet only. Rub out any answer you wish to change and mark clearly the answer you think is correct. Answer-sheets should be kept flat at all times. No rough work should be done on the answer-sheets. If you should need another pencil during the test, raise your hand. Always check to be sure that each answer you mark belongs to the question you have just attempted".

4. When candidates are clear about the procedure the supervisor should say:

   "Turn to page one. Begin".

5. The supervisor should write down the exact time at which he says "Begin" and what the time will be after 20 minutes, 25 minutes and 30 minutes.

   After 20 minutes the supervisor should announce:

   "You have 10 minutes more",

   and after 25 minutes,

   "You have 5 minutes more",

   and after 30 minutes,

   "Stop writing".

6. Immediately after the test has been completed all test booklets must be collected. Unless the second session of testing is to follow immediately the answer-sheets should also be collected.

F. Procedure for Test X (Pink) and Test Y (Yellow)

1. Each candidate should indicate on his/her answer-sheet, in the space provided, the colour of the paper on which his/her test booklet is printed. This is most important.

2. The supervisor must make sure at this stage that all pupils understand how to fill in the answer-sheet correctly.

3. As for Section E, paragraph 3 (if this session of testing follows immediately after the General Ability Test (Verbal) then this may be omitted).

4. When there are no further questions the supervisor should say:

   "Turn to page one. Begin".

5. The supervisor should write down the exact time at which he says "Begin" and what the time will be after 20 minutes, 30 minutes and 40 minutes.

   After 20 minutes the supervisor should announce:

   "You have 20 minutes more",

   and after 30 minutes,

   "You have 10 minutes more",

   and after 40 minutes,

   "Stop writing".

6. Immediately after the test has been completed all test booklets and answer-sheets must be collected.

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G. Return of test material

All answer-sheets and test booklets, whether used or unused, should be returned to the Research Unit, Joint Matriculation Board, Manchester M15 6EU as soon as both tests have been completed. Before returning test material, please separate answer-sheets of candidates entered for the JMB/WMEB joint examination in 1979 from those of other pupils should there be any.

The box(es) in which the tests were sent to the school may be used for their return. Labels for this purpose have been provided.

An alternative to the use of GPO parcel post (postage costs will be refunded) is to use the Medallion Services of National Carriers Ltd. A consignment note and label are attached.

The nearest of the following N.C.L. area depots should be contacted:

N.C.L.,
Lawley Street,
Birmingham.

tel. 359 6411.

N.C.L.,
Vernon Road,
Stoke-on-Trent.

tel. 411331.

N.C.L.,
Bradford Place,
Walsall.

tel. 33211.

Joint Matriculation Board

Investigation into Language Barriers in Chemistry 1979

SURNAME__________ OTHER NAMES__________

SCHOOL__________

For each question make a thick pencil stroke under the appropriate letter joining the two dots as in this example. Rub out completely any mark you wish to change.
Do not use ink or ball-point pen.

PUPIL INFORMATION Boy Girl

PART I

Please refer to the white question booklet and answer the 40 questions in the spaces numbered 1 - 40 below.

1	14	27
2	15	28
3	16	29
4	17	30
5	18	31
6	19	32
7	20	33
8	21	34
9	22	35
10	23	36
11	24	37
12	25	38
13	26	39
		40

PART II

You will have been provided with either a pink or a yellow question booklet. *Please indicate in the box below the colour of the booklet you have been given.*

Pink Yellow

The booklet contains 33 questions which are numbered 41 - 73. Please answer the questions in the spaces numbered 41 - 73 below.

41	52	63
42	53	64
43	54	65
44	55	66
45	56	67
46	57	68
47	58	69
48	59	70
49	60	71
50	61	72
51	62	73

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Chemistry questions in original (Test X) and simplified (Test Y) form together with approppiate comment.

(The correct response is indicated by *)

(a) Qualifying Words.

Original Question (X)

56. In which one of the following are the metals arranged in increasing order of activity?

A. Sodium, calcium, iron

B. Calcium, iron, sodium

C. Iron, sodium, calcium

* D. Iron, calcium, sodium

Simplified Question (Y)

In which one of the following are the metals arranged in decreasing order of activity?

A. Iron, calcium, sodium

B. Calcium, iron, sodium

C. Iron, sodium, calcium

* D. Sodium, calcium, iron

From Table X11 all groups showed a significant improvement with the simplication. By far the best distractor in the original form was A and this was not the case in the simplifeid form. This perhaps reflects that the activity of metals is more familiarly taught and learned in decreasing order and in the original form the expression "increasing order" required another thinking stage and consequently found to be more difficult.

Original Question (X)

68. Crystalline sodium chloride does not conduct electricity but fused sodium chloride has an appreciable electrical conductivity. The reason for this observation is that

A. solid sodium chloride contains no ions.

B. the passage of electric current forms ions in molten sodium chloride but not in the solid form.

C. melting sodium chloride produces sodium ions and chloride ions.

* D. ions present in solid sodium chloride are not free to migrate but can do so when the substance is molten.

Simplified Question (Y)

Solid sodium chloride does not conduct electricity but sodium chloride does conduct when molten. The reason is

A. solid sodium chloride contains no ions.

B. the passage of electric current forms ions in molten sodium chloride but not in the solid form.

C. melting sodium chloride produces sodium ions and chloride ions.

* D. ions present in solid sodium chloride are not free to migrate but can do so when the substance is molten.

