THE APPLICATION OF OBJECTIVE TESTS FOR ASSESSING ACADEMIC ACHIEVEMENT IN SCIENCE

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Previous investigations have found certain abilities which are associated with science achievement. Ten such abilities were selected and a battery of mental tests, which measure these abilities, is chosen.

The history and development of each ability is traced and a brief description of each test is given. The sample chosen for this investigation consists of 96 students of Alliance High School, Kikuyu, Kenya. These students have completed two years of their secondary school education.

The results of the battery of mental test and science examinations are analysed in various ways. Histograms are drawn for all the tests and examinations, and corrections are made for the two tests which show skewed distributions.

An item analysis is carried out on all the questions in the objective examinations for both Physics and Chemistry. A number of questions are rejected and the scores of revised examinations are used in further analyses.

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The raw data is processed by computer and the means and standard deviations are calculated and then a correlation matrix for the twenty-nine variables is produced.

The correlations between the tests and examinations are generally positive as would be expected, but there are a number of negative correlations. Comments are made about the inter-correlations between the science examinations and individual abilities as measured by the tests. Tests of memory and word fluency abilities have no significant correlations with the science examinations. The objective examinations in science are found to have a greater number of significant correlations with the tests of mental abilities than have the conventional examinations in science.

The sample is divided into four groups according to scores on the objective and conventional science examinations, so that abilities required for the two types of examination can be compared. The means of the scores on all tests and examinations for these four groups are found and the significance of difference between the means are calculated. There are some tests whose means show a significant difference between the group good at objective and poor at conventional examinations and the group poor at objective and good at conventional examinations. General reasoning, inductive and spatial abilities are associated with success in the objective examinations, and verbal abilities favour, to a small extent, success in the conventional examinations.

It is clear that those students who are good at both types of examination have superior abilities in general reasoning, induction, and concepts of space whereas the verbal, perceptual, numerical,memory and fluency abilities are not significantly different between good and poor students in science.

Ten principal components are extracted from the data and then a Varimax solution is obtained which produces seven components which have a meaningful psychological interpretation. The only science achievement factor is the first, whichhas acontribution of variance of 26.5% and is identified as a factor of general science reasoning achievement. The other six factors are identified as II-Numerical Perceptual; III-Spatial

Orientation; IV-Verbal, Ideational, Perceptual Judgement; V-Word Fluency; VI-Verbal Comprehension; and VII-Expressional Fluency.

Two second order factors are extracted from the correlations between the Promax factors obtained. The first factor is identified as a general science scholastic intelligence factor and the second as a numerical, memory, word fluency facility.

These factor analyses suggest that the reasoning ability and general intelligence are the most important abilities for achievement in science at the academic level tested.

CHAPTER I

APPRAISAL OF EXAMINATIONS

Kenya has inherited an educational system similar to that of Britain owing to its close ties for many years with the United Kingdom. The first secondary schools were developed under the supervision of teachers and administrators from Britain and the examination procedure was moulded on the British pattern. Thus it is appropriate to consider examinations in Britain, for developments and modifications which have taken place in examinations in Britain have also been adopted in Kenya.

(a) Examinations in Britain

It is not known when the first written examinations were set, but tradition says that there were written examinations in China some two thousand years ago. (Report, 1960). In Britain, written examinations were first used widely in the 1850's for admission to the Home and Indian Civil Service, to the Royal Military Academy and for admission to London University, and at the same time scholarships at Cambridge were thrown open to competition. In 1861 the Clarendon Commission recommended that examinations for Public Schools should be on competitive basis. (Report, 1960).

This new outlook led to the proliferation of examinations, and in 1868 the Report of the Schools Inquiry Commission proposed that a statutory council for examinations should be set up. From this proposal came the origin of the Oxford and Cambridge Schools Examination Board which set examinations for secondary schools. With the increase in the number of secondary schools, spurred on by the Education Act of 1902 which enabled the new local education authorities to aid and establish them, came a multiplicity of examinations at different levels and for different purposes. The Report of the Consultative Committee in 1911 drew attention to this uncoordinated growth and recommended that external examinations "should so be conducted as to assist and emphasize the principle that every secondary school should provide, for pupils up to an average age of 16, a sound basis of liberal education which would serve as a foundation upon which varieties of further education could be based". In 1917 the Board of Education introduced two examinations; the School

Certificate intended for pupils about the age of 16, and Higher School Certificate for those two years older. These examinations were to be conducted through universities and a Secondary School Examination Council was set up to advise the Board on its function as a coordinating authority.

The Norwood Committee of the Secondary School Examination Council issued a Report in 1943 which condemned the existing examination system and recommended radical changes and their preference was for a scheme which would replace the School Certificate examination with an internal examination under the control of the teachers. The Secondary School Examination Council Report in 1947 sought to create the General Certificate of Education Ordinary level examination, an examination which would be taken after five years of secondary education. The Report (1960) of the Secondary School Examination Council recommended that a new examination, the Certificate of Secondary Education, should be set up and cater for the 20% to 60% ability range of the 16-year-old age group, which would not normally take the General Certificate of Education. This Report recommended that the Certificate of Secondary Education examinations should largely be in the hands of teachers serving in the schools, divided into about twenty regional Examining Bodies.

It can be seen that many people are aware of the importance of examinations and are seeking to find better ways of conducting these examinations, which affect the lives of large numbers of children. Alongside these changes in the system of examinations has been an enquiry into the types of examinations which are most suitable for these pupils.

(b) Purpose of Examinations

There have always been criticisms of examinations, but they have become more vocal over the past twenty years. Even as early as 1868 a Commission was set up to enquire into the examination system in Britain. This was followed in 1911 by the Report of the Consultative Committee, and in 1938 the Spens Committee was concerned by the way the School Certificate examination dominated the framework and content of curriculum.

In 1943 the Norwood Report urged that the School Certificate examinations should be replaced by an internal examination under the control of the teachers. The Report (1960) recommended that any new examination should be largely in the hands of the teachers and that regional Examining Bodies should be responsible for the setting and moderation of any examinations, internal or external.

There is no perfect examination, but they do have uses which can be summarised as follows: (Vernon, 1956. Report, 1960.)

1. They are used as tests of achievement, giving both pupil and teacher a measure of what the pupil 'knows'.

2. They are used as 'yard-sticks', to compare pupils with one another and to group them appropriately.

3. They are used to indicate to the teacher how effective the teaching is, and what is being understood by the pupil.

4. They are used to assess the efficiency of the school and its teachers in relation to other schools and teachers.

5. They are used as guides for predicting future achievement of pupils and for selection for further education and professions.

6. They are used by employers for a common guide as to the ability of prospective employees.

7. They stimulate both pupils and teachers to work harder, even on those sections of the work which they do not find so interesting. Teachers like to see their pupils do well in examinations and so put more effort into their teaching.

Vernon (1956) states that the traditional written examinations generally fail to fulfil these many different functions and considers that the conventional, essay-type, question can be considerably improved and that the new-type, objective question can be introduced with benefit.

Valentine (1969) summarised the role of the General Certificate Examination as (i) a model and pace-setter for what is taught and learned in schools and (ii) a measurement device for assessing the proficiency of individual students, but he concludes that the present examinations must be much improved in order to fulfil these functions.

The Report (1960) comes to the conclusion that examinations serve a useful purpose in Britain, but stresses that the examination should suit the pupils and enable them to find a place in the community most suited to their abilities.

(c) Review of conventional examinations

The conventional, or essay-type, examination is composed of a number of questions, which need twenty or thirty minutes for answering. The candidate normally is allowed to choose a given number of questions from the paper; a 2½ hours examination might ask for answers to five or six questions.

That this is the best way to test subjects ranging from History to Chemistry has generally been accepted, except by a few educationists, until recently. Ballard (1923) strongly criticised this kind of examination and showed how unreliable the essay was as a measure of a child's ability, and how a child's work could fluctuate from week to week. Hartog and Rhodes (1935) gave instances when essays were marked completely differently by markers, but little has been done to change the kind of examinations which are set for the present General Certificate of Education.

A summary is given of the advantages and disadvantages of conventional, essay-type, examinations, which are discussed at length by many writers, e.g. Vernon (1956), Ebel (1965).

<u>Advantages</u>

1. They are relatively easy and quick to set.
2. Candidates are required to express their knowledge and understanding in writing and therefore show that they can organize, plan and assemble their facts and ideas, and can present them so

that they can be easily followed and understood by the examiner.

Disadvantages

1. They take a long time to mark and depend on the subjective judgement of the marker. Wiseman (1956) showed that three essays from each student, all marked by three markers, are required if the reliability of essays is to be comparable to the reliability of objective tests.

2. The examination can sample only a small field of the work covered during the course. This means that some parts are examined in detail, whereas others are ignored so that an element of chance is introduced, encouraging the candidate to guess which questions are likely to be set.

3. It is difficult to determine exactly what each question is designed to test, and different markers look for different qualities. A candidate who is poor at expressing himself verbally, may in fact have a good knowledge and understanding of the subject.

Eggleston (1965) reviews some of the deficiencies of the conventional examination. Eggleston states that we have come to accept that the conventional examinations, which demand answers written in about 20 minutes, are efficient and the only acceptable technique for measuring attainment, or at best constitute an indispensible technique, which may perhaps be augmented by short-answer questions. He continues:

> "An effective assessment procedure, designed to measure attainment in secondary school Chemistry must ideally measure all the definable attainments relevant to such a course and sample them often enough to account for variations of performance in relation to topic and time. The abilities required to score high marks in conventional written examinations, even in science subjects, are predominantly to receive a written communication, selectively to recall facts and to communicate a written answer. Few teachers would

> doubt that these are important abilities appropriate to 'O' level standards of attainment in science subjects. What can be questioned, is the apparently restricted range of abilities required."

Most examinations which are designed for pupils in secondary schools are at present of the conventional type requiring essay-type written answers. Although good candidates will probably do well on any type of examination, it is suggested by a number of writers that the conventional examination is unable to measure the wide range of abilities required for particular subjects.

(d) <u>Review of objective examinations</u>

The objective, or new-type, examination contains a large number of specific questions requiring only a brief answer, on which all markers will agree as to the rightness or wrongness of the answer. This kind of question has been used extensively in the United States for a long time to measure attainment. Shortly after 1900, Thorndike, Binet and others devised tests to measure intelligence and Binet's Intelligence test of 1908 and the Intelligence Examinations for the American Army in 1917 gave an impetus to objective testing in the U.S.A.

In Britain the objective test for measuring achievement did not catch on despite Ballard's (1923) plea for its consideration, but psychologists have used them widely for testing intelligence, particularly in the 11+ selection examinations and in Armed Forces selection. Some Examination Boards have recently introduced them into their 'O' level examinations and the Nuffield Science Teaching Project have used them in their trial examinations.

Meyer (1936) studied methods used by students preparing for different types of examinations. He found that the type of examination affected the way in which students revised; for essay-type questions they studied to get a general view of the material, making summaries of the work covered, and for multi-choice questions the students studied to get details and underlined relevant material.

Cook (1936) made a comparison of results obtained in objective and essay-type examinations in Biology. He found that the objective examination was just as reliable as the essay-type, and the objective examination had a higher correlation with an intelligence test than did the essay-type examination.

A number of investigations into scientific ability have used objective examinations, Chary (1948), Lewis (1964, 1967) and there has been much discussion in the School Science Review (1967, 1968) and Education in Chemistry (1965, 1967) about the use and introduction of objective tests into the science examinations at all levels.

Although objective-type questions have been hailed as the answer in avoiding the worst defects of the conventional questions, they have in fact their weakness. The advantages and disadvantages have been discussed by many writers, e.g. Hawkes (1936) Vernon (1956), Ahmann (1962), Ebel (1965).

Advantages

1. They can be marked objectively as there is only one correct answer. They are easy and quick to mark by hand or machine and therefore can be conveniently administered to large numbers.

2. They sample the whole field covered by the course and therefore can measure as many abilities as the examiner requires.

3. A candidate cannot bluff the marker or impress him by the quality of his writing.

Disadvantages

1. The cost of duplicating or printing is high as the questions require many pages.

2. A long time is required to set the tests and they should be pre-tested if possible. There can be a subjective element in the setting of the questions, but this can be partially eliminated by using a committee to construct the questions.

3. It is sometimes said that the examination favours the quick-witted type of candidate, whose ability to think coherently and to present evidence in a clear-cut way is not tested. If the tests are highly speeded this might be the case, so enough time should be given for the majority of candidates to finish as much as they can do.

4. If alternatives are given, it is said that candidates may spot the right answer without really knowing why it is the answer. This can happen if the alternatives are not equally attractive, and a correction for guessing can be made so that indiscriminate guessing is penalised.

5. It is said that these question measure only trivial aspects of ability, such as memory, and cannot test real understanding of the subject, or a candidate's ability to interpret and organize facts or his initiative and creativity. Vernon (1956) states that objective tests can measure

abilities other than memory and in fact there is a danger that they require abilities over and above those which the questions are expected to measure.

There is no doubt that by their nature, objective questions are more reliable than the conventional questions. It is suggested that objective questions can be used to measure particular abilities and objective-type examinations can test a wide range of abilities required for any given subject. Objective questions have their weaknesses, but these can be eliminated by careful construction of the items.

(e) Educational objectives of science teaching

Since the beginning of the 20th Century there has been a steady increase in educational research and one of its aims has been to define more clearly the precise nature of the abilities of man. Even now psychologists have only a partial understanding of these abilities, but there have been numerous attempts to classify educational objectives, so that teaching can be channelled into useful objectives and that tests can be devised to measure the abilities which are encouraged in learning.

Bloom (1956) divided the educational objectives into two parts:

(i) knowledge and (ii) intellectual abilities and skills. These were sub-divided as follows:

(i) Knowledge
- (a) knowledge of specifics
- (b) knowledge of ways of dealing with specifics
- (c) knowledge of universals and abstractions

(ii) Intellectual abilities and skills
- (a) comprehension
- (b) application
- (c) analysis
- (d) synthesis
- (e) evaluation.

Lewis (1967) used this framework as a basis for placing science questions into categories for use in the tests he set to measure scientific abilities.

There have been many attempts to compile lists of the educational objectives of science teaching.

The Science Masters' Association Report (1938) made two major categories (i) the acquisition of scientific information and knowledge and (ii) the development of scientific modes of thought. Since that time there have been numerous attempts to list the categories of scientific ability which should be encouraged. Such attempts have been made by Greene (1953), Noll (1957), Schwab (1963), and Kessen (1964). The introduction of Nuffield science has meant that the objectives of science teaching were stated clearly. For example the Chemistry Handbook for Teachers (1964) lists the following qualities that examinations should encourage.

1. Facility in recalling information and experience.

2. Skill in handling materials, manipulating apparatus, carrying out instructions for experiments and making accurate observations.

3. Skill in devising an appropriate scheme and apparatus for solving a practical problem.

4. Skill in handling and classfying given information (including graphical information and quantitative results).

5. Ability to interpret information with evidence of judgement and assessment.
6. Ability to apply previous understanding to new situations and show creative thought.
7. Competence in reporting, commenting on and discussing matters of simple chemical interest.
8. Awareness of the place of Chemistry amongst other school subjects and in the world at large.

Eggleston (1965) lists ten abilities which the Certificate of Secondary Examination board science panels intend to measure.

1. Ability to use knowledge
2. Application of facts to problem solving
3. Use of principles
4. Ability to draw conclusions
5. Ability to devise experiments
6. Ability to handle data, to classify and interpret
7. Ability to work to given instructions
8. Ability to make observations
9. Ability to use simple apparatus, skill in manipulation,experimental technique

10. Originality - ability to speculate, exercise imagination in hypothesis construction.

Lewis (1965) reviews the attempts which have been made over the past thirty years to compile objectives in the teaching of science and states that there are three main general trends which are apparent. Firstly, there is an increasing acknowledgement that science is an essential part of our culture, secondly there is a greater recognition of levels of development in the student i.e. the pattern of objectives will differ at each level, and thirdly there is an increasing emphasis on objectives other than memorization of factual knowledge.

Certain objectives for the teaching of science are being suggested and it is important that examinations must assist the process of learning and teaching by testing that these objectives have been achieved. Lewis concludes that multiple-choice objective types of questions can prove a valuable supplement to the traditional form of science examination.

(f) Examinations in Kenya

Entry to secondary schools has been based on an examination taken during the last year of primary schooling. This examination, the Primary Examination, has consisted of three papers, English, Mathematics and General Knowledge. Up until 1967 these papers were set in the traditional way, requiring essays and written answers. In 1968 the examination changed completely to an objective one in which the pupil had to select the correct answer from various alternatives. The large increase in the number of pupils taking the examination made it necessary to introduce the objective type examination,which could be quickly and efficiently marked by computer.