In addition to the significant improvement in the total sample there are significant improvements for Ability Groups 2 and 3, and Boys "Crystalline", "fused" and "appreciable electrical conductivity" may have added to the difficulty of the thinking stages required to solve the original questions and as a result the facility values were depressed.

Original Question (X)

67. The volume of dry ammonia gas measured at one atmosphere pressure and at room temperature needed to produce 1 mole of gaseous nitrogen molecules is

A. 2 litres

B. 4 litres

C. 24 litres

* D. 48 litres

Simplified Question (Y)

The volume of ammonia measured at room temperature and atmpspheric pressure needed to produce 1 mole of gaseous nitrogen molecules is

A. 2 litres

B. 4 litres

C. 24 litres

* D. 48 litres

There were no significant changes for this item.

Original Question (X)

57. Which one of the following solutions of a salt in water is most dilute?

A. 10g of salt dissolved in 100 ml of water

* B. 5g of salt dissolved in 80 ml of water

C. 4g of salt dissolved in 50 ml of water

D. 2g of salt dissolved in 20 ml of water

Simplified Question (Y)

Which one of the following splutions of a salt in water is most concantrated?

A. 10g of salt dissolved in 100 ml of water

* B. 7g of salt dissolved in 60 ml of water

C. 4g of salt dissolved in 50 ml of water

D. 2g of salt dissolved in 20 ml of water

There were no significant changes for this item.

(b) Negatives.

Original Question (X)

70. Which one of the following statements is NOT true of the elements in the Periodic Table?

* A. Elements with similar properties are arranged in horizontal rows.

B. The elements in Group 1 become more reactive with increasing atomic mass.

C. The elements in Group V11 become less reactive with increasing atomic mass.

D. All the elements in Group 1V have four electrons in the outer shell of their atoms.

Simplified Question (Y)

Which one of the following statements is true of the elements in the Periodic Table?

* A. Elements with similar properties are arranged in vertical columns.

B. The elements in Group 1 become less reactive with increasing atomic mass.

C. The elements in Group V11 become more reactive with increasing atomic mass.

D. All the elements in Group 1V have five electrons in the outer shell of their atoms.

From Table X11 all groups showed a significant improvement with the simplification with the exception of Ability Group 1 which was in the same direction, but less than significant.

Original Question (X)

44. Which of the following particles does not have the same number of electrons as a calcium ion?

A. A potassium ion

* B. A potassium atom

C. An argon atom

D. A chloride ion

Simplified Question (Y)

Which of the following particles has the same number of electrons as a calcium ion?

A. A potassium atom

B. A potassium ion

C. A magnesium ion

D. A chlorine atom

Ability Group 3 showed a significant improvemnnt with the simplification but Ability Group 1 showed a significant deterioration with the simplification. An examination of effect of the various distractors showed that for Ability Group 3 responses A, C and D become poorer distractors in the simplified version whereas for Ability Group 1 responses A and C become more effective distractors.

Original Question (X)	Simplified Question (Y)
45. Which statement is not true?	Which statement is true?
A. The proton does not have the same mass as an electron.	A. The proton has the same mass as an electron.
B. The hydrogen molecule contains two atoms.	B. The hydrogen molecule contains one atom.
C. Isotopes of chlorine do not have different numbers of protons in their atoms.	C. Isotopes of chlorine have different numbers of protons in their atoms.
* D. The element with atomic number 13 is a non-metal.	* D. The element with atomic number 13 is a metal.

The attempted simplification brings about a significant deterioration for the tøtal sample, girls, and Ability Group 3. In all cases the distractor B in the simplified version tands to be particularly effective.

Original Question (X)	Simplified Question (Y)
69. Which one of these statements about carbon dioxide is incorrect?	Which one of these statements about carbon dioxide is correct?
* A. It is the only product formed by the action of hydrochloric acid on marble chips.	A. It is not the only product formed by the action of hydrochloric acid on marble chips.
B. It gives a white precipitate when passed into lime water.	B. It does not give a white precipitate when passed into lime water.
C. It is an acidic oxide.	C. It is a basic oxide.
D. Its molecule is made up from two oxygen atoms and one carbon atom, linked covalently.	D. Its molecule is made up from two carbon atoms and one oxygen atom linked covalently.

In the original version the negative is in the stem and the simplified version has the negative in the correct response and one of the distractors. The only significant difference is for Ability Group 1 who found it easier with the negative in the stem.

The presence of a negative expression does seem to have an influence on performance and this may be due to the increased thinking stages that may be required to solve a question with a negative expression. From, for example, the results of question 45 this is not the only factor operating because in trying to match responses between the two versions a response may be produced e.g. B in simplified 45 that proves to be a more effective distractor.

(c) Bits of information.

Pink 55. Original Question (X)

The table below shows some of the properties of elements represented by the letters A - D. Which one of the elements shows four typical metallic properties?

Element	State at $0^{\circ}C$	State at $1000^{\circ}C$	Conductivity of electricity when solid	Type of oxide
A	liquid	gas	insulator	basic
B	solid	solid	conductor	acidic
C	liquid	gas	insulator	acidic
* D	solid	solid	conductor	basic

Yellow 55 Simplified Question (Y)

The table below shows some of the properties of elements represented by the letters A - D. Which one of the elements shows typical metallic properties?

Element	Conductivity of electricity when solid	Type of oxide
A	insulator	basic
B	conductor	acidic
C	insulator	acidic
* D	conductor	basic

From Table X11 in addition to the Total Sample, Ability Group 3 showed a significant improvement when the question was simplified by removal of two columns of information.

Original Question (X)

53. The order of increasing chemical reactivity (least reactive first) of four halogen elements is

iodine, bromine, chlorine, fluorine.

From this information it can be deduced that

* A. chlorine displaces both iodine from potassium iodide solution and bromine from potassium bromide solution.

B. iodine displaces bromine from potassium bromide solution.

C. bromine displaces chlorine from potassium chloride solution.

D. bromine displaces both iodine from potassium iodide solution and fluorine from potassium fluoride solution.

Simplified Question (Y)

Fluorine is more active than chlorine
Chlorine is more active than bromide
Bromine is more active than iodine

From this it can be deduced that in solution

* A. chlorine displaces both iodine from potassium iodide and bromine from potassium bromide.

B. iodide displaces bromine from potassium bromide.

C. bromine displaces chlorine from potassium chloride.

D. bromine displaces both iodine from potassium iodide and fluorine from potassium fluoride.

The reorganisation of the bits of information in the simplified version brought about a significant improvement for the Total Sample, Ability Group 3 and Ability Group 2.

Original Question (X)

51. The burning of calcium in oxygen produces an oxide which, when it is added to water, gives a solution whose pH value is

A. 1.

B. between 2 and 7.

C. 7.

* D. between 8 and 14.

Simplified Question (Y)

Calcium oxide dissolves in water. The solution would have a pH of

A. 1.

B. between 2 and 7.

C. 7.

* D. between 8 and 14.

Original Question (X)

54. If a crystal of hydrated copper (11) sulphate is placed carefully at the bottom of a beaker of water to stand for several days, a blue colour gradually spreads through the liquid. The best way to describe the spread of colour is

A. dilution.

B. dissolving.

*cC. diffusion.

D. melting.

Simplified Question (Y)

The spread of colour from a crystal through still water is called

A. dilution.

B. dissolving.

* C. diffusion.

D. melting.

There are no signifieant changes for either of these items although for most categories the changes brought about minor improvements.

Original Question (X)

52. A piece of copper, when heated directly in the bunsen flame, turns black but when heated in a hard glass tube from which all air has been removed it does not turn black. Which one of the following statements is true about copper? When heated

A. in the tube it loses weight.

B. in air it stags the same weight.

* C. in the tube it stays the same weight.

D. in the tube it gains weight.

Simplified Question (Y)

Copper when heated in air turns black. Copper when heated in the absence of air does not turn black. Which one of the following statements is true about copper? When heated

A. in the absence of air it loses weight.

B. in air it stays the same weight.

* C. in the absence of air it stays the same weight.

D. in the absence of air it gains weight.

The removal of a number of bits of informàtion from the stem in the simplified version brings about a significant deterioration in the girls, and a smaller deterioration in some of the groups.

The expression "in the absence" which is used in the simplified version but not in the original version may be a factor that is influencing the performance in this question.

In some instances the reductionoof the bits of information in the stem seems to make the question easier perhaps because the thinking necessary to solve the quemtion has been reduced. It is easier to handle the information when some of the extraneous information has been removed.

(d) <u>The arrangement of the bits of information in the stem.</u>

<u>Original Question</u> (X)

65. Which of the following could be a salt which, when a solution is electrolysed, gives a brown deposit at the negative electrode and evolves a yellowish green gas at the positive electrode?

A. Potassium bromide

B. Lead chloride

* C. Copper (11) chloride

D. Calcium iodide

<u>Simplified Question</u> (Y)

A solution of a salt is electrolysed. At the negative electrode a brown deposit forms and at the positive electrode a yellowish green gas is evolved. Which of the following could the salt have been?

A. Potassium bromide

B. Lead chloride

* C. Copper (11) chloride

D. Calcium iodide

From Table X11 the simplification brought about an improvement for all groups but only the Total Sample was a significant improvement.

The simple sentences of the simplified version seem to have been easier to handle than the longer single sentance with the embedded clause.

In the simplified question the part of the stem that is asking the question is much nearer the responses whereas in the original version the question comes right at the beginning of the stem and information has to be read before getting to the responses.

<u>Original Question</u> (X)

66. Which one of the following solutions when added to $20cm^3$ 80 2M sulphuric acid would form a neutral solution?

The equation for the reaction is

H_2SO_4+2KOH $\quad$ K_2SO_4+$2H_2O$

A. $20cm^3$ of 2M potassium hydroxide

* B. $40cm^3$ of 2M potassium hydroxide

C. $10cm^3$ of 2M potassium hydroxide

D. $40cm^3$ of M potassium hydroxide

<u>Simplified Question</u> (Y)

Given this equation

H_2SO_4+2KOH $\quad$ K_2SO_4+$2H_2O$

Which of these solutions would exactly neutralise $20cm^3$ of 2M sulphuric acid?

A. $20cm^3$ of 2M potassium hydroxide

* B. $40cm^3$ of 2M potassium hydroxide

C. $10cm^3$ of 2M potassium hydroxide

D. $40cm^3$ of M potassium hydroxide

This simplification brought about an improvement for most groups but only for the Total Sample and Ability Group 1 were the improvements signigicant.

In the simplified version the arrangement is information, question and responses, whereas in the original version the arrangement is question, information and responses. Perhaps having the question close to the responses is easier to think about than having the question then information before getting to the responses.