If a pupil does well enough, he may be selected to continue secondary schooling. The first secondary school for African students was founded in 1926 and the students sat the Junior Secondary School Certificate two years later. In 1940 the Cambridge School Certificate for Overseas was introduced into secondary schools and this was taken at the end of the fourth year. Students who wished to continue education went to Makerere University College, Uganda, and sat the Higher School Certificate two years later. In 1961 African schools in Kenya were able to continue education to the Higher School Certificate standard, and students took this examination at school for the first time in 1962.

The Kenya African Secondary Schools Examination (KASSE), which was set and marked in Kenya, was introduced in 1948 for students who had completed two years of secondary education. Those who did well enough were allowed to take the Cambridge School Certificate two years later. In 1955 this examination was abolished as students were able to continue for four years and sit the School Certificate examination, making the KASSE redundant.

In 1965 the Kenya Junior Secondary Examination (KJSE) was introduced for students who had completed two years at secondary school or its equivalent. This was made necessary by the enormous increase in the number of secondary schools following Independence in 1963.

Most of these new schools were only able to offer two years of secondary education, so it was necessary to re-introduce an examination to cater for students who needed a qualification after two years of secondary education.

Over the next few years East Africa will be accepting the responsibility for the setting and marking of the School Certificate and Higher School Certificate examinations, and the East African Examinations Council will question the nature and purpose of examinations. The next years will see an increasing number of pupils in primary schools, and already objective type examinations are being tried in the Certificate of Primary Education. At present the Kenya Junior Secondary Examination is of the conventional type, but more objective questions are being tried. There is a great need for research in the type of question most suited to pupils at different stages and the abilities which can be measured by different types of questions.

Examinations in Kenya are in the process of change, and modern methods of examinations are required to cope with the large numbers of pupils with only a relatively small number of personnel available for the setting and marking of examinations.

CHAPTER 2

The Scientific Abilities

(a) Structure of Abilities

The faculties or powers of the mind have been of great interest down the centuries, but it is only relatively recently, during the past 100 years, that people have attempted to investigate them scientifically. Sir Francis Galton (1822 - 1911) suggested that individuals might have different intellectual capabilities and James Mckeen Cattell (1860 - 1944) investigated the sensory reactions. This was followed in 1904 by the construction of intelligence tests in France by Alfred Binet (1857 - 1911) to find pupils who were suitable for teaching. The early years of the 20th Century saw the beginning of what is known as pedagogy, through pioneers like Edward Lee Thorndike and Binet.

Before 1920 educational psychologists thought of intelligence as a collection of faculties, such as judgement, practical sense, initiative. (Vernon, 1961). School subjects or new methods of teaching were introduced because they were thought to develop a particular faculty.

For example, nature study was thought to stimulate the power of observation, or learning poetry to develop the memory (Ballard, 1923). Such mental faculties could not be directly observed or verified, so psychologists began to prefer to deal with operational or behaviouristic concepts derived from measurable activities of the human mind.

The way of measuring such abilities is by testing and if two or more tests correlate positively then the tests can be said to be measuring a distinct ability. Thus Vernon (1956) defines an ability "It implies the existence of a group or category of performances which correlate highly with one another and which are relatively distinct from (i.e. give low correlations with) other performances."

Spearman (1904) put forward a Two Factor Theory in which he postulated a general factor, g, which he suggested might depend on the general mental energy with which each individual is endowed, and specific factors, s, which he compared to a large number of mechanisms or engines which could be activated by this energy. He said that the specific factors were largely affected by education and training, whereas the general factor was innate and ineducable.

Thomson (1916) put forward a Theory of Bonds in which he thought of the mind as consisting of an immense number of 'bonds', including inherited reflexes, acquired habits and associations. A person's performance at any one test would involve the activation of a large number of such bonds.

Burt (1917) provided evidence for verbal, numerical and practical factors in the school subjects of children in addition to the general factor. Stephenson (1931) administered seven verbal and eight non-verbal tests to 1,037 girls aged 10 - 12 years. The correlations of verbal tests and non-verbal tests could be accounted for by a general factor, g, and a verbal group factor. El Koussy (1935), who gave 26 tests to 162 boys aged 11 - 13, showed the presence of spatial factor, k, in addition to the general factor.

Vernon (1947) confirmed the importance of the general factor in his tests on Navy and Army recruits. After the removal of g, Vernon found two major group factors, the verbal-numerical-educational factor, v:ed, and the practical-mechanical-spatial factor, k:m. On further analysis Vernon found that these factors could be subdivided, the v:ed factor giving minor group factors of verbal, v, and numerical, n, and the k:m factor giving mechanical information, spatial and manual group factors. Vernon (1950) represented the relationship between these factors with the Hierarchical Group Factor Theory which had first been suggested by Burt (1949). In this theory Burt had arranged the general factor, major group factors, minor group factors and specific factors in the form of a genealogical tree.

After 1930 the analysis of abilities in the U.S.A. took a different turn from Britain, when in 1931 Thurstone extracted a number of components from tests of attitudes and personality traits of approximately equal variance, which he explained without the need of a general factor. Thurstone (1938a) published the first of a series of investigations into the primary mental abilities of children, students and instead of using the concept of a general factor and major group factors, he proposed a series of distinct multiple factors, namely, Verbal Relations -V,Number -N, Perceptual-P, Rote Memory-M, Word Fluency-W, Inductive Reasoning-I, and Space-S. In later work he modified some of these factors and constructed a series of tests to measure these various factors. Most American psychologists have followed the Theory of Multiple Factors proposed by Thurstone. During the 1939-45 war and since 1945 there has been intensive research by the Armed Forces and the U.S. Employment Service into the development of aptitude tests. From their work with the U.S. Army Air Force Guildford (1956a) and his co-workers have produced a boxlike model which he calls the structure-of-intellect model. This model classified intellectual traits along three dimensions, operations, contents and products, comprising 120 psychological factors.

(b) Measurement of science ability

One of the earliest studies of general educational abilities was carried out by Burt (1917) when he gave thirteen objective tests of achievement in various school subjects, including nature study, to 120 children aged 11+. The inter-correlations suggested that a general educational factor entered into all the subjects tested, and verbal, manual and arithmetic factors were also present.

Zyve (1927) attempted to set a Scientific Aptitude test as a diagnostic test to show the aptitute of students for training in science. He set tests of reasoning, accuracy of observation, clarity of definition and experimental bent, and obtained predictions of .74 to .95 for different branches of science, but more recent analysis show his predictions should be much lower, .33 to .57. Earle (1936) found that reasoning problems and analogies in verbal and numerical material correlated most highly with achievement scores in science.

Pawley(1937) administered 14 tests to 67 1st year teacher training students to determine abilities involved in learning Chemistry. He gave apparatus assembly, arrangement, matching of substances, reasoning, spatial and mechanical tests extracting a general intelligence in verbal ability factor with 34.1% variance and also a spatial factor involving memory and manipulation of spatial concepts,and possibly a practical factor.

Among 560 Training College students Vernon (1939) found that Stephenson's non-verbal g test correlated more highly with arithmetic and science subjects than with arts subjects. Using verbal, non-verbal, American Co-operative achievement, personality and interest tests, Vernon showed three main types of ability, scientific-mathematical, arts-humanistic and practical.

To 126 boys in technical schools Berridge (1948) set tests in the mechanics, hydrostatics and heat branches of Physics, plus 13 tests of abilities, such as vocabulary, reasoning, general intelligence, deduction, induction memory, spatial, and identified the following five factors:

1. General intelligence and reasoning. This factor was required for Physics and is similar to the abilities required for the mixed intelligence test. This factor indicated most strongly an ability to solve problems or puzzles.
2. Verbal - the ability to acquire knowledge of words. Physics was a relatively non-verbal subject, requiring less verbal ability than the mixed intelligence test.
3. Space. This was an important factor, particularly in the branches of Physics which involved principles of mechanics.
4. Mathematical - particularly evident in heat and hydrostatics.
5. Memory. This factor appears in the mechanics test, and is associated with a number factor in the hydrostatics test.

Chary (1948) gave objective tests in Physics and Chemistry plus intelligance tests to 57 boys and 50 girls in order to determine any sex difference in performance.

In his analysis for the significance of difference between the means of the boys' scores, he extracted a general factor of memory for factual attainment and a second factor associated with reasoning and problem solving. Chary suggested that his results showed that Chemistry was associated with memory and problem tests, and Physics with the general intelligence and reasoning tests.

Ellis (1949) identified a scientific factor in School Certificate marks in Physics, Chemistry, Mathematics and Geography. Angus (1949) administered 11 tests of science, the Otis Gamma Intelligence test as well as non-verbal and interest tests and suggested that intelligence played a large part in predicting success in science. Young (1948) devised tests of inference in science subjects and then related them to tests of intelligence and school attainment to 501 pupils of 1st - 5th Years at Scottish Secondary Schools and concluded that intelligence is a major factor of ability to draw inferences from science experiments.

James (1950) set various tests in Biology to 5th Form boys and girls. These tests contained biological questions designed to involve abilities such as verbal memory, memory for spatial imagery, inductive and deductive reasoning and logical thinking. From the results of these tests, an intelligence test and the School Certificate marks in Biology, he extracted three factors, (1) an educational factor of ability to learn Biology (2) a logical reasoning factor and (3) a factor involving visual imagery of biological material.

Khan (1951) devised tests for accuracy of observation, definition, classfication, interpretation, application, generalisation, planning of experiments and resourcefulness, all in science, and administered these tests to 307 pupils and extracted factors of (1) general intelligence (2) verbal reasoning, and (3) visual imagory.

Jog (1955) set a battery of verbal, non-verbal, spatial and practical tests of ability as well as attainment tests in arithmetic and algebra to account for differences in the Physics performances of 150 boys.

He found that besides the general intelligence factor, factors of visuo-mechanical ability and industry were important for attainment in Physics.

Muthulingham (1963) made a factor analysis of results obtained from 10 tests, including definitions, problem situations, reasoning, application of principles, ability to analyse, observation, physics, chemistry, attitudes towards science and interests in science, which were administered to girls in their 5th Year. Muthulingham found a general scientific ability factor which was a general factor of verbal scientific ability. This is the only factor she attempted to identify.

Lewis (1961) analysed the results of the Junior Certificate examination in English, Latin, French, History, Geography, Arithmetic, Algebra, Geometry along with three objective tests in Physics, Chemistry and Biology, taken by 173 boys in two Belfast grammar schools. Using the centroid analysis technique Lewis extracted four factors; (1) a general factor accounting for 42.3% of the total variance, (2) a scientific group factor independent of the mathematical subjects (3) a mathematical factor (4) a factor which separates

History and Geography from English, Latin and French. As the science examinations were the only ones to be tested by objective tests, there is a possibility that the scientific factor may have been produced by the test procedure.

Lewis (1964) followed these findings by setting a battery of tests which measured the verbal, spatial and number abilities and administered them to 307 boys and girls in their 3rd and 4th year at grammar schools in Belfast. Objective tests of attainment in Physics, Chemistry and Biology were administered to the same pupils. From a centroid analysis and a rotation of the centroid factors, the following five factors were obtained: (1) general factor G with a variance of 18.9%, (2) verbal factor V, (3) numerical factor N, (4) spatial factor S, and (5) scientific factor Sc. Lewis found that attainment in Physics, though not in Chemistry and Biology, seemed to depend to some extent on spatial ability, quite apart from the general and scientific factors. The verbal factor loadings on the Chemistry and Physics tests were negligibly small. The number factor had small loadings on the science tests, indicating that attainment in school science shows no appreciable overlap with the number factor.

An investigation into scientific abilities for boys at post- 'O'-level was reported by Lewis (1967). 191 boys from five schools in the Manchester area were given ten tests including verbal, numerical and spatial abilities, plus tests in physics, chemistry and biology. The science tests all contained objective questions of the multiple-choice type divided into three sections; (1) knowledge (2) comprehension and application and (3) evaluation. The correlations were factor-analyzed and the four significant factors obtained were rotated in accordance with the varimax criterion. Lewis identified four factors:

1. A factor of scholastic, including scientific, achievement which had high loadings on all science tests, although the evaluation tests has the smallest loading.

2. A reasoning factor which had moderate loadings on the three science tests of evaluation, and negligible loadings on the knowledge and comprehension and application tests.

3. A factor of numerical ability, having high loadings on the number tests; the only other significant loading being on the test of evaluation in Physics.

4. A factor of verbal ability, with negligible loadings on all science tests except the test of evaluation in Chemistry.

Lewis suggests that the reason for these results may be that the instruction and training received by the testees in their 'O' level science courses is such that their performance on the tests of comprehension and application is similar to that on the tests of factual knowledge, their performance on the tests of evaluation is noticeably different. As far as the evaluation of scientific data is concerned, the formal training received appears to be less relevant, and the performance on evaluation tests being influenced to about an equal extent by general reasonig.

Abilities required for success in science subjects have been the concern of a number of investigations over the past thirty years or so, and it is clear that a number of abilities have been recognized as being involved in the learning of science.

From these investigations the following mental factors have been identified on one or more occasions.

1. <u>number ability</u>, which is associated with mathematical ability, required for mathematical aspects of science,

2. <u>reasoning ability</u> which is required for problem solving and seeing relationships,

3. <u>spatial ability</u> required for manipulating and visualising apparatus,

4. <u>verbal abilities</u> related to general scholastic aptitude and the understanding of verbal material,

5. <u>memory ability</u> connected with the ability to memorize facts, diagrams and terminology of science,

6. <u>general intellactive ability</u> which is related to educational and scholastic success,

7. <u>scientific ability</u> specifically required for science subjects.

In recent attempts to describe the objectives of science teaching (Chapter 1(e) particular skills and abilities have been listed. It is possible to associate each of these objectives with particular mental abilities.

For instance, the first quality mentioned in the Chemistry Handbook for Teachers (1964) 'facility for recalling information and experience' is clearly a memory ability for scientific facts. Similarly such skills as handling materials involve spatial abilities, and handling and classifying information require numerical and reasoning abilities. Likewise most of the objectives listed by Eggleston (1965) can be translated into identifiable mental abilities. Application of facts to problem solving requires reasoning abilities, drawing conclusions require inductive abilities, and originality and the ability to speculate require ideational abilities.

Thus investigations into the abilities required for success in science have confirmed that science examinations can measure at least some of the educational objectives of science teaching.

(c) <u>The aim of the research</u>

In recent years methods of examining have undergone a major rethinking. The functions and uses of the traditional questions are being challenged and objective type questions are being reconsidered as a substitute (Vernon, 1964). In East Africa the setting and marking of school examinations are gradually being transferred from Britain to the East African Examinations Council.

There has been much criticism of both types of examinations. The question arises as to which is the best method of examining science. Do the objective questions give a student a better chance of displaying his scientific abilities? Do the traditional type questions depend too much on verbal and fluency abilities? To answer such questions as these it was decided that two types of examination, conventional essay-type and multiple-choice objective type, should be set in Chemistry and Physics and an attempt should be made to discover which abilities were being measured by both types of examination.

Educational objectives of science teaching have clearly been stated and can be linked to well-known mental abilities. On the basis of the educational objectives mentioned in Chapter 1(e), the following abilities were selected as representing the important abilities involved in the learning of science: number, general reasoning, induction, space, perceptual, memory, verbal comprehension, general intelligence, word and ideational fluencies. In addition to a battery of tests which measure these abilities, examinations in Chemistry and Physics of the conventional and objective types were to be constructed and administered to ninety-six students in order to test the hypothesis that -

> "Objective type examinations measure a wider range of abilities than conventional type examinations in Chemistry and Physics at the Form 2 level in a Kenya secondary school".

After administering tests of the ten mental abilities and the examinations in science it was hoped that, by using well-known statistical methods, it would be possible to discover the abilities which are required for conventional and objective examinations in science, and whether in fact the objective type examination is a better method for measuring scientific abilities.

CHAPTER 3

The Test Battery

Twenty-five tests designed to measure the ten mental abilities, which had been selected as representing the important abilities in the learning of science, were chosen from various sources. Many of the tests were taken from the battery constructed by L.L. Thurstone for use in the Chicago Tests of Primary Mental Abilities, which were suitable for students in the age 11 - 17 years range. Other tests published in the U.S.A., particularly by the Educational Testing Service, and in Britain were selected. Some tests were constructed by the writer and by colleagues in Kenya when suitable tests were not easily available. In all tests words and phraseology were altered where necessary to suit the subjects tested.

These twenty-five tests are described under ability headings: number, general reasoning, induction, space, perceptual, memory, general intelligence, verbal comprehension, word fluency and ideational fluency. A brief history of the development of each ability is also given.

The conventional examinations and the multiple-choice objective examinations were constructed by the writer with assistance from colleagues and from the National Institute of Education in Uganda.

A complete copy of all the tests and examinations will be found in the Appendix.

(a) <u>Mental ability tests</u>

<u>Number Ability</u> Burt (1917) in his investigation of the distribution of abilities suggested that there was an arithmetic factor in school work. Later Kelley (1928) found the number factor. In the research on Primary Mental Abilities, Thurstone (1938a) found the number factor, N, in simple computational tests of addition, subtraction, multiplication and division. Coombs (1941) found a distinct number factor in some of the 18 mathematics tests he administered along with 16 tests of mental abilities. Wrigley (1958) who investigated the nature of ability in elementary mathematics in school children isolated a numerical factor, in which he used the tests of addition, multiplication, subtraction and division prepared by Thurstone. French (1951) could say that the 'number factor is the clearest of them all' since he cited 35 analyses in which the

number factor had been found before 1951.

Two of the tests prepared by Thurstone were chosen for reference tests to measure the number ability. Both the Addition and Multiplication tests are known to have high loadings on the number ability and were found to be the best two tests in Zimmerman's (1953) re-analysis of Thurstone's data.

<u>TEST 01ADDT</u> ADDITION

For the addition tests there are 70 sums with four numbers, between 10 and 100, to be added. An answer is given and the subjects are required to indicate below the sum, whether it is right (R) or wrong (W)

	61	73	23
	34	29	56
	78	56	55
	53	33	82
	226	211	216
R	~~:::~~	:::	~~:::~~
W	:::	~~:::~~	:::

The first and third examples are right so the subjects should mark the dots on the R line. The second answer is incorrect therefore should be marked on the dots of the W line.

Scoring: the number correct.

Time: after a try-out on other students a time of 8 minutes was found to be sufficient to allow about 10% of the subjects to complete the test.

<u>TEST O2MULT</u> MULTIPLICATION

The multiplication test was set out in a similar way except that the subjects were given 70 multiplications of the type below. Numbers between 20 and 100 were to be multiplied by numbers from 3 to 9.

	64	39	46
	7	4	8
	448	166	358
R	~~:::~~	:::	:::
W	:::	~~:::~~	~~:::~~

The first example should be marked right and the second two wrong.

Scoring: the number correct

Time: 8 minutes.

<u>General Reasoning Ability</u>

Spearman (1927) thought that reasoning depended solely on the general factor of intelligence, g.

Thurstone (1936b) found a factor on which the test of Arithmetical Reasoning was most heavily weighted and tentatively suggested that this was a reasoning factor. Zimmerman (1953) re-analysed Thurstone's original data and the factor R, later called restrictive reasoning, showed up more clearly with loadings on Arithmetic Reasoning, Division, Number Series and a small loading on Vocabulary. This he compared with the general reasoning factor which Guildford (1947) had suggested. Sutherland (1941) had found that arithmetical problems required a general factor which had high loadings on Intelligence, Reasoning and Letter Series tests.

In the Army Air Forces Research undertaken by Guildford and co-workers, a factor was repeatedly found with a high loading on the arithmetic reasoning tests. They called this factor 'general reasoning' and by trying out a number of hypotheses as to the nature of the factor (Green, et al 1953), he demonstrated that the important aspect of solving problems in arithmetic reasoning tests "has something to do with comprehending or structuring problems of certain kinds in preparation for solving them". (Guildford, 1956b).

French (1957) also found the general reasoning factor on arithmetic reasoning tests administered in his 'Pure-Factor' analysis. Butt (1957) in his work on the reasoning abilities at adolescence found various reasoning factors including one similar to Guildford's general reasoning, with loadings on arithmetic-reasoning tests.

Vernon (1961) states that reasoning ability is one of the commoner definitions of intelligence and that if a factor g is allowed (which most of the American psychologists do not isolate) the factor g should contain the whole variance of reasoning factors.

Reasoning should be an important ability in science, and it is hoped that both the conventional examination and the objective examination would require this ability, even though the objective examinations are criticised for testing mainly recall and memory abilities. Two tests of general reasoning were selected, the Ballard Reasoning test comprising 100 items of simple arithmetical reasoning problems which had to be solved, and Guildford's Necessary Arithmetic Operations test which requires the subjects only to structure the problem in preparation for solving. The Ballard test is known to have loadings on the numerical factor as does the Necessary Arithmetic operations test, although there is no computation required in the latter.

TEST 03AREA   Arithmetical Reasoning

This test of 100 items was divided into three parts. Each had 33 or 34 simple arithmetical problems and a box was provided for the answer e.g. A plank 20 ft. long is laid on the top of one which is 14ft. long so that it is 2ft. over at one end. How much is it over the other? $\square$

Scoring: 1 mark for each correct answer   Maximum 100

Time: 15 minutes for each part.

TEST 04AROP   NECESSARY ARITHMETIC OPERATIONS

In this test the subjects are given **thirty** mathematical problems with four options for solving each of them. The option required for solving was to be selected. e.g. A coat marked Shs. 40.00 was sold for Shs. 29.95 during a sale. What was the per cent reduction?

1 - divide and add,

2 - substract and divide

3 - multiply and substract,

4 - add and divide.

Scoring: Score = Number right - $\frac{\text{Number wrong}}{3}$

Time: 8 minutes for each part.

TEST 07SEEP Seeing Problems

Although this test is not strictly a test of reasoning, it is described here because it does involve reasoning as well as ideational and verbal abilities. This test is said to measure a reasoning ability which involves seeing implications in a certain situation (Guildford, 1967). The subjects are given the names of common objects, e.g. 'candle' or 'rope' and are asked to write down, within 1 minute, five problems which occur to them when they think about the object, what it is, what it is made of, etc.. This is a common situation in science, for scientists need to go beyond the immediate experiment and try to think of the implications and problems the experiment presents. This test may measure a students ability to predict, to visualize and suggest hypotheses.

This test was adapted from a test produced by the Sheridan Supply Company and contains four sections each with three objects.

Scoring: 1 mark for each problem suggested

Time: 3 minutes for a set of three objects.

Induction Ability

Thurstone (1938a) first identified the induction factor which had high loadings on Figure Classification, Number Series and Pattern Analogues. He described induction as the ability to discover the general rule connecting figures, numbers or letters. Sutherland (1941) also found a small factor which he called induction and compared it with Thurstone's ability for finding the rule or principle. French (1957) found an induction factor measured by the Letter Sets tests and Butt (1957) called one of his reasoning factors an induction factor which had a high loading on the Vernon's Letters and Numbers Test.

Green, et al (1953) postulated that there may be a reasoning ability for discovering rules and principles and seeing relations, similar to Thurstone's I, but found no clear evidence for its independent existence, but since that time Guildford (1967) states that using his model of the Structure of Intellect there appears to be little further need for the concept of induction which can be replaced with concepts that are more precise and richer in meaning and have ties to empirical referents. This does not mean that there is no such ability, but that Guildford has been able to split up this complex ability into abilities which fit his structural pattern.

Even if induction is not a 'pure' factor Butt (1957) has shown that there is a clear-cut Induction group factor in the Number and Letter Series test devised by Vernon and showed that it could be related to success in science.

Although none of the investigations into the scientific abilities has identified an induction factor, it seems very probable that the processes of induction are used at all levels of science. For instance it is necessary to find the rules and principles underlying natural phenomena and to see relations between one experiment and another. In order to identify this ability, if possible, two tests to measure this factor were set.

TEST 05LENO Letters and Numbers

In this test which was constructed by Vernon, wherever there is a dot, there is one letter or number missing and the subjects have to find the rule or principle in order to find the missing letter or number e.g. hot cold wet dry fast slow down ..

100 baa 201cab 106 bag 543....

Scoring: 1 mark for each correct answer Maximum 40

Time: 20 minutes

TEST 06LEST Letter Sets

This is a test to find the set of letters which does not obey the rule of the other four. There are five groups of four letters, of which four groups are related by a general rule, the fifth does not fit this rule. There are 30 items:

e.g.	NOPQ	DEFL	ABCD	HIJK	UVWX
	PABQ	SEFT	VIJW	COPD	FUZG

Scoring: $S = R - \frac{W}{4}$: score after correction of guessing.

Time: 7 minutes for each part of 15 items.

Spatial Ability

Early investigations on spatial abilities were closely linked with work on mechanical and practical abilities. Cox (1928) found a mechanical factor, m, present in tests involving mechanical models, jig-saws, paper-folding and described it as 'an aptitude and mental activity underlying the comprehension of mechanical relations'. Kelley (1928) found a spatial factor in some tests on children aged 10 - 16. El Koussy (1935) published results of 26 paper-and-pencil tests administered to 162 school boys and found a k factor and explained it in terms of visual imagery 'the ability to obtain, manipulate and utilize visual spatial imagery'. Thurstone (1938a) identified a visual spatial factor in a number of space tests. Both Dempster (1948) and Emmett (1949) found evidence for a spatial factor in school children of 11+.

Since 1945 subdivisions of the space factor have been made by many workers including Thurstone and Guildford. Thurstone (1950) listed three factors S_1, S_2 and S_3. S_1 he described as 'the ability to recognize the identity of an object when it is seen from different angles' or 'the ability to visualize a rigid configuration when it is moved into different positions as in the Flags test', S_2 'the ability to imagine the movement or internal displacement among the parts of a configuration that one is thinking about, such as in the Cards test'.

Michael and Guildford (1957) also found three factors, SR-O-space relations and orientation, Vz-visualisation and K-kinaesthetic. Thurstone's Flags, Cards and Figures tests would show the first factor SR-O.

Vernon (1961) noted that the spatial ability tends to link up with the mathematical abilities at advanced levels. Peel (1948) reported that the spatial ability is associated with scientific interests.

Roe (1953) in a study with high level scientists reported that physicists had higher scores on spatial tests than any other group of scientists studied. Sultan (1962) found a very strong spatial factor linked to the general factor running through his tests, both verbal and non-verbal, which suggests that spatial ability, rather than verbal ability, is associated with abstract conceptual or mathematical thinking. Smith (1967) found the first bipolar factor of his analysis to be a spatial factor opposed to a v:ed factor, in his tests on 200 boys in technical and comprehensive schools.

As was shown in Chapter 2(b) most of the investigations carried out on scientific abilities in schools have identified a spatial-visual factor. Science requires the visualization and manipulation of apparatus, drawing of diagram , of circuits and general visualization of size, and therefore there should be a factor which relates to this ability. The Flags, Cards and Figures tests, originally devised by Thurstone, were chosen as the tests for the spatial factor.

TESTS O8FLGS   Flags

This test presents the subjects with a row of five flags. The flags have a small shaded square in one corner and the flags which are like the first flag are marked. This requires the subjects to visualize what the flags would be like if they were rotated in the plane of the page.

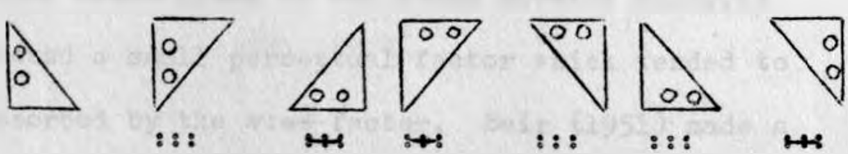
Below is a row of flags. Mark all flags that are like the first flag in the row

Scoring: Score = No. Right - No. Wrong. Maximum 60.

Time: 8 minutes.

TESTS O9CRDS   Cards

This is a similar test to the Flag test except cards are used. In each row mark every card that is like the first card in the row.

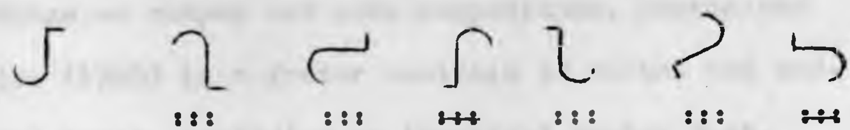


Scoring: Score = Right - Wrong Maximum 54.

Time: 8 minutes.

TEST 10FIGS Figures

This is again similar to the Flags and Cards tests. In each row below, mark every figure which is like the first figure in the row.



Scoring: Score = Right - Wrong Maximum 54

Time: 8 minutes.

Perceptual Ability

Thurstone (1938b) claimed a perceptual factor in the battery of Primary Mental Ability tests. He found the factor in speeded tests, both verbal and non-verbal, and described it as 'the facility in perceiving detail that is imbedded in irrelevant detail'. Vernon (1950) made a factorial analysis of clerical tests given to 400 women service recruits and found a small perceptual factor which tended to be absorbed by the v:ed factor. Bair (1951) made a factor analysis of 17 clerical apptitude tests including number comparison and name comparison tests, and called the first factor 'Perceptual Analysis' with span and accuracy playing major parts, with highest loadings on number and name checking tests. The second factor was a speed factor, again with high loadings on number and name comparisons. Denton and Taylor (1955) in a factor analysis of verbal and non-verbal tests, including an identical number test, found that this first factor had a high loading on number and perceptual abilities. Sultan (1962) in a factorial study of creative thinking identified a perceptual speed factor.

The Minnesota Clerical Test was chosen as the reference tests for this ability of perceptual speed. In the studies of Bair, Denton and Taylor, the Minnesota Clerical Tests came out with high loadings on this factor. The Name Comparison test was adapted by the writer using African local names, substituted for their American original.

Vernon (1961) in his review of this factor states that the evidence suggests that there are factors of perceptual speed for verbal and non-verbal detail, which overlap to join verbal and spatial factors. There is evidence therefore for a rather unstable perceptual factor related to speed and accuracy in dealing with verbal-numerical detail as an off-shoot of the verbal factor.

It was thought that tests in science might have a perceptual-speed ability, which might be related to the attention which students give to scientific detail, both verbal and numerical. Science experiments can sometimes be wholly misunderstood if the student is not quick enough to understand the detail. It was also thought that the actual form of the science test may reflect this perceptual ability. To read and follow directions in multiple-choice questions may require the ability to 'perceive detail that is imbedded in irrelevant detail' as Thurstone described it.

TEST 11PERW Perceptual Words

This test consists of names; names of people, companies, buildings and streets and so on. If the two names are exactly the same the subject is required to make a tick mark (✓) on the line between them; if they are different, a cross (x) on the line.

Thompson's Falls ___x___ Thomson's Falls

Thakrar J.K. ___x___ Thakrar K.J.

Pictorial Review ___✓___ Pictorial Review

Scoring: 1 mark for each correct answer. Maximum 75

Time: 5 minutes.

TEST 12PERN Perceptual Numbers

This perceptual test has 50 pairs of numbers and the subject is instructed to put a tick (✓) on the line between the pairs of numbers if identical, a cross (x) if different.

3,562,315 ___x___ 3,526,315

2047.321 ___✓___ 2047.321

Scoring: 1 mark for each correct answer. Maximum 50

Time: 1½ minutes.

Memory Ability

Spearman (1927) admitted that g enters into many learning and reproductive activities, but regarded retentivity as an entirely distinct mental function. Smith and McDougall (1919) showed that practice in memorising produces improvement in retention and found correlations of .53 between two tests of logical memory. Thurstone (1938a) claimed a distinct memory factor as found in word-number and figure recognition tests. Woodrow (1939) also found a similar factor of memory especially in number span, digit span and word building tests. Coombs (1941) found a memory factor for word-number and initials tests in his factorial study of the number ability and Carroll (1941) extracted a memory factor on paired associates tests, English-Turkish, Turkish-English and Word-Number. Taylor (1947) also found the memory factor in first names and word-number tests. All of these results show a factor of rote memory, when the material has no meaning or associations.

Vernon (1961) points out that this kind of memory is not that which is tested by teachers and says that memory refers to so many different things. Investigations have been mado to sub-divide the memory factor and Kelley (1954) suggested three memory factors: (i) rote memory for words and numbers, (ii) meaningful memory for related material (iii) span memory for grasping numbers and letters at a single presentation. Thurstone (1951) added two more factors to his rote memory for paired associates M-1, an M- 2 factor, memory for pictures and geometrical design, and an M-3 factor, keeping in mind some perceptual detail.

Guildford (1956a) found that memory was one of the operation categories required for classifying intellectual factors and in his Structure of Intellect Model there are 24 cells in the memory matrix, of which Guildford (1967) claims to have demonstrated 14 of them. This confirms the views of other invetigations that the factor of memory is complex.