Original Question (X)

47. A compound, where both ions have the same electronic arrangement as argon (2,8,8) has a formula of the type X_2Y. Which of these compounds is it?

* A. Potassium sulphide

B. Aluminium chloride

C. Sodium fluoride

D. Potassium oxide

Simplified Question (Y)

Which of the following compounds has a formula of the type X_2Y where both ions have the same electronic arrangement as argon (2,8,8)?

* A. Potassium sulphide

B. Aluminium chloride

C. Sodium fluoride

D. Potassium oxide

The simplification brought about an improvement for most groups but only for the Total Sample was the improvement significant.

In the simplified version the embedded clauses had been removed and this arrangement was apparently easier for the candidates perhaps because it made the thinking stages less convoluted.

Original Question (X)

64. From an analysis of 24g of antimony oxide, which showed that 20g were antimony and 4g were oxygen, which of the following formulae would correctly represent antimony oxide, knowing that the atomic weight (relative atomic mass) of antimony was 120 and that of oxygen was 16?

A. SbO

B. SbO_2

C. Sb_2O_5

* D. Sb_2O_3

Simplified Question (U)

An analysis of 24g of antimony oxide showed that 20g were antimony and 4g were oxygen. Knowing that the atomic weight (relative atomic mass) of antomony was 120 and that of oxygen was 16, which of the following formulae would correctly represent antimony oxide?

A. SbO

B. SbO_2

C. Sb_2O_5

* D. Sb_2O_3

Original Question (X)

71. Assume that air contains nitrogen and oxygen only and the boiling point of nitrogen is lower than that of oxygen. If $100cm^3$ of air is liquefied and then allowed to warm up, which one of the following will result?

A. $20cm^3$ of oxygen will come off first and then $80cm^3$ of nitrogen.

B. $80cm^3$ of oxygen will come of first and then $20cm^3$ of nitrogen.

C. $20cm^3$ of nitrogen will come off first and then $80cm^3$ of oxygen.

* D. $80cm^3$ of nitrogen will come off first and then $20cm^3$ of oxygen.

Simplified Question (Y)

Assume that air contains nitrogen and oxygen only. Remember that the boiling point of nitrogen is lower than that of oxygen. If $100cm^3$ of air is liquefied and then allowed to warm up, which one of the following will result?

A. $20cm^3$ of oxygen will come off first and then $80cm^3$ of nitrogen.

B. $80cm^3$ of oxygen will come off first and then $20cm^3$ of nitrogen.

C. $20cm^3$ of nitrogen will come off first and then $80cm^3$ of oxygen.

* D. $80cm^3$ of nitrogen will come off first and then $20cm^3$ of oxygen.

Original Question (X)

72. Use your knowledge of the structure of sodium chloride and the knowledge that the formation of potassium bromide involves the transfer of one electron from each potassium atom to each bromine atom to predict which one of the following statements best describes the composition of a crystal of potassium bromide?

A. A lattice containing equal numbers of potassium atoms and bromine atoms arranged in a definite pattern.

* B. A lattice containing equal numbers of potassium ions and bromide ions arranged in a definite pattern.

C. A lattice containing equal numbers of potassium ions and bromide ions arranged in no definite pattern.

D. Many separate molecules each made up of one potassium atom and one bromine atom.

Simplified Question (Y)

The formation of potassium bromide is similar to the formation of sodium chloride in that each metal atom loses one electron to each non-metal atom. Which one of the following best describes the composition of a crystal of potassium bromide?

A. A lattice containing equal numbers of potassium atoms and bromine atoms arranged in a definite pattern.

* B. A lattice containing equal numbers of potassium ions and bromide ions arranged in a definite pattern.

C. A lattice containing equal numbers of potassium ions and bromide ions arranged in no definite pattern.

D. Many separate molecules each made up of one potassium atom and one bromine atom.

There were no significant changes for any of these three items. The altezations in the organisation of the information may have been of such a nature that they did not influence the thinking necessary to solve the question and as a result changes in performance were minor.

(e) Pompous Expressions.

	Original Question (X)	Simplified Question (Y)
58.	In which of the following compounds is there a tendency for covalency to predominate?	Which one of these compounds is covalent?
	A. Calcium fluoride	A. Calcium fluoride
*	B. Sulphur chloride	* B. Sulphur chloride
	C. Sodium bromide	C. Sodium bromide
	D. Potassium iodide	D. Potassium iodide

From Table X11 the simplification brought about a significant improvement for the Total Sample and for Ability Group 1.

	Original Question (X)	Simplified Question (Y)
59.	Which of the following procedures would be expected to produce on exactly 0.1 molar solution of sodium chloride (formula weight = 58.5)?	To make an exactly 0.1 molar solution of sodium chloride (formula weight = 58.5) what would you do?
	A. Dissolving 5.86g of sodium chloride in 100 ml of water.	A. Dissolve 5.85g of sodium chloride in 100 ml of water.
*	B. Dissolving 5.85g of sodium chloride in water and making up with water to 1 litre of solution.	* B. Dissolve 5.85g of sodium chloride in water and make up with water to 1 litre of solution.
	C. Adding 100 ml of a molar solution of sodium chloride to 1 litre of water.	C. Add 100 ml of a molar solution of sodium chloride to 1 litre of water.
	D. Adding 5.85g of sodium chloride to 1 litre of water and shaking until dissolved.	D. Add 5.85g of sodium chloride to 1 litre of water and shake until dissolved.