It is not yet clear exactly what kind of memory is required for recalling scientific knowledge. Guildford's definition of memory as 'the ability for the retention or storage with some degree of availability of information in the same form it was committed to storage and in connection with the same cues with which it was learned' suggests that scientific memory can only be tested with scientific material.

The memory factor has been found in a number of previous investigations of scientific ability. Pawley (1937) extracted a spatial factor involving memory and manipulation of spatial concepts. Chary (1948) suggested that ability in Chemistry was associated with memory for equations and experiments. Berridge (1948) extracted a small memory factor in the ability for school Physics, and James (1950) found a factor for memory of a visual kind for words and diagrams in the learning of Biology.

<u>TEST 130BMR</u> Object-Number Test

This is a test devised by Thurstone and requires the subject to memorize the number which is associated with an object, e.g. desk, chair etc. This is a paired associate test, which has been found to have a high loading on the rote memory factor. There are two sub-tests which each have 15 objects and numbers. The subject has 3 minutes to memorize the number associated with each object; then he has 2 minutes to write down the number against the objects listed on another page. e.g. tree 58

post 65

Scoring: 1 mark for each correct answer. Maximum 30

Time: 10 minutes.

<u>TEST 14PCMR</u> Picture Memory

This test was designed by the writer to try to test memory associated with pictures of everyday objects, e.g. book, ruler, spectacles. Twenty pictures were drawn on the page and the subject had two minutes to recognize and remember their names; he then had 1½ minutes to write down as many as he could recall. This would be a test of 'intermediate' memory, associated with pictures which might be relevant to the kind of memory required to recall diagrams and apparatus in science experiments

Scoring: 1 mark for each correctly named object

Time: 3½ minutes.

General Intelligence

Until the 1930's most psychologists tested intelligence by means of verbal problems, on the grounds that the highest achievement of man's intelliectual powers was reached through verbal symbols and concepts. Stephenson (1931) found that the correlations between seven verbal and eight non-verbal tests were accounted for by a single factor, which he identified with g. Smith (1964) makes a plea for the measurement of intelligence with non-verbal tests and criticizes many local educational authorities for relying too much on verbal intelligence tests for the 11+ selection.

It has been found that nearly half the communality of many group verbal intelliegence tests consists of the verbal ability, v, rather than g, although the non-verbal tests will be have loadings on spatial abilities. Butt (1957) has found that Vernon's Letters and Numbers test is a good measure of g, and Vernon (1961) points out that the g-variance can be reduced on intelligence tests by coaching and practice.

As might have been expected many of the investigations on science ability have produced a general factor associated in some way with the factor of general intelligence, e.g. Lewis (1964) extracted a general factor with a variance of 18.9 % of the total variance, suggesting that g has a large influence on ability in science.

Irvine (1966) in his experiments in Rhodesia found a general factor g, in his 26 tests with 1600 African primary school children and concluded that "what is called intelligence may, in Africa, be at this point in social history, far more a product of education than in western societies, and the variance in an intelligence test score may owe more to environmental influences, at present, than to any other source." Vernon (1967) found that tests given to African primary school children in East Africa did not produce different results than in western schools provided the kinds of tests used were made familiar before testing.

15OTIS General Intelligence

An intelligence test based mainly on verbal relations was chosen to test an 'intelligence' factor. As the Letters and Numbers test had already been incorporated, it was hoped that both verbal and non-verbal intelligence could be tested. Education in Kenya has largely been dependent on verbal-educational abilities, the v:ed factors, that it was thought the Otis test would be a good measure of general intelligence. The test was checked for unfamiliar words and altered to make it applicable to the subjects. This test is mainly based on verbal relations and analogies, but also includes some non-verbal-numerical questions.

e.g. Food is to the body as (?) is to an engine.

1. wheels, 2 fuel, 3 smoke, 4 motion, 5 fire.....( )

One number is wrong in the following series.

What number should it be?

1 6 2 6 3 6 4 6 5 6 7 6 ....( )

Scoring: 1 mark for each correct answer. Maximum 75

Time: 30 minutes.

Verbal Comprehension

Verbal ability is usually inextricably bound up with education and with Alexander's X-factor of industriousness and interest (Vernon 1961). As the past and present type of education lays so much importance on verbal abilities, it is not clear what is being measured. Sometimes it is thought of as verbal reasoning which has a high loading on general ability, and sometimes it is thought to be measured by straightforward vocabulary tests.

Burt (1917) suggested a verbal factor in reading, which would now be regarded as the v:ed factor by British psychologists. Kelley (1928) and Stephenson (1931) found a significant verbal factor in tests of vocabulary, sentence completion and verbal analogies. Thurstone (1938a) claimed a verbal realtions factor, V, found in tests dealing with ideas and meanings of words. Thurstone (1948) divided this factor into three parts, V - understanding of verbal material best measured by vocabulary tests, W - fluency in finding words and F - ideational fluency with words.

Morgan (1956) found a verbal factor best measured by tests of vocabulary and also found a verbal comprehension factor. Sultan (1962) isolated V using Thurstone's vocabulary test.

Other researches have identified a verbal factor associated with the use of words in context of writing and reading. In an investigation into problem solving in arithmetic, Sutherland (1941) found a verbal factor involving the use of words in arithmetic problems. Rogers (1953) from his tests on verbal fluency found as his first factor a general factor associated with a verbal-educational factor. Denton and Taylor (1955) also found a general factor of verbal ability in the factor analysis of mental abilities. Although they included tests for word fluency, ideational fluency and verbal comprehension, they did not have a vocabulary test. Morgan (1956) found a minor factor of verbal comprehension found in reading and writing sentences, and Vernon (1962) found in a study of verbal tests that there were various types of comprehension.

Heinonen (1963) found that the first factor in an investigation to differentiate Primary Mental Abilities at different ages was a factor of verbal comprehension for the ages 13 - 15.

It seems therefore, that there is more than one ability present in verbal tests. There is the ability to understand the meaning of words measured by vocabulary tests, which Thurstone claims would measure verbal ability in the wider context, and then the ability to understand words in the context of sentences, paragraphs, and the production of fluent writing. The latter ability might be called 'verbal comprehension'.

It was decided to set tests for both these abilities to discover if they bore any relation to students' ability in science. Conventional examinations require the ability to communicate verbally and therefore require verbal abilities. Objective examinations require the students to read and comprehend the questions and to extract relevant material from them, but requires no ability to communicate on paper. It was thought that there may be some distinction between these abilities on the different types of examinations.

Therefore the following tests were set, all except the vocabulary, being set and arranged by the English Department of Alliance High School.

<u>TEST 20VOCB</u> Vocabulary

This was adapted from the vocabulary test constructed by Thurstone. The subjects are required to mark which has the same meaning as the first word in a row of five words..

e.g. Mark the word which means the same as the first word in the row:

quiet	blue	still	tense	watery
	⁝⁝⁝	⁝⁝⁝	⁝⁝⁝	⁝⁝⁝
defective	concealed	mythical	faulty	external
	⁝⁝⁝	⁝⁝⁝	⁝⁝⁝	⁝⁝⁝

Scoring: 1 mark for each correct answer.

Time: 20 minutes.

<u>TEST 16EXPR</u> Expression and Comprehension

This test consisted of three paragraphs in answer to questions about the piece.

e.g. Use two sentences to describe how the loot is divided between the tribe.

Scoring: Maximum 22 marks for accuracy and relevance.

Time: ½ hour.

TEST 17COMP Comprehension

This test consisted of two paragraphs from 'Elephant Bill' by Col.W. Williams. There were 8 multiple-choice questions, each with four alternative answers and the subjects were required to select the best alternative.

e.g. The most important characteristic of the young elephants we learn of from the first paragraph is their:

(a) intelligence

(b) greed

(c) naughtiness

(d) shyness.

Scoring: 2 marks for each correct answer

Time: ½ hour

TEST 18ESSY Essay

A choice of nine titles was given and 1 hour was allowed for the essay. The subjects were warned to re-read the essay and check for mistakes.

Scoring: Maximum 40 marks. The essay was marked by an experienced English teacher, who looked for relevance, fluency and accuracy of English.

<u>TEST 19SENT</u> Sentence Structure

The first question required the subjects to re-write eight sentences according to the instructions given.

e.g. The coffee wasn't of a good grade so it could not be exported.

(Re-write using.....<u>enough</u> .. and omitting...<u>so</u>)

The second question asked the subjects to join two given sentences by using one of the sentence connectors <u>nevertheless</u>, <u>consequently</u>, <u>moreover</u>, <u>therefore</u>, <u>however</u>. There were five pairs of sentences.

e.g. She is rich. She is unhappy.

Scoring: 2 marks each for correct answers in the first question. 1 mark each for correct answers in the second question.

Time: ½ hour.

Word Fluency

From his battery of primary mental abilities Thurstone (1938a) found an additional factor to his verbal relations, V, and identified it as a factor which required the production of words at speed under easy restrictions, e.g. words beginning with s. This was identified as word fluency, W. In his revised analysis Zimmerman (1953) found that this factor separated from V, which is concerned with ideas and meanings of words. Carroll (1941) found a factor A, which was similar to Thurstone's W, and Taylor (1947) claimed three fluency factors, one of which was similar to Thurstone's W. In his work on verbal abilities in primary school children, Morgan (1956) found a fluency factor in addition to the verbal factor. Shousmith (1958) also extracted a general fluency factor in his tests with primary school children. He called it a general fluency which he defined as 'a general facility or quickness with words and in writing and involved the facility of association with little or no reference to meaning and was analogous to Thurstone's W'. Sultan (1962) used Thurstone's tests of First Letters and Prefixes and extracted a word fluency factor with high loadings on these tests.

From this evidence there seems to be a well-defined factor of word fluency which requires the production of words with little reference to their meaning. It was thought that the conventional type examination in science may require this facility so three tests were used. They were Thurstone's well known tests of First Letters, Prefixes and Suffixes.

TEST 21LETT First Letters

The subject is required to write down as many words as time permits all beginning with the same letter e.g. s

Scoring: 1 mark for each different word

Time: 4 minutes.

TEST 22 PRFX Prefixes

The subject is required to write down as many words as possible all beginning with the same prefix e.g. CON-.

Scoring: 1 mark for each different word

Time: 4 minutes

TEST 23SUFX Suffixes

The subject is required to write down as many words as the time permits ending with the same suffix e.g. -TION

Scoring: 1 mark for each different word

Time: 4 minutes.

Ideational Fluency

In a factorial study of fluency in writing Taylor (1947) claimed to have distinguished three fluency factors, one of them being a fluency associated with naming of classes of things, e.g. naming of round things, or blue objects. This he called ideational fluency. Thurstone (1948) also identified an ideational factor. Other minor factors of ideational fluency were found by Carroll (1941) in 42 tests of verbal ability; Rogers (1953) in 26 tests of verbal fluency, and by Morgan (1956) in his work on verbal abilities in primary school children. Shousmith (1958) found a similar factor to Thurstone's ideational fluency, F, in his investigation of fluency in essay writing of those children about to leave primary school. His tests included intelligence, vocabulary, essay, categories and theme. He defined this factor as the 'facility in using ideas chiefly in the verbal context'. Guildford (1967) describes it as a divergent-production ability, in which the subject is required to produce lists of things or ideas on topics with little restriction. Sultan (1962) found anideational fluency factor with high loading on his 'Topics' test.

It was thought that scientific ability might require the ability to produce ideas in the written form. Classification is an important aspect of science, e.g. acids, metals, so the Categories test was chosen. The kind of ability requred in the Theme test, where the subject is required to write as much as he can about a single topic, was also chosen, although it was thought that this kind of ideational fluency would not be required at this level of science, where there is little scope for 'free' fluency writing.

Both the Theme and Categories test were adapted from those published by the Educational Testing Service.

<u>TEST 24THME</u> Theme

In this test the subjects are asked to write a few paragraphs about two given topics e.g. 'a parcel', 'a locked door'. They are asked to include as many ideas as possible, and write as much as they can within the time allowed.

Scoring: 1 mark was given for any idea related to the topic

Time: 4 minutes for each topic.

<u>TEST 25CATG</u> Categories

This is a test to see how **many** things, which are alike in some way, the subjects can name in the time allowed, e.g. how many things that are always red or that are red more often than any other colour.

Scoring: 1 mark for each thing, which is correct for the category.

Time: 3 minutes for each part.

(b) Conventional Examinations

These were designed to be the kind of examinations which any pupil at the end of Form 2 in a secondary school might have to take. Care was taken to see that the questions were typical of conventional examinations, by reference to previous examinations and by experience of the kind of question set in the Cambridge School Certificate on these particular topics.

26 CHCN Chemistry Conventional

The course covered included the usual topics in a two-year course of Chemistry. It might be summarised as follows:

Mixtures, compounds and physical methods of separation.

Chemistry of air and water.

Acids, alkalies and salts.

Metals and non-metals; their differences of properties

Preparation and properties of oxygen, hydrogen carbon dioxide and chlorine.

There were six questions from which four were to be chosen and answered in 1½ hours. Each question carried the same mark of 25.

<u>TEST 27PHCN</u> Physics Conventional

The Physics course covered the basic ideas of the usual topics, and in some instances only a brief introduction was given. The following topics were treated at some length:

Mechanics, hydrostatics, light and heat and the following were treated briefly:

Sound, electricity and magnetism.

It was hoped that the conventional examination could have included parts of all these topics, but it was pointed out by the Physics teacher that the students had spent the previous two terms on mechanics and light and therefore would not be familiar enough with the other parts to justify questions on them. If the students had been told just before the examination that it would include all aspects of the physics covered in the first two years, then it was thought that the answers to these questions would merely test how quickly the students could re-learn and memorise work which had been taught over a year previously. Therefore it was decided just to examine those two sections in which they were recently taught.

Six questions were set from which four were to be chosen and answered in 1½ hours.

(c) Objective Examinations

Questions in an objective examination have only one correct answer. There are many types of questions which fulfil this condition, e.g. true/false items, simple recall one word answers, multi-choice items, matching items, rearrangement items. These have been discussed at great length by many writers e.g. Lindquist (1951), Vernon (1956) Ahmann (1962) Furst (1958)Nelson (1958) and Educational Testing Service (1963)

It has been pointed out by Vernon (1962) that it does take a little time for students, who are unfamiliar with new-type tests, to learn how to tackle this kind of question. Vernon found that British students improved their performances in new-type examinations as they became more familiar with this kind of test. For reasons such as this, it was decided to restrict the type of question to 'multiple-choice', so that the students would not be put off by the form of question. Also the students had become familiar with multiple-choice question in their English studies, and the writer had also included some in previous science tests. Another advantage was that some of the ability tests were in the form of multiple-choice questions.

After deciding that the questions would all be in the form of multiple-choice, a first draft of the questions was prepared. Many books and objective examinations, prepared in the U.S.A., were consulted. An attempt was made to cover as wide a range of topics and abilities which the students could be expected to have covered. No attempt was made to put questions into categories, such as information, comprehension, analysis, synthesis and evaluation as suggested by Bloom (1956), because not enough was known about what individual questions measured, but an attempt was made to cover as many as possible of the abilities listed as educational objectives of science teaching. Use was made of the classification suggested by Nelson (1958) who gave the following kinds of items:

Recall, Recognizing and appraising assumptions

Problem solving

Evaluating hypothes s

Experimental tests of hypotheses

The Chemistry Handbook for Teachers (1964) contained some questions which were adapted for use in the Chemistry examination. The Examinations Bulletin No. 8(1965) suggested that one important scientific ability involved interpretation of data in tabular form, in graphical form, in diagramatical form and an attempt was made to include this kind of question.

An expert at the National Institute of Education, Uganda looked through the first draft of the questions and made some valuable comments on the wording and content of the questions. Unfortunately it was not possible to try out these questions beforehand as there was no parallel group of studdnts available for testing.

<u>TEST 28CHOB</u> Chemistry Objective

This contained 60 items to be answered in 1½ hours, which was found to be sufficient time for most students to complete the paper. The more difficult items were spread throughout the paper, although the first eight questions tested mainly recall to give students a good start.