	Original Question (X)	Simplified Question (Y)
60.	Which one of the following observations is used to detect the presence of carbon dioxide?	Which one of these is a test for carbon dioxide?
	A. Relights a glowing splint.	A. Relights a glowing splint.
	B. Bleaches damp litmus.	B. Bleaches damp litmus.
*	C. Forms a white precipitate when passed through a solution of calcium hydroxide.	* C. Forms a white precipitate when passed through a solution of calcium hydroxide.
	D. Forms a white precipitate when passed through a solution of sodium hydroxide.	D. Forms a white precipitate when passed through a solution of sodium hydroxide.

Original Question (X)

62. When an atom of a metallic element ionises it

* A. loses electrons.
  B. chahges the structure of its nucleus.
  C. gains protons.
  D. is reduced.

Simplified Question (Y)

When a metal atom changes to an ion it

* A. loses electrons.
  B. changes the structure of its nucleus.
  C. gains protons-
  D. is reduced.

Original Question (X)

73. The sequential stages involved in the large scale purification of water supplies for use in towns and cities are

  A. chlorination, storage, filtration, distribution.
  B. collection, distribution, filtration, storage.
  C. extraction, sterilisation, distillation, storage.
* D. collection, filtration, chlorination, distribution.

Simplified Question (Y)

Which one of the following is the order in which water is purified for use in towns and cities?

  A. chlorination, storage, filtration, distribution
  B. collection, distribution, filtration, storage
  C. extraction, sterilisation, distillation, storage
* D. collection, filtration, chlorination, distribution

For these four items there were no significant changes.

Original Question (X)

61. The process used to obtain hydrated copper(11) sulphate from a dilute solution of copper(11) sulphate is called

  A. filtration.
  B. precipitation.
  C. neutralisation.
* D. crystallisation.

Simplified Question (Y)

Hydrated copper(11) sulphate is obtained from a dilute solution of copper(11) sulphate by

  A. filtration.
  B. precipitation.
  C. neutralisation.
* D. crystallisation.

For Ability Group 1 and the Girls there was a significant deterioration with the attempted simplification. The removal of the expression - 'the process' may have made the information in the simplified stem more compressed, more abstract, and made response A a more plausible distractor.

Original Question (X)

63. The laboratory preparation of nitrogen by passing air through sodium hydroxide solution and then over heated copper produces nitrogen which contains

A. oxygen.

B. carbon dioxide

* C. noble gases.

D. nitrogen dioxide.

Simplified Question (Y)

If air is passed through sodium hydroxide solution and then over heated copper, the gas collected contains nitrogen and

A. oxygen.

B. carbon dioxide.

* C. noble gases.

D. nitrogen dioxide.

For the Total Sample, Ability Group 1, Boys and Girls there was a significant deterioration with the attempted simplification. In its original version it is a preparation of nitrogen and the wording of the latter part of the stem indicated that nitrogen is produced plus something else. The compression in the simplified version makes it more abstract. It is air that is involved and the gas collected contains nitrogen and response A oxygen becomes a more effective distractor, perhaps because nitrogen and oxygen are the main gases in the air.

Pompous expression is a very subjective phrase. If there are expressions that need to be understood in order to go through the thinking stages to solve a question and if these expressions are 'unfamiliar' as in example 58, then these will adversely influence performance. If on the other hand there are expressions where removal makes the question more abstract as in example 63, then these expressions improve performance.

The balance between precise formal language and difficult pompous language is delicate as is the balance between simple accurate language and brief compressed language.

(f) Passive Voice.

Original Question (X)

46. Equal numbers of protons are contained in which one of the following pairs of particles?

* A. Na and Na^+

B. Na^+ and Ne

C. CI^- and Ar

D. K^+ and Ca^{2+}

Simplified Question (Y)

Which one of the following pairs of particles contains equal numbers of protons?

* A. Na and Na^+

B. Na^+ and Ne

C. CI^- and Ar

D. K^+ and Ca^{2+}

Original Question (X)

49. A compound with the formula XY_3 would be likely to be formed from which of the follðwing pairs of elements?

* A. Phosphorus and hydrogen

B. Hydrogen and sulphur

C. Sulphur and chlorine

D. Chlorine and carbon

Simplified Question (Y)

Which of the following pairs of elements are likely to form a compound with the formula XY_3?

* A. Phosphorus and hydrogen

B. Hydrogen and sulphur

C. Sulphur and chlorine

D. Chlorine and carbon

Original Question (X)

50. In which of the following would both compounds not have been decomposed when heated separately with a bunsen burner?

A. sodium nitrate, silver oxide

B. mercury oxide, zinc nitrate

* C. potassium carbonate, calcium oxide

D. copper carbonate, lithium nitrate

Simplified Quwstion (Y)

Which pair of compounds would both decompose when heated separately with a bunsen burner?

A. sodium nitrate, calcium oxide

B. zinc oxide, lithium nitrate

* C. copper carbonate, mercury oxide

D. potassium carbonate, silver oxide

From Table X11 there were no significant changes in any of these three items. Passive voice may be familiar to the candidates and the attempted simplifications do not influence the thinking stages that are necessary to solve these questions.

Appendix N

I Verbal Recognition

IA Recognizing a Synonym

The bird was audible

A. It made a noise which could be heard

B. It was very beautiful to look at

C. It was a long way from home

D. It was flying very slowly

IB Instance Recognition

Which of the following is a sense organ

A. the brain

B. the heart

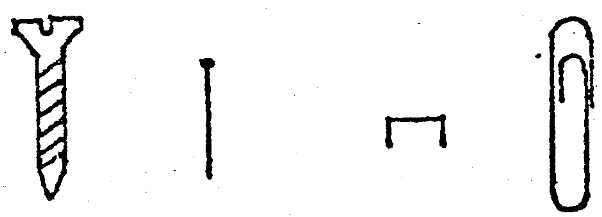
C. the tongue

D. the legs

E. the stomach

II Diagram Recognition

Which drawing shows a pin?



(A) (B) (C) (D)

III Context Usage

Which sentence uses the word convenient correctly?

A. Mary found it convenient to do her housework at night, when the house was quiet.

B. The cook made some soup which tasted very convenient.

C. The books were sold to the children: the books did not cost much so the children were convenient.

D. Bill was sick, but after a week he felt convenient again.

IV Sentence Completion

When the plant was put inside the jar of gas, its leaves changed from green to yellow. The leaves were:

A. adjusted by the gas

B. deflected by the gas

C. displaced by the gas

D. resisted by the gas

E. affected by the gas

V Gap Filling

From the list of words pick the word that best completes the sentence.

The school held ____________ to see which boy could kick a football the longest distance.

A. an argument

B. a substitution

C. a competition

D. an effort

E. an error

Appendix O

WORDS IN TERTIARY TEST

abnormal
accumulate
action
analysis
appropriate
associate
average
characteristic
classify
concept
consecutive
contrast
converge
converse
convert
correspond
disintegrate
distinguish
diversity
effect
efficient
factor
function
fundamental
illustrate
incident
initial
instantaneous
invert
logic
modify
negligble
probability
propagate
proportion
rate
relevant
significant
simultaneous
spontaneous
standard
stimulate
uniform
valid
criteria
hypothesis
postulate
substitute
symmetrical
tabulate
theory

(51)

Appendix P

Percentage correct on items at four grade levels
(from "Words in Science" - P.L. Gardner)(142)

Word	School Form 1	2	3	4
ability	71	79	88	90
abnormal	85	87	93	95
absence	74	78	80	85
abundant	72	82	93	94
accumulate	61	70	87	92
accurate	75	79	88	92
*action	46	57	64	76
adjacent	73	83	95	96
adjust	64	75	77	73
adopt	88	82	93	92
advantage	85	89	95	92
affect	87	93	88	91
agent	72	80	87	93
agriculture	75	82	93	96
airtight	82	87	96	94
*algebra	48	58	71	81
alternate	64	82	91	92
analysis	68	78	81	92
ancestor	84	87	91	92
angle	80	85	93	95
annual	70	78	90	90
aperture	67	73	83	87
apply	83	88	93	94
appropriate	70	79	91	83
approximate	81	79	86	89
*arid	53	72	86	92
ascend	83	88	92	92
ash	84	90	93	94
assignment	80	87	95	94
associate	70	78	78	84
assume	76	85	91	87
attract	87	90	95	96
*audible	45	60	69	75
automatic	78	85	88	92
**average	35	54	60	61
avoid	89	93	90	94
aware	88	92	93	94
basic	87	93	96	97
bind	86	95	97	98
bounce	79	87	87	89
boundary	76	84	91	91
breed	82	86	93	95
breeze	89	93	94	94
brittle	75	86	92	94
bud	89	91	94	94
bulb	84	92	95	91
bump	88	86	92	93
calculate	68	83	92	96
camouflage	85	88	95	95
canal	83	93	97	95
cancel	83	91	88	95
capable	76	84	92	85
capacity	82	88	96	97
capture	89	92	96	93
caution	86	92	92	95
cave	81	89	95	94
characteristic	73	79	88	91
chew	88	90	96	95
chip	82	88	89	93
clamp	80	90	95	96
climate	80	89	89	93
coarse	76	84	92	92
coil	89	91	97	96
*coincide	60	77	90	93
collapse	88	94	95	96
column	63	63	73	79
combination	86	91	94	97
commence	86	91	96	95
compare	89	91	94	98
*complex	52	64	77	82
*component	49	63	76	87
*composition	49	61	81	91
compress	83	88	93	95
**concept	32	45	61	74
**conception	31	44	63	74
conclusion	76	86	88	91
conical	62	72	79	83
consecutive	68	78	81	88
consist	88	93	97	91
consistent	68	79	87	92
constant	71	79	92	96
*constituent	44	51	63	81
construct	86	93	95	95
*consume	47	62	76	85
contact	87	92	97	96
container	80	84	88	92
contents	87	92	95	96
*continent	54	64	71	79
continual	89	91	96	94
**contract	39	59	70	80
*contrast	51	53	60	68
*contribute	58	72	86	89
convenient	83	91	97	97
convention	61	72	82	85
*converge	58	74	81	87
**converse	38	39	38	41
convert	72	84	88	91
co-ordination	81	89	92	94
cord	87	93	94	93
core	85	93	92	90
**correspond	35	44	58	61
creation	88	93	95	98
*crest	50	66	72	74
criticise	66	72	79	83
*crude	42	62	71	87
[illegible]st	87	92	95	97