The multiple-choice questions were constructed, keeping in mind the educational objectives of science teaching, and the abilities which were considered to be important in the learning of science. Although it is difficult to classify the questions precisely into different categories, questions were constructed with the following categories in mind:

1. Recall. This is one of the simplest forms of questions, testing the subject for memorisation of the knowledge and experience gained e.g. Q.5
2. Problem Solving This is a very important mental activity for the study of science, requiring many abilities but mainly reasoning and induction abilities. e.g. Q.43
3. Interpretation of data. Science requires the handling and manipulation of information with particular emphasis on the number and reasoning abilities.e.g. 38 - 41

4. <u>Evaluating hypotheses.</u> Science progresses through the formulation and testing of hypotheses, requiring reasoning, induction and general intelligence abilities.

   e.g. Q.23 - 34

5. <u>Recognising and appraising assumptions.</u> The scientist must be able to think logically and see when certain assumptions are made. Abilities which might be relevant are the reasoning, inductive, and verbal abilities.

   e.g. Q.46 - 51

6. <u>Experimental test of hypotheses.</u> Scientific laws are discovered by the continual testing of hypotheses and this requires spatial, perceptual, ideational abilities as well as abilities of reasoning. e.g. Q.22

7. <u>Comprehension.</u> A scientist has to be able to understand written material and be able to communicate his findings. All written questions require some degree of verbal ability and comprehension. e.g. Q. 9 - 10.

In this way, it was considered that the questions covered most of the knowledge and understanding which students at this level of academic achievement in science might be expected to have reached.

The knowledge required for the objective examination was the same as for the conventional examination, being the work covered in the first two years of secondary school course in Chemistry.

TEST 29PHOB Physics Objective

This examination contained 55 items to be answered in 1½ hours which was in fact sufficient time for most of the students to complete the paper.

It was decided to examine the same kind of abilities as tested in the Chemistry objective examination. It has been mentioned that the conventional Physics examination covered only light and mechanics, but it was necessary to include questions on hydrostatics, heat, sound and electricity on the objective paper because not enough questions were available on mechanics and light. The Physics teacher was consulted about this and agreed that all the questions on the paper should be in the ability range of the subjects. It was thought that although the two Physics tests covered different limits of knowledge, the range of abilities required would be fairly typical for the different types of examination at this academic level.

Questions were constructed bearing in mind the educational objectives of science teaching and the abilities considered to be important in the learning of science. Categories of questions, similar to those set for the Chmistry objective examination, are as follows:

Recall, e.g. Q.3, 6.
Problem solving, e.g. Q.33
Interpretation of data, e.g. Q 10, 13
Evaluating hypotheses, e.g. Q 24, 27.
Recognizing and appraising assumptions, e.g. Q 28 - 32
Experimental test of hypotheses, Q 53 - 55
Comprehension, Q 20 - 23.

CHAPTER 4

The Experiment

(a) Application of the Tests and Examinations

The Tests and Examinations

The 25 Ability Tests and 4 Chemistry and Physics Examinations were administred to 96 students of which 94 completed all tests and examinations. A list of the tests and examinations, with the times allowed for each, are given in Table 1, page 90.

The subjects

It was necessary to decide at what level to hold this experiment. The school chosen was Alliance High School, Kikuyu, Kenya, where the writer had been a teacher for six years at the time of the experiment. The class of students chosen were in their second year (Form 2) of secondary education and the experiment was held during the third term of the academic year in 1966.

TABLE I Tests, Examinations and Times

Reference	Name	Time
01ADDT	Addition	8 min.
02MULT	Multiplication	8 min.
03AREA	Arithmetical Reasoning	3 x 15 min.
04AROP	Necessary Arithmetic Operations	2 x 8 min.
05LENO	Letters and Numbers	20 min.
06LEST	Letter Sets	2 x 7 min.
07SEEP	Seeing Problems	4 x 3 min.
08FLGS	Flags	8 min.
09CRDS	Cards	8 min.
10FIGS	Figures	8 min.
11PERW	Perceptual Words	5 min.
12PERN	Perceptual Numbers	1½ min.
13OBMR	Object -Number Memory	2 x 5 min.
14PCMR	Picture Memory	3½ min.
15OTIS	General Intelligence	½ hr.
16EXPR	Expression and Comprehension	½ hr.
17COMP	Comprehension	½hr.
18ESSY	Essay	1 hour
19SENT	Sentence Structure	½ hour
20VOCB	Vocabulary	20 min.
21LETT	First Letters	4 min.
22PRFX	Prefixes	4 min.
23SUFX	Suffixes	4 min.
24THME	Theme	2 x 4 min.
25CATG	Categories	2 x 3 min.
26CHCN	Chemistry Conventional	1½ hour
27PHCN	Physics Conventional	1½ hr.
28CHOB	Chemistry Objective	1½ hr.
29PHOB	Physics Objective	1½ hr.

Alliance High School is an extra-provincial school, founded in 1926, which draws its pupils from all over Kenya. In order to be considered for entry into Form 1, the pupils must have completed seven or eight years of primary education and have passed the Kenya Primary Examination (now the Certificate of Primary Education). In most cases this means that pupils who enter Alliance are near the top of the class in their Primary schools, and so it is considered that Alliance High School gets as good an entry as possible. It was decided to choose the students who had reached Form 2, because they had completed two years in the School, in the same class, doing exactly the same subjects. They had not been 'streamed' but were placed in three parallel classes all of equivalent standards, and for most subjects were taught by the same teachers. Form 3 was considered, but rejected because it had been streamed for science and this would limit the scope of any experiment. Form 2 also happened to be the level at which the new examination, the Kenya Junior Secondary Examination, was to be introduced in 1967, making the end of the second year a recognized examining stage.

Each of the three classes had 32 pupils making a total of 96 pupils. Students in Kenya are on an average older than those in highly developed countries, due partly to the longer time required for primary school and partly to the later start to their school life. The ages of the pupils ranged from 16 to 19 years and the average age was 18.0 years. There were 24 tribes represented taken from all parts of Kenya. Although to enter Alliance High School, marks in the K.P.E. must have been similar for all students, the kind of teaching and standard of education in the primary schools would have varied widely, but with two years at Alliance High School one would have expected that these different educational environmental differences would be eliminated to some extent, as all 96 pupils have equal opportunities for two years. There are four years of schooling to the Cambridge School Certificate, so that the end of Form 2 represents the half-way stage. Subjects studied in Form 2 are English Language and Literature, History, Geography, Religious Knowledge, Mathematics, Physics, Chemistry, Biology, Swahili, Art, Music and Handwork.

Physics, Chemistry and Biology are taught as three separate subjects by different teachers, but generally the same teacher teaches all three classes in that subject.

The Procedure

The Science examinations were taken during the normal end-of-year school examinations in November as part of the school examination routine. These examination marks went towards a total mark which determined the final class position of each pupil. The science marks were used to divide the class into three streams for the sciences in the following year. Thus the pupils knew that these examinations were important and therefore all would be expected to do their best.

The mental ability tests were taken during October and November. The Headmaster of the School kindly allowed the writer to use three periods of about two hours each on Saturday mornings, when the classes would have normally attended a school talk by the Headmaster, and one two-hour period in the afternoon after the examinations were completed. Tests 16 - 19 were taken as part of the end-of-year English examination. Pupils who missed any of the tests through illness, or other reasons, were asked to complete the tests during an evening private study period.

The purpose of the experiment was explained to them in outline and the co-operation was very good. The kinds of tests were new to them and a great interest was shown in the novelty of the tests, and a great deal of trouble was taken over explaining how each test should be answered, so that everyone knew exactly what to do. There was no evidence of confusion over the instructions and the writer was satisfied that they were done to the best of their ability. The whole sample was tested at the same time in one large room (the dining hall) and care was taken to supervize properly with the help of three or four senior students. The times of some of the tests were altered to suit the speed of working of the students, but all students were allowed exactly the same time. 94 students completed all the tests and examinations and these scores were used in the analysis of results.

The marking

All the tests, except the English tests No. 16 - 19 and the Physics conventional examination No. 27 were either marked by the writer or under his direct supervision.

The English tests were marked by the English teachers and the Physics conventional examination was marked by the Head of Physics. The raw scores were transferred to a large sheet of paper and recorded against the name of each student.

(b) <u>Histograms</u>

The raw scores for the subjects were tabulated and histograms were constructed to check for normal distributions. The limits for the intervals were selected so that there were between seven and ten class intervals. In the diagrams of the histograms the base is labelled with the score intervals rather than the exact limits (Garrett 1966). Thus, the first interval in the histogram of Test 1 actually begins at 14.5, the exact lower limit of the interval, and ends at 22.5, the exact upper limit of the interval. As all scores on the tests were in units, this means that the interval 15 - 22 includes all the scores of 15, 16, 1 17, 18, 19, 20 and 21.

All of the histograms, with the exception of Flags Test 08 and Figures Test 10, show approximately normal distributions. Some of them show 'tails' either at the low end of the scale or at the high end. Tails at the high end of the scale are particularly noticeable in the tests which require the subjects to write down their answers, expressing ideas in words or continuous prose, e.g. Test 07 Seeing Problems, Test 18 Essay, Test 22 Prefixes, Test 24 Theme, suggesting that a few subjects excel at this kind of ability. There is also a tail at the high end for both the Chemistry and Physics objective examinations, probably because there are a few subjects who are very good at this kind of science examination. Test 03 Arithmetical Reasoning and Test 04 Necessary Arithmetic Operations show low tails in their histograms, indicating that some subjects are particularly poor at these reasoning tests.

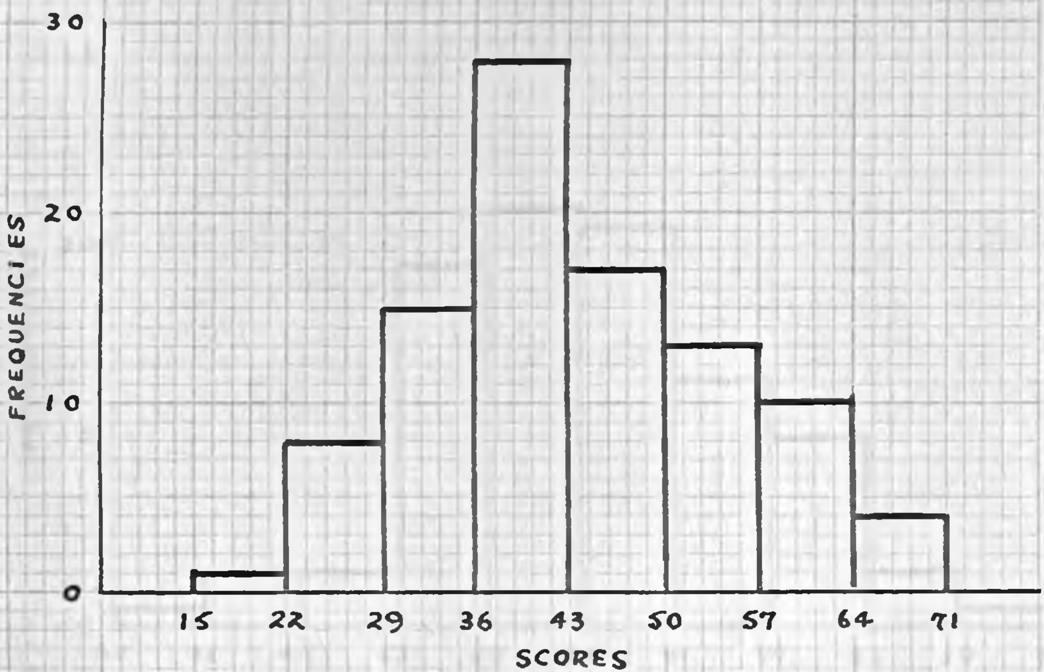
Test 08 Flags and Test 10 Figures were both negatively skewed indicating that many of the subjects found little difficulty with these two spatial tests.

It is interesting that the Test 09 Cards has an approximately normal distribution which shows that this test was found to be much more difficult than the other two spatial tests. This may be due to the fact that the cards have more complicated shapes than the flags or figures, and there are two or three aspects of shape which must be considered before getting the correct answer.

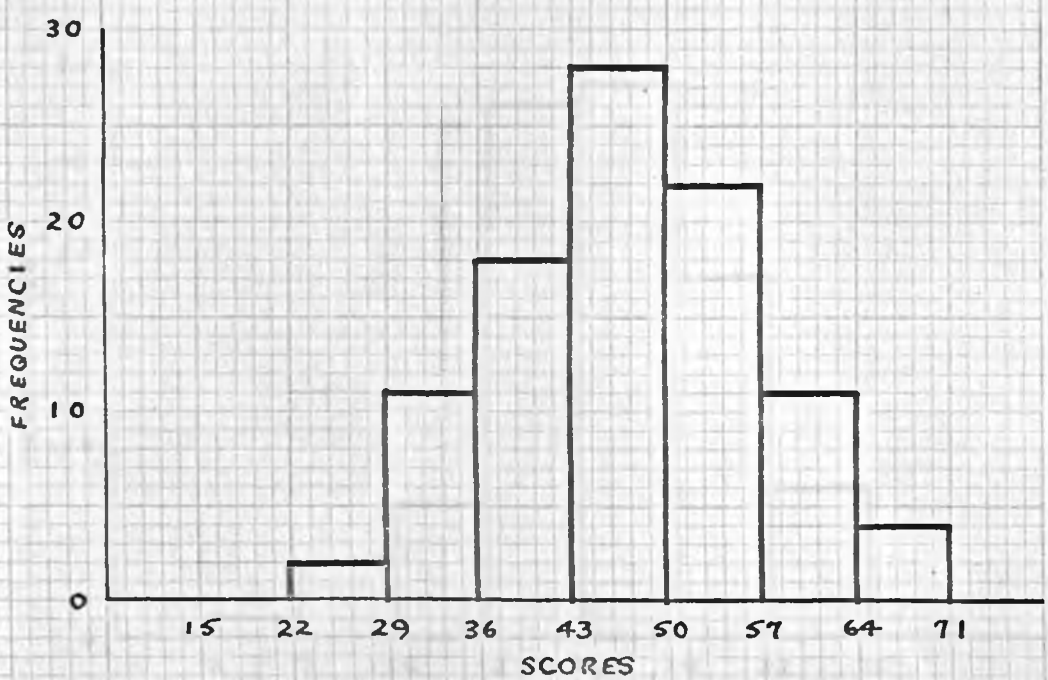
The histograms for the Test 08 Flags and Test 10 Figures were normalized by changing to a C-Scale which is based on the normal distribution, as suggested by Guildford (1956c) in which the top 1% scores 10, the next 3% scores 9, the next 7% scores 8, down to the last 1% which scores 0. Both the original and normalized histograms have been drawn.