* see last page

cultivate	76	84	92	92
cure	82	85	88	90
decay	72	79	83	90
decimal	89	93	93	95
decrease	80	82	96	97
define	74	78	90	97
deflect	64	75	80	83
degree	66	78	84	85
dependent	85	92	95	99
depth	82	90	90	95
derive	74	73	84	91
descend	69	85	92	93
**descendant	32	47	52	62
description	84	93	95	92
detect	61	71	79	83
device	67	81	87	88
*devise	53	65	69	84
diagnose	69	79	90	95
diagonal	69	75	85	86
dial	88	91	92	93
*diameter	48	67	81	86
dimension	77	86	93	95
disc	83	85	92	88
discuss	84	92	95	97
**disintegrate	18	22	27	38
disperse	62	74	85	90
displace	67	72	73	82
distinct	71	85	90	93
distribute	79	85	91	96
disturb	89	89	87	88
*diversity	49	58	66	78
*dominant	51	67	81	88
doubt	82	91	94	95
drain	87	90	93	94
drought	85	88	95	93
duplicate	89	93	98	96
edible	77	85	91	93
*effect	45	46	62	70
*efficient	48	56	68	72
elastic	74	86	86	86
*emit	46	58	65	79
enable	62	76	83	83
equipment	89	93	95	96
equivalent	88	92	93	97
erect	75	85	91	93
essential	63	71	82	86
estimate	76	76	82	89
evacuate	78	85	94	93
exact	70	85	88	85
exception	79	87	93	96
excess	70	79	90	94
excite	69	77	80	89
exclude	68	79	91	95
exert	64	68	88	87
expand	89	91	93	96
expel	77	82	87	93
experience	88	93	92	97
explode	86	88	93	94
expose	70	76	89	90
*external	53	68	82	90
extra	87	88	93	91

extreme	79	88	92	93
**factor	35	62	67	76
film	64	72	75	84
fin	82	79	81	75
fog	66	79	75	81
formation	88	93	96	96
function	88	94	96	95
*fundamental	53	66	73	75
generate	67	81	86	87
globe	88	91	91	95
**grain	31	35	39	48
grind	79	85	89	90
hatch	82	86	84	87
horizon	85	91	92	95
hygiene	88	92	97	98
identical	85	87	84	84
identify	82	90	93	95
*illuminate	49	71	84	89
*illustrate	56	59	70	76
imagination	78	82	88	91
*immerse	52	62	80	85
impact	66	77	85	87
*incident	42	54	54	62
*incline	47	47	61	63
index	78	84	81	89
indicate	85	91	94	96
industry	87	93	97	96
inflate	77	83	85	83
influence	63	73	79	90
inhabit	84	84	91	95
inhale	88	94	96	96
**initial	35	45	47	64
inquiry	86	92	93	97
insert	88	90	95	93
instantaneous	77	84	92	96
instrument	88	88	94	94
intake	71	82	85	92
intelligence	89	89	91	94
interfere	84	87	90	94
internal	79	86	93	94
*interpret	56	67	77	83
intersect	89	94	98	95
interval	88	96	96	97
invent	89	88	95	91
*invert	45	54	68	79
involuntary	67	80	89	92
irritate	69	77	89	86
isolate	63	77	90	97
junction	74	78	87	92
**latitude	35	45	47	52
**law	39	51	72	78
layer	77	83	95	95
leaf	86	88	87	91
leak	87	86	94	95
level	79	84	91	87
liberate	54	71	86	90
limit	69	81	86	91
*linear	52	59	77	80
logic	61	69	70	78
**lubricate	37	45	70	84
*magnitude	50	74	85	80

majority	86	88	96	95
manufacture	74	82	91	91
margin	87	92	94	96
mate	84	90	92	95
mature	74	82	92	92
maximum	63	74	84	90
measure	87	86	88	89
medium	87	90	90	94
method	82	87	95	95
mild	75	85	90	89
*minimum	52	67	82	81
mobile	87	90	96	97
modify	57	61	76	87
moisture	89	89	94	94
molten	64	75	86	92
multiple	70	72	85	90
multiply	86	89	94	97
naked	65	68	75	80
*negative	39	61	73	77
neglect	78	86	95	92
*negligble	52	68	62	73
*neutral	53	67	78	82
observation	74	77	92	88
obvious	67	73	83	84
occasional	89	93	98	92
occur	84	83	90	93
*omit	42	59	74	81
operate	88	92	95	90
opinion	83	87	93	92
oppose	68	71	84	82
origin	64	78	87	87
*outline	56	70	80	80
overcome	85	92	95	90
overhead	88	91	90	88
*partial	39	51	59	68
particle	82	84	94	86
penetrate	76	84	91	94
per	88	86	88	91
*percentage	41	51	49	55
permanent	76	84	89	90
*perpendicular	47	67	84	81
*phenomenon	56	59	73	81
pierce	87	90	95	91
pivot	82	87	91	92
*plot	51	81	90	95
positive (test)	64	72	78	81
*positive (number)	42	86	92	92
practise	87	91	98	93
predict	71	85	93	94
preparation	74	78	85	82
presence	74	84	92	92
previous	64	72	84	89
primary	63	71	76	83
primitive	67	65	86	86
*probability	52	58	68	76
procedure	81	88	94	94
process	66	76	84	91
profile	67	81	88	90
proof	77	87	87	90
propagate	67	69	70	71
propel	84	90	90	93
proportion	65	67	74	81
pump	69	81	88	84
purify	81	92	92	93
**random	12	18	36	35
**rate	25	39	47	58
*recoil	52	63	71	75
reference	67	77	85	93
refine	76	84	88	90
reflect	62	62	79	80
regular	69	76	76	85
*regulate	50	61	75	82
reject	89	93	96	97
relationship	79	89	92	94
*relative	41	58	63	74
relevant	66	75	84	88
reliable	88	91	94	95
*repel	58	71	83	88
replace	88	94	94	95
*represent	59	74	83	86
research	86	94	96	96
*residue	57	65	79	81
*resist	55	72	79	90
resource	64	76	86	86
respond	72	80	87	90
retard	62	80	87	90
**revise	33	40	50	58
rigid	60	68	82	85
rim	81	86	94	92
rotate	83	91	95	93
*row	53	49	55	57
rule	78	84	83	88
scale	76	85	95	94
scratch	88	88	95	93
screen	87	89	90	92
sea weed	88	92	93	94
section	61	65	76	86
*sense	47	53	65	68
sensitive (to light)	64	68	83	82
sensitive (instrument)	75	79	86	88
*sequence	57	63	63	80
sign	79	87	90	92
significant	83	86	93	94
simplify	78	86	91	91
*simultaneous	54	66	71	77
sink	86	91	91	88
smear	74	80	89	93
source	79	89	94	94
spark	88	91	95	94
spiral	76	82	89	89
splint	87	90	92	92
**spontaneous	15	26	39	45
stable	85	93	95	94
stagnant	63	69	79	87
stain	64	81	86	90
*standard	41	50	72	76
stationary	85	93	95	95
steady	87	93	91	94
*stimulate	43	48	57	71
structure	88	92	97	96
submerge	70	76	82	85
substance	87	96	94	94
substitute	64	76	87	8[illegible]
successive	79	88	93	96