TABLE X   HISTOGRAMS

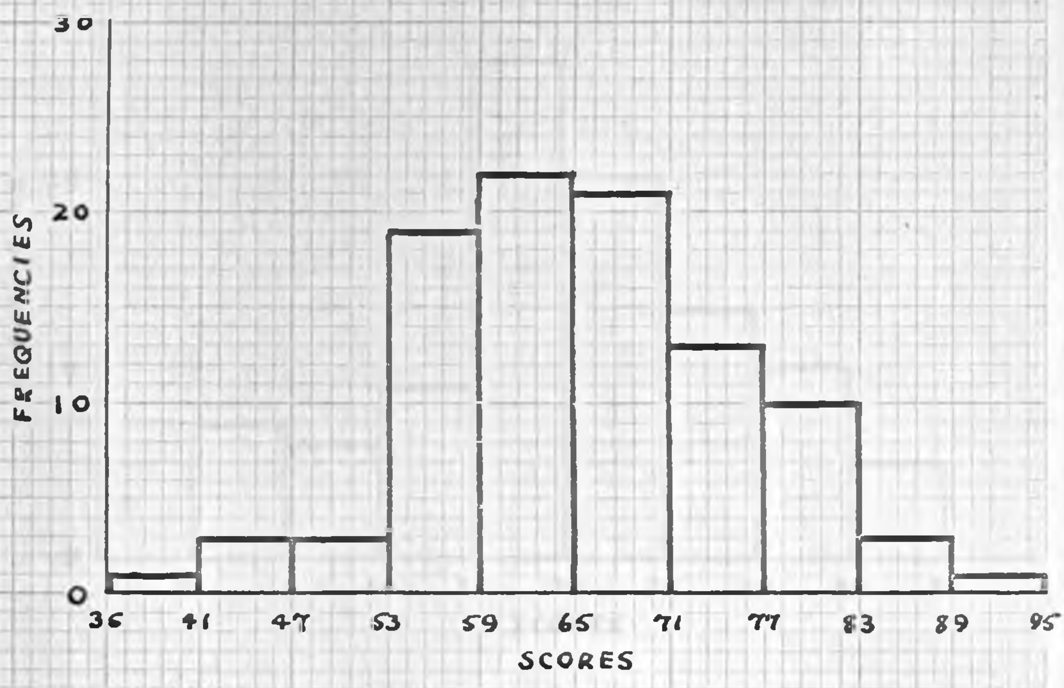
TEST 01ADDT   ADDITION



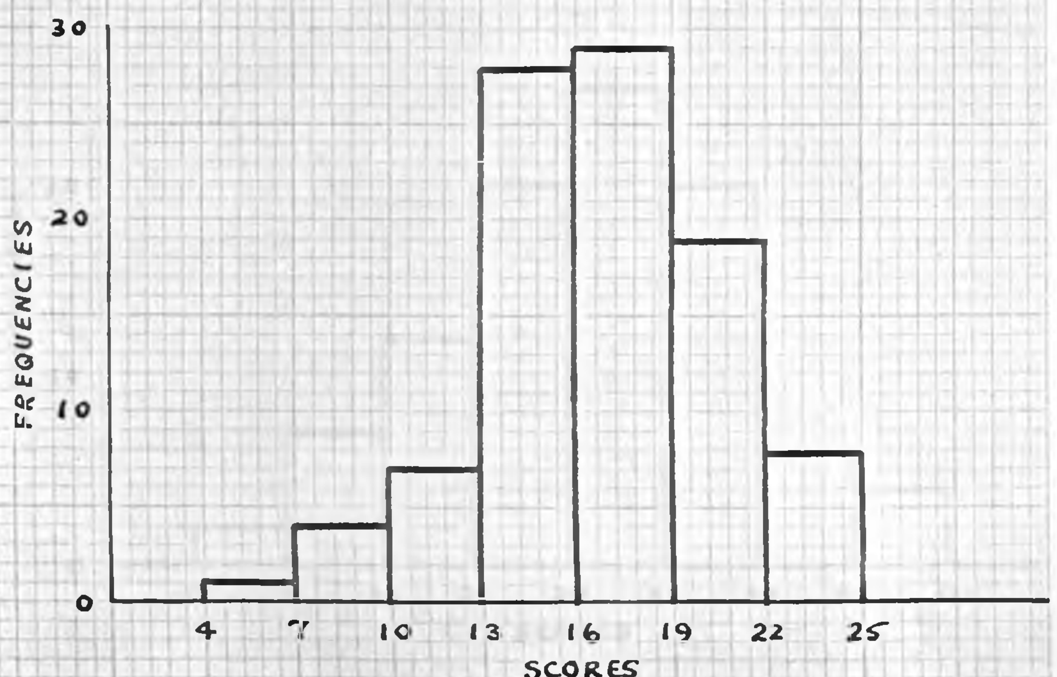
TEST 02MULT   MULTIPLICATION



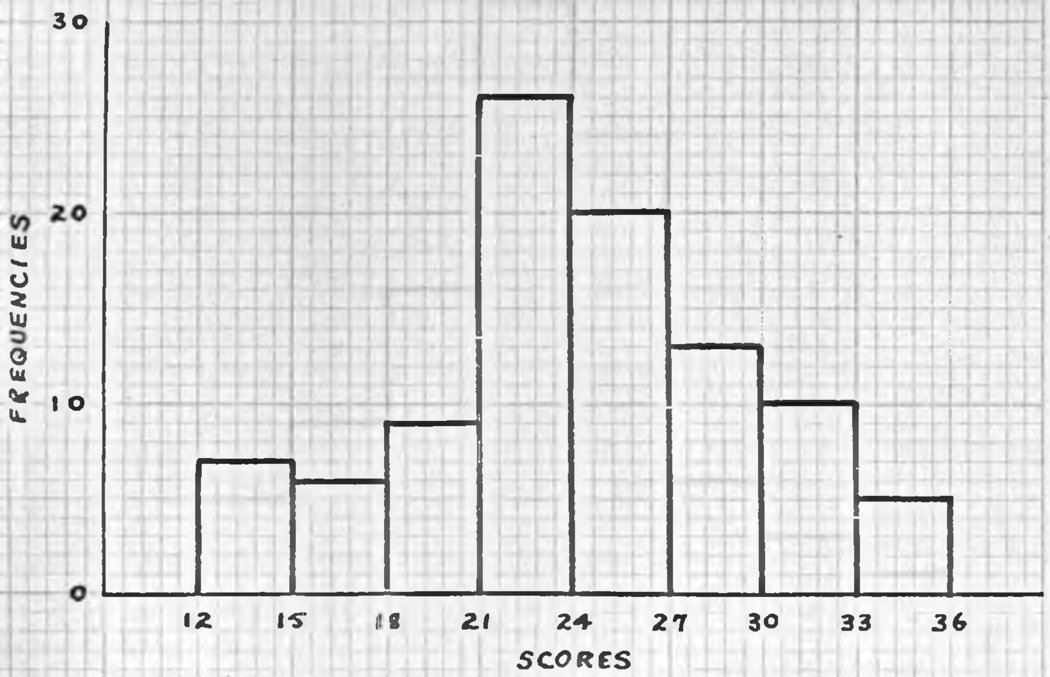
TEST 03AREA ARITHMETICAL REASONING



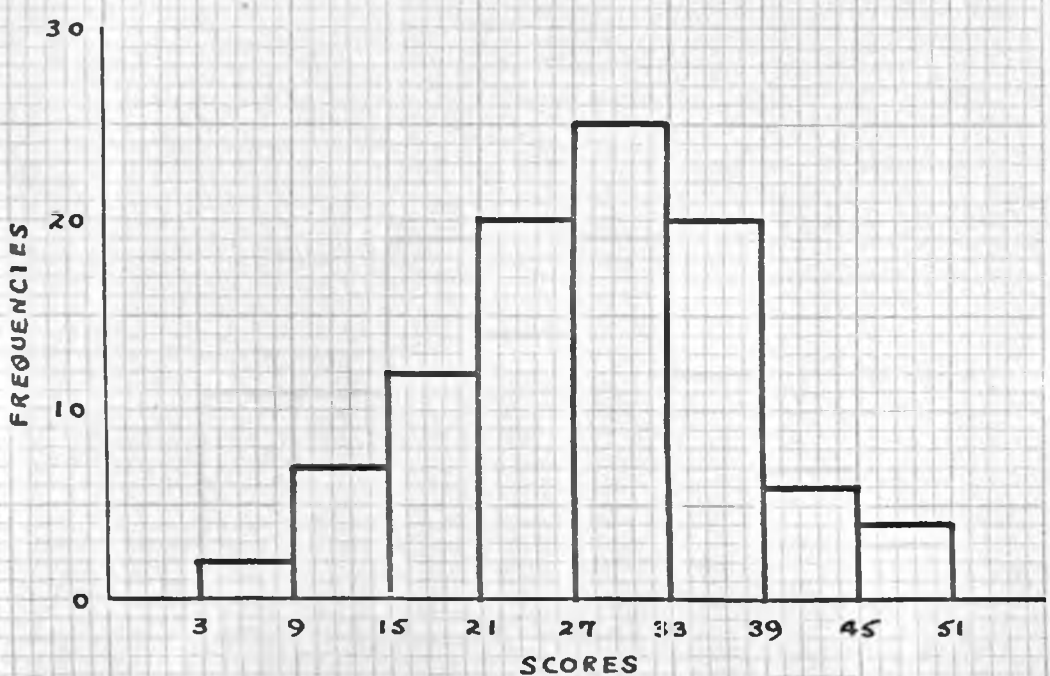
TEST 04AROP NECESSARY ARITHMETIC OPERATIONS