suckle	63	69	81	78
summary	85	89	95	98
suspend	62	72	84	87
*symbol	54	73	84	91
**symmetrical	23	35	48	60
system	70	77	85	84
systematic	78	93	94	93
table	80	88	95	95
tabulate	75	78	89	93
*tank	43	56	56	65
temporary	66	73	80	90
tend	82	87	94	94
tension	75	78	87	93
*textbook	55	63	66	80
theory	67	78	78	74
thrust	69	77	83	88
tide	77	82	92	90
topic	48	59	61	66
trace	85	90	91	92
transform	78	85	91	88
transmit	85	84	95	96
treatment	67	75	79	86
trough	85	86	91	95
tube	77	83	91	90
tweezers	81	81	92	93
typical	77	87	93	97
uniform	73	87	87	96
upset	85	94	94	96
**valid	30	50	65	79
variable	80	90	93	96
variety	87	93	96	97
vertical	64	72	84	87
*vessel	56	70	78	90
vigorous	82	84	92	93
violent	84	89	96	96
vital	61	75	85	91
vocal	71	83	91	94
weed	80	86	91	90
wilt	78	82	90	90

* Students at first form level scored 40-60% correct on the item testing the word.

** Students at first form level scored less than 40% correct on the item testing the word.

School forms 1,2,3 and 4 equate approximately with ages 12,13,14 and 15 respectively.

Non-technical Words in Science

INSTRUCTION SHEET

(a) Preparing the Tests. The number of questions in your test will depend on the length of time you have available. There is no need to have questions in any particular order, nor to give it as one big test. The number of copies of each test which you duplicate will depend on the number to be tested at any one time. There is no real advantage in testing all your sample at the same time.

(b) Administering the Tests. It is important to explain to candidates why they are being assessed in this way, so that they will take the exercise seriously. The type of answer grid used should be familiar to the candidates. Do not discourage guessing, apply usual test discipline. Allow time for all candidates to attempt all questions.

(c) Marking and Collecting Information for Response Sheets. With large samples some form of computer-assisted marking of answer grids would be an advantage. Check that the programme provides number of candidates selecting each response for each question. With small class samples the number of candidates selecting each response for each question could be readily obtained by a show of hands.

It is hoped that these very general points are of some assistance. With interested people in so many varied situations it is impossible to be more specific. In general it is hoped that the exercise will blend in with normal instruction and normal procedures within your institution.

RESPONSE SHEET

1. Unless otherwise stated it will be assumed that all groups are following a science course.

2. Use one sheet for each word tested. In rectangle A write the word in the top left-hand corner and set out the complete question used underneath. In rectangle B record your results as numbers in the appropriate column. The Groups 1 to 7 refer to age bands. Group 1 corresponds to the first year of a secondary school with entry at 11+ years of age, Group 7 is therefore the upper or second-year sixth form. If your school is a 13-18 years school the results of your youngest form would therefore be entered against Group 3. The youngest form in a Scottish school would usually be Group 2.

3. Indicate the correct response with an asterisk (*)

4. An example of what is required is attached.

Please remember to enclose clear identification of your name, school and address.

RESPONSE SHEET

ABSENCE

The absence of light made it hard for the boy to see.

A. There was a small amount of light

B. The light was shining in his eyes

C. There was no light

D. The light was very bright

Year Group	Number Selecting					
	A	B	*C	D	E	F
1	10	12	52	9	-	-
2	10	10	60	1	-	-
3	6	2	40	2	-	-
4	5	2	44	0	-	-
5	3	1	46	0	-	-
6	1	0	19	0	-	-
7	1	0	19	0	-	-

RESPONSE SHEET

Year Group	Number Selecting					
	A	B	C	D	E	F
1						
2						
3						
4						
5						
6						
7						

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