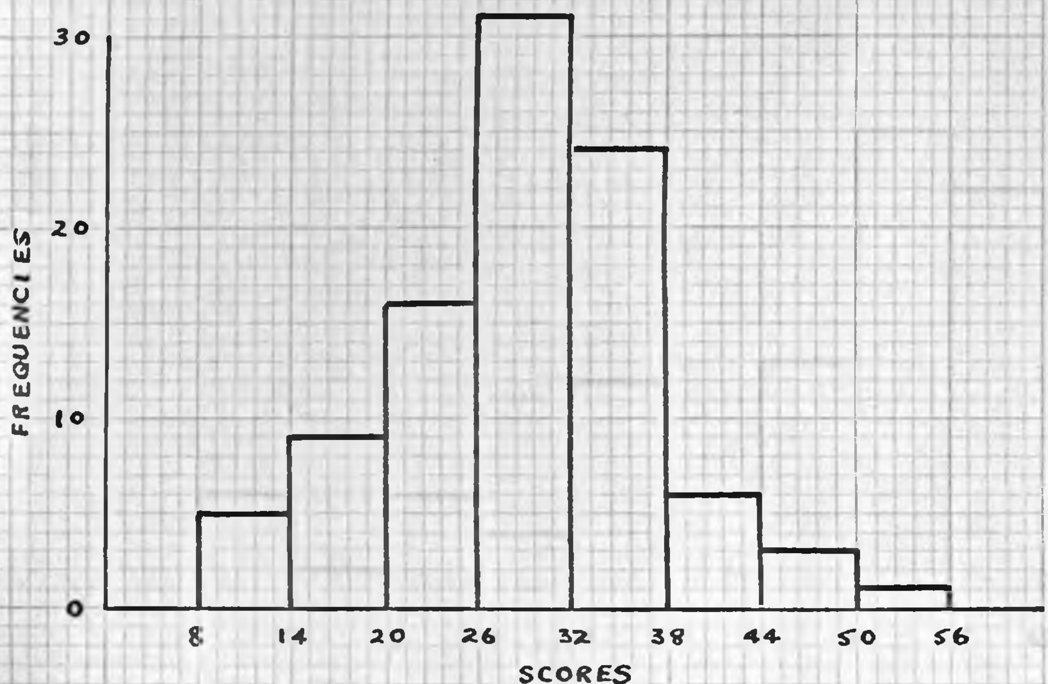
TEST 05LENO LETTERS AND NUMBERS



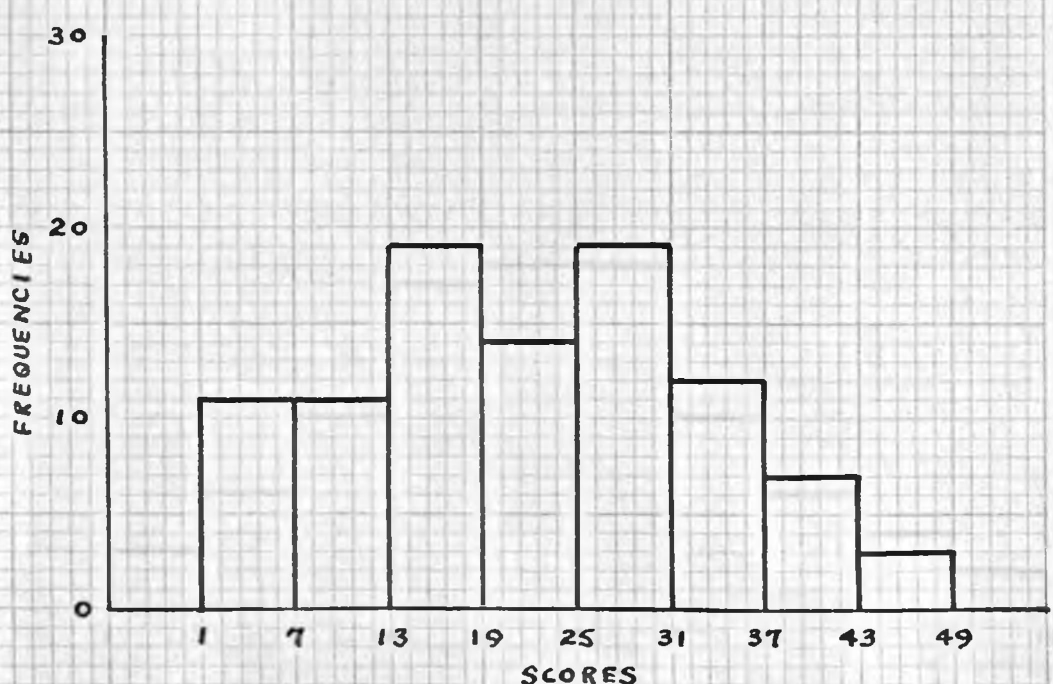
TEST 06LEST LETTER SETS



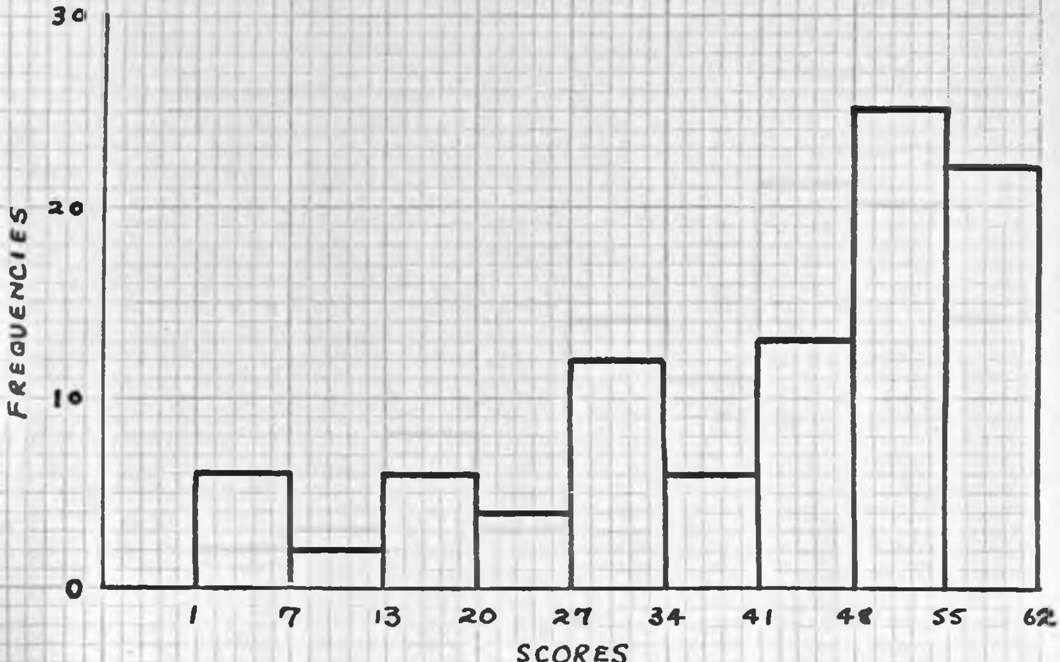
TEST 07SEEP SEEING PROBLEMS



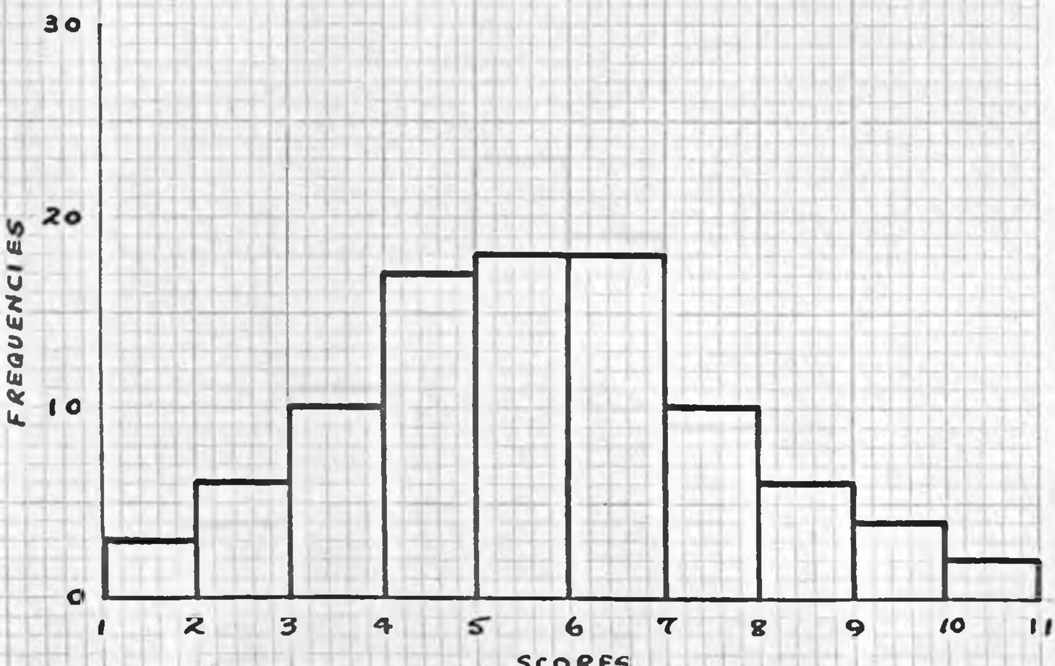
TEST 09CRDS CARDS



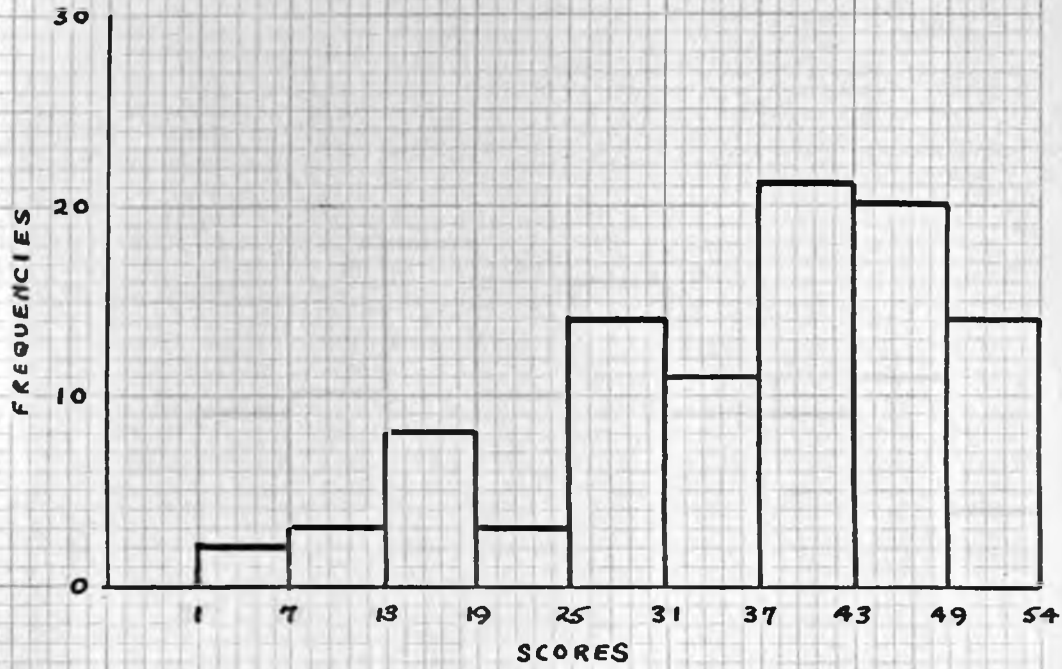
TEST O8FLGS FLAGS



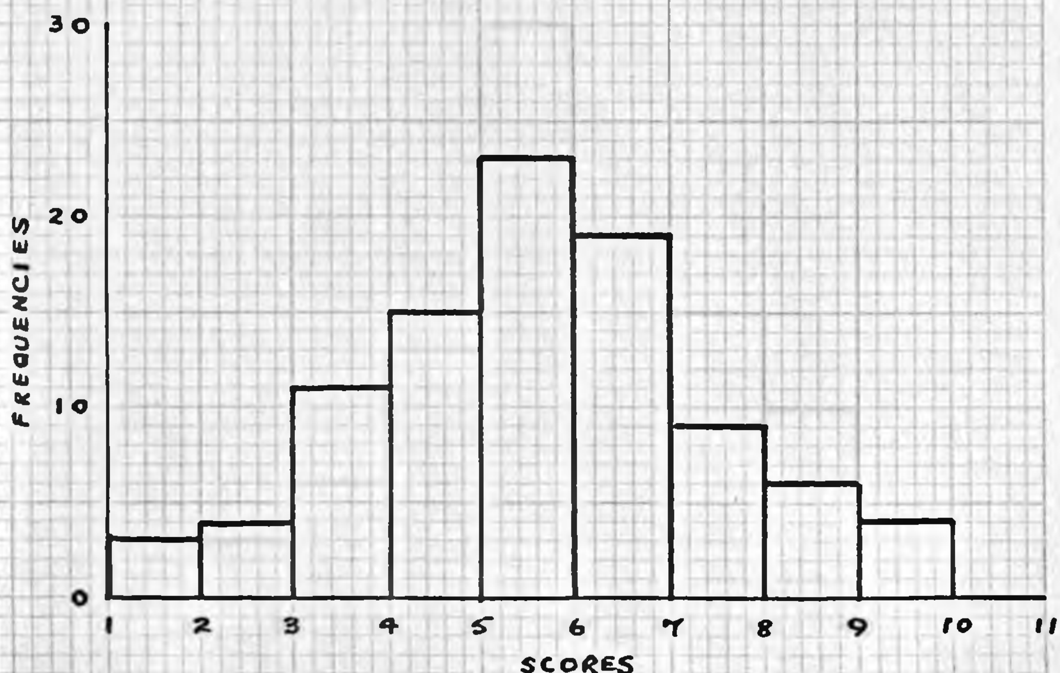
TEST O8FLGS FLAGS - NORMALISED



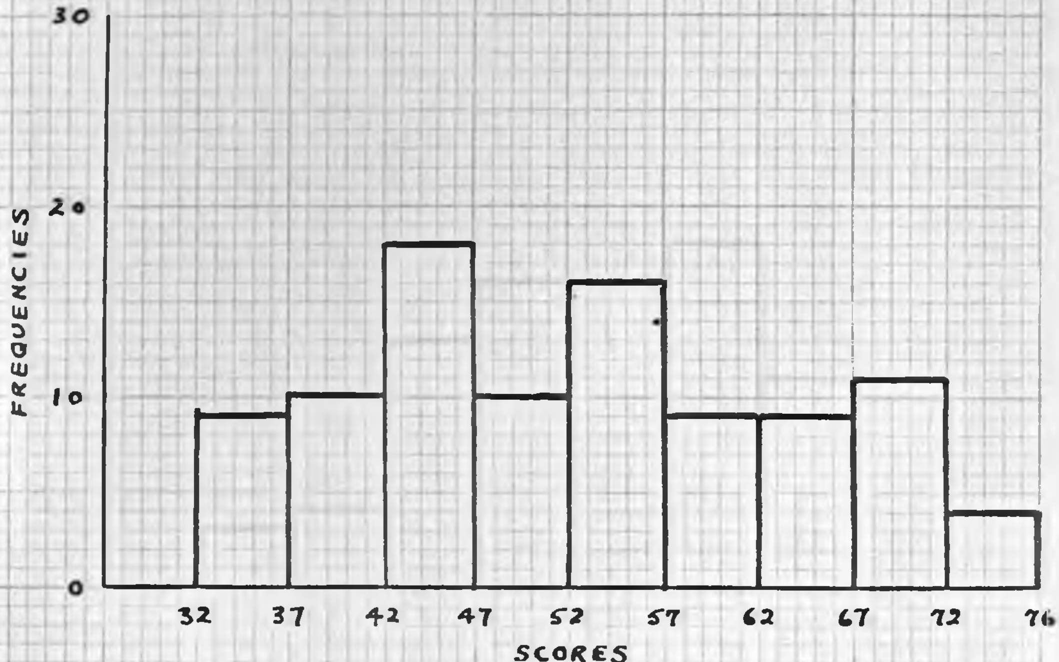
TEST 10FIGS FIGURES



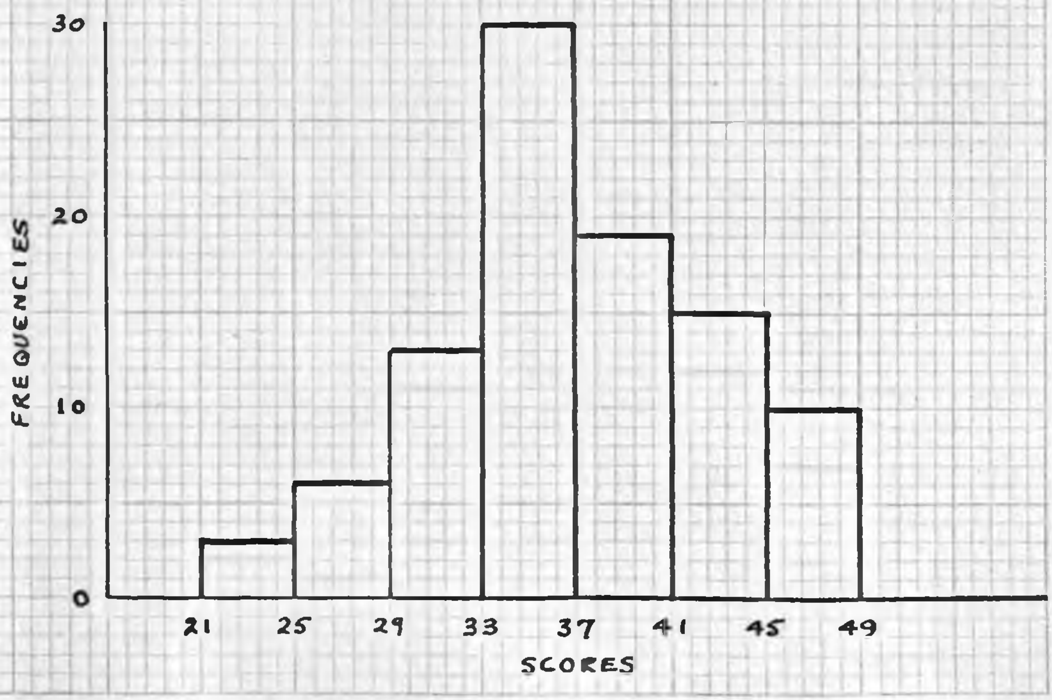
TEST 10FIGS FIGURES - NORMALISED



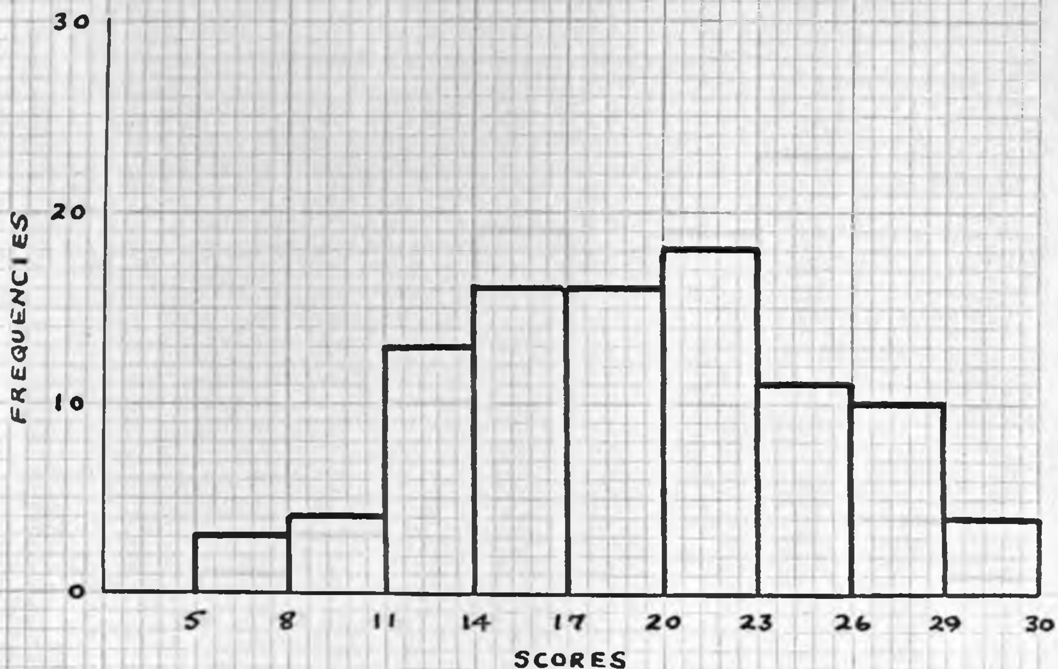
TEST 11PERW PERCEPTUAL WORDS



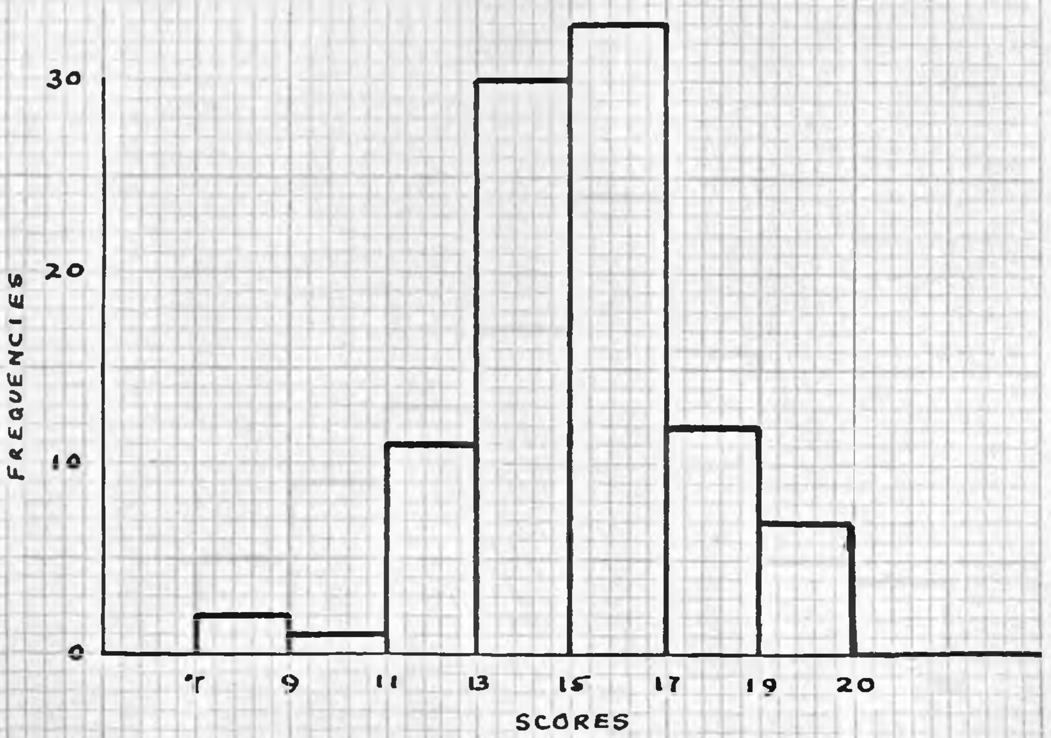
TEST 12PERN PERCEPTUAL NUMBERS



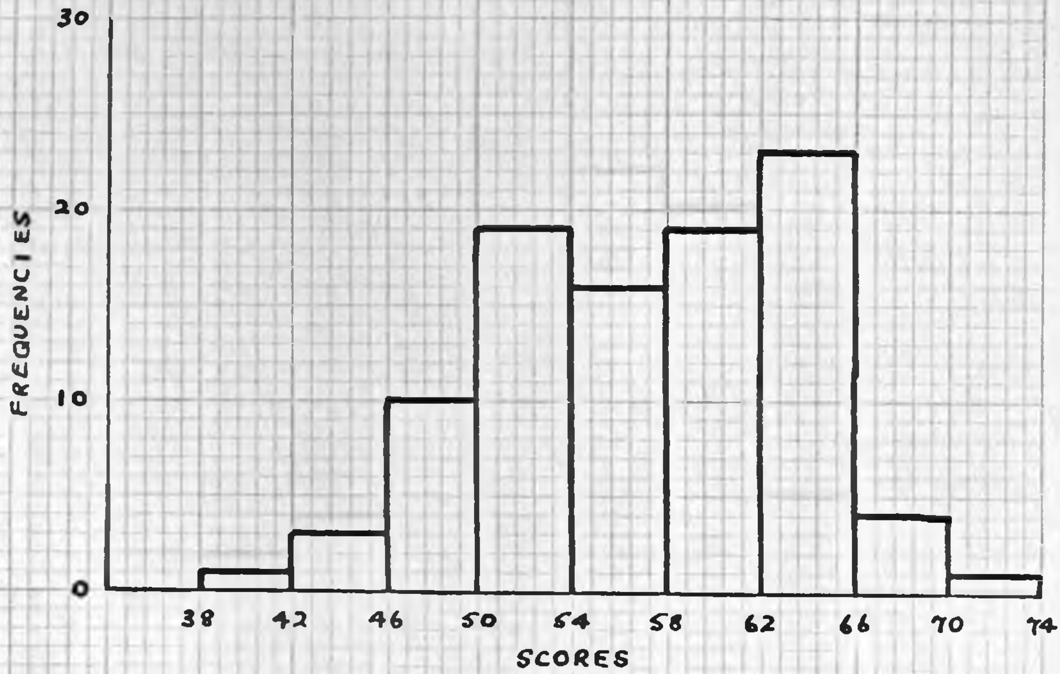
TEST 130BMR OBJECT-NUMBER



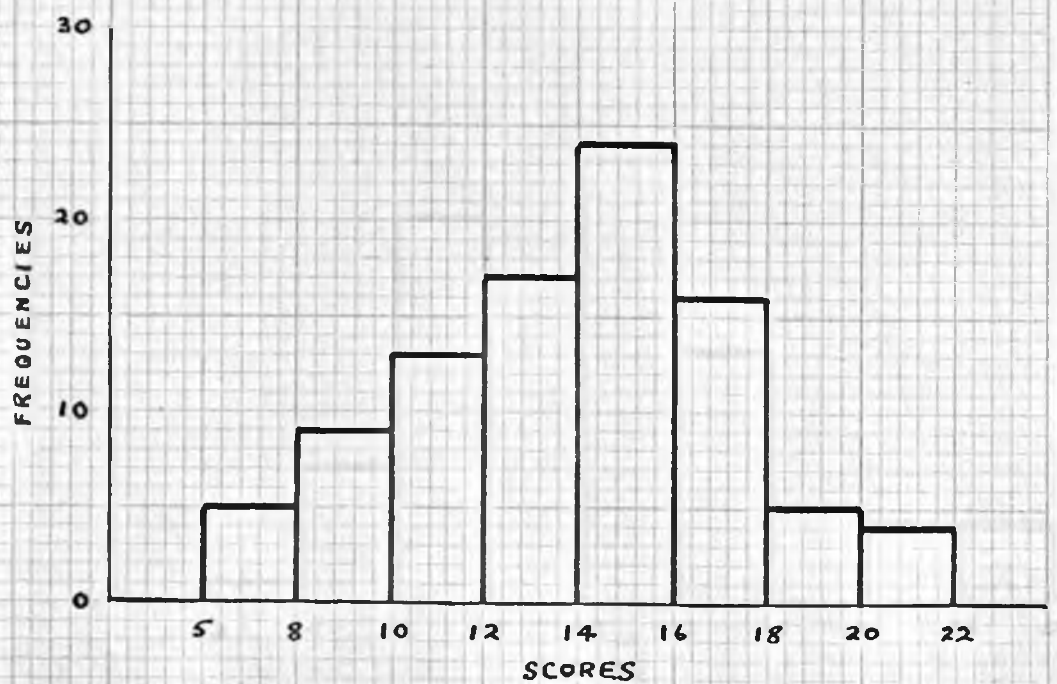
TEST 14PCMR PICTURE MEMORY



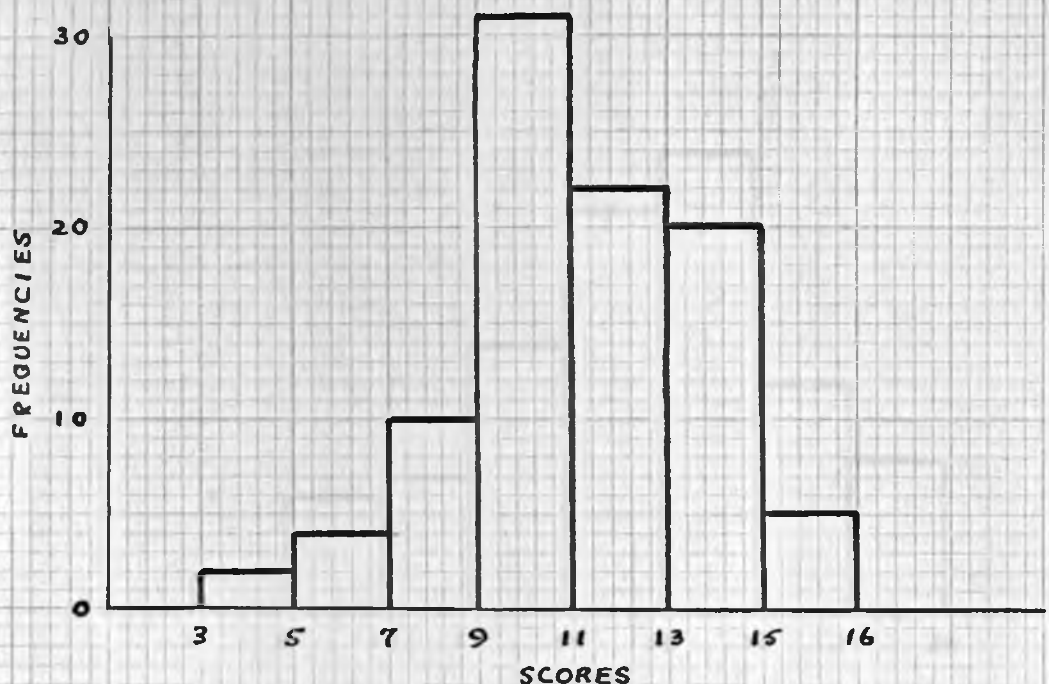
TEST 15OTIS OTIS INTELLIGENCE



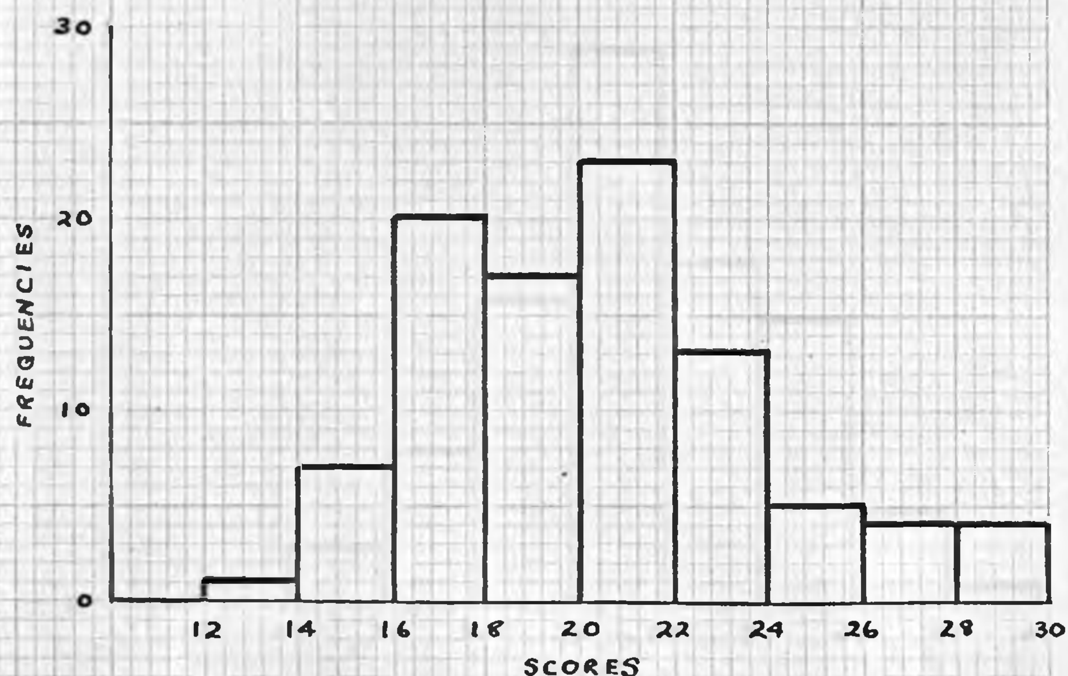
TEST 16EXPR EXPRESSION AND COMPREHENSION



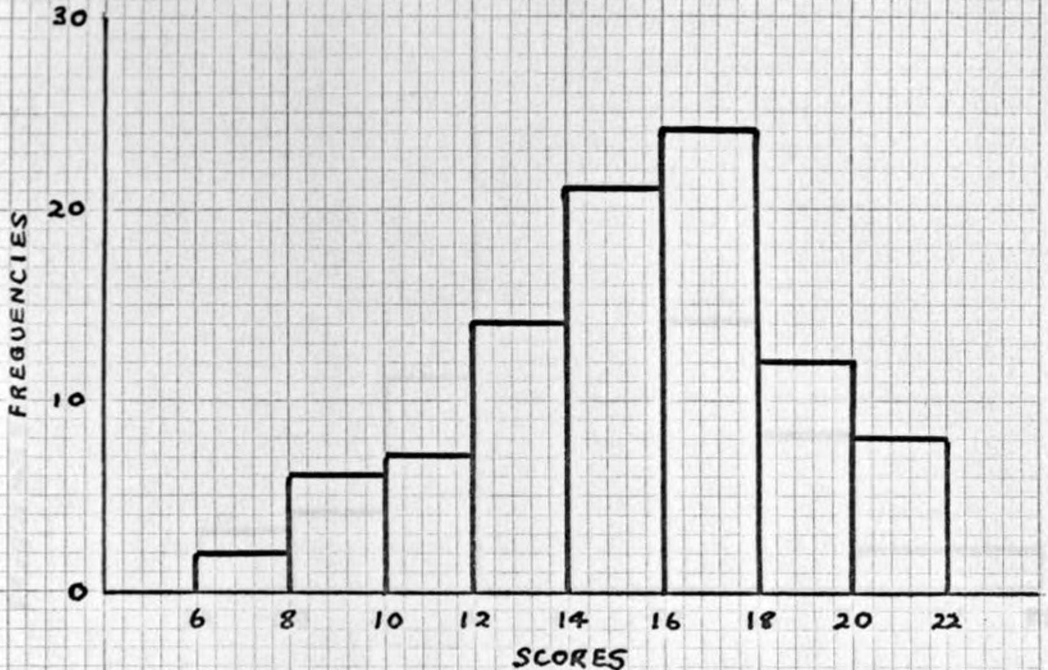
TEST 17COMP COMPREHENSION



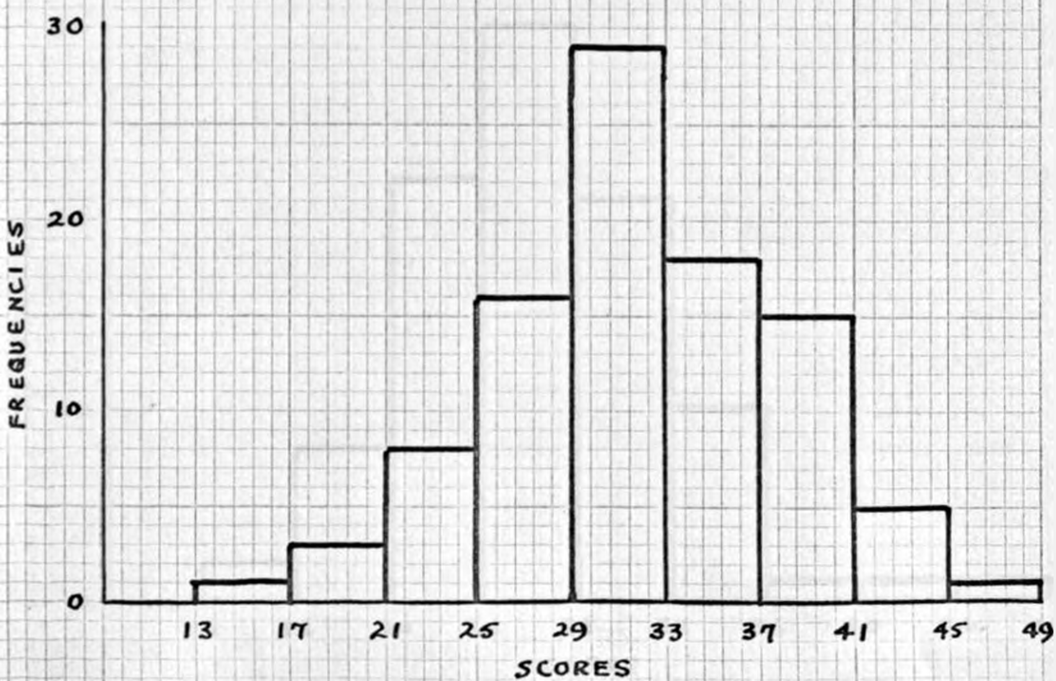
TEST 18ESSY ESSAY



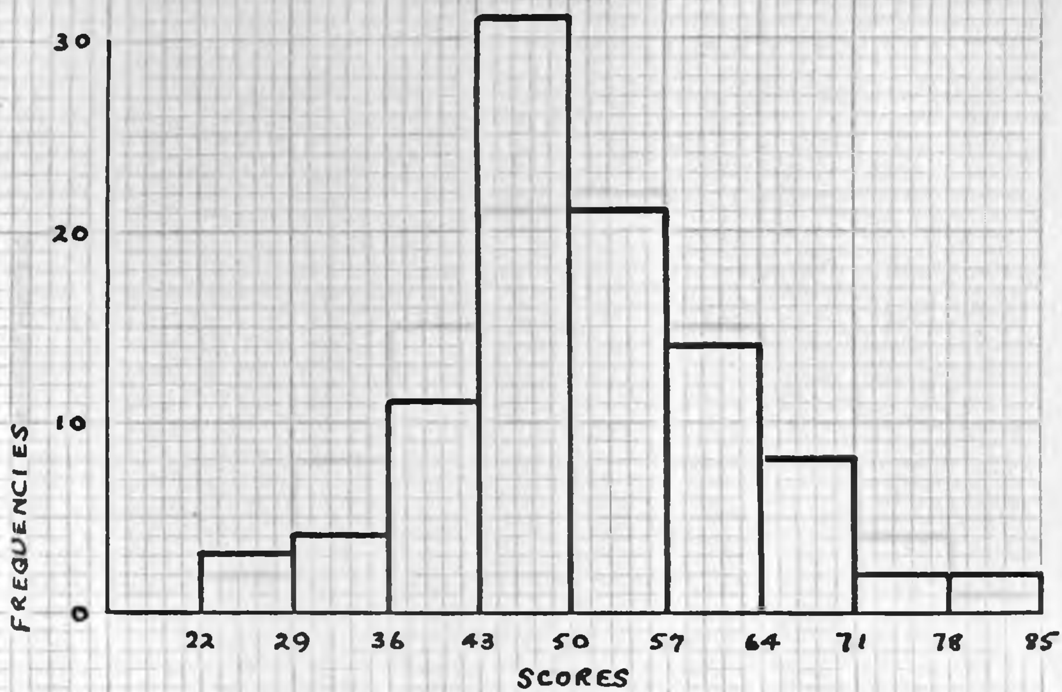
TEST 19SENT   SENTENCE STRUCTURE



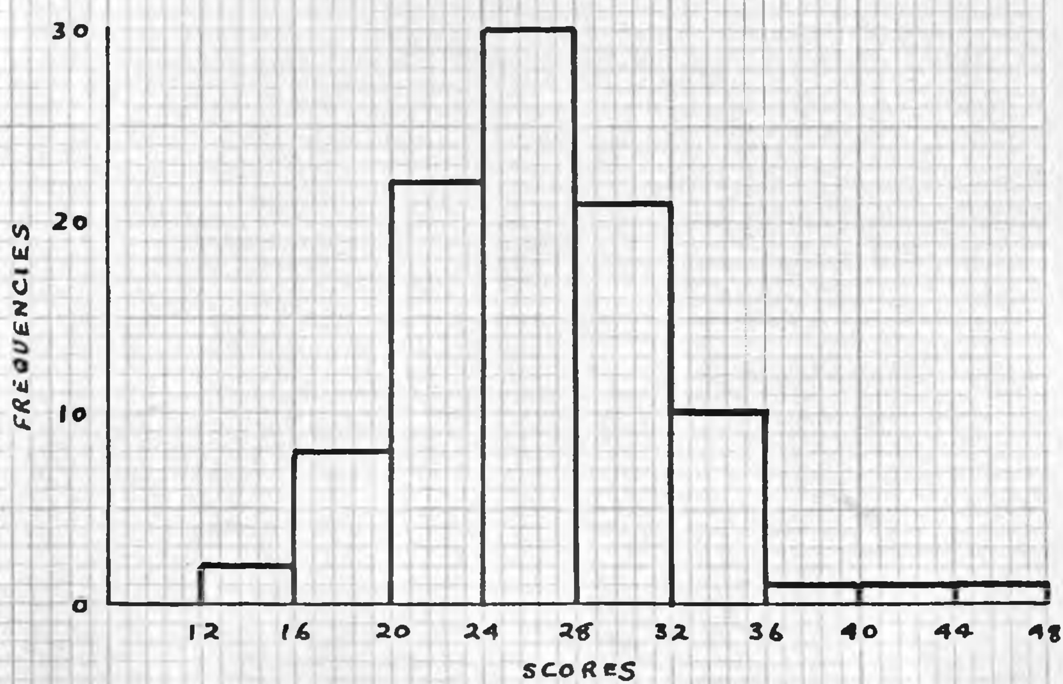
TEST 20VOCB   VOCABULARY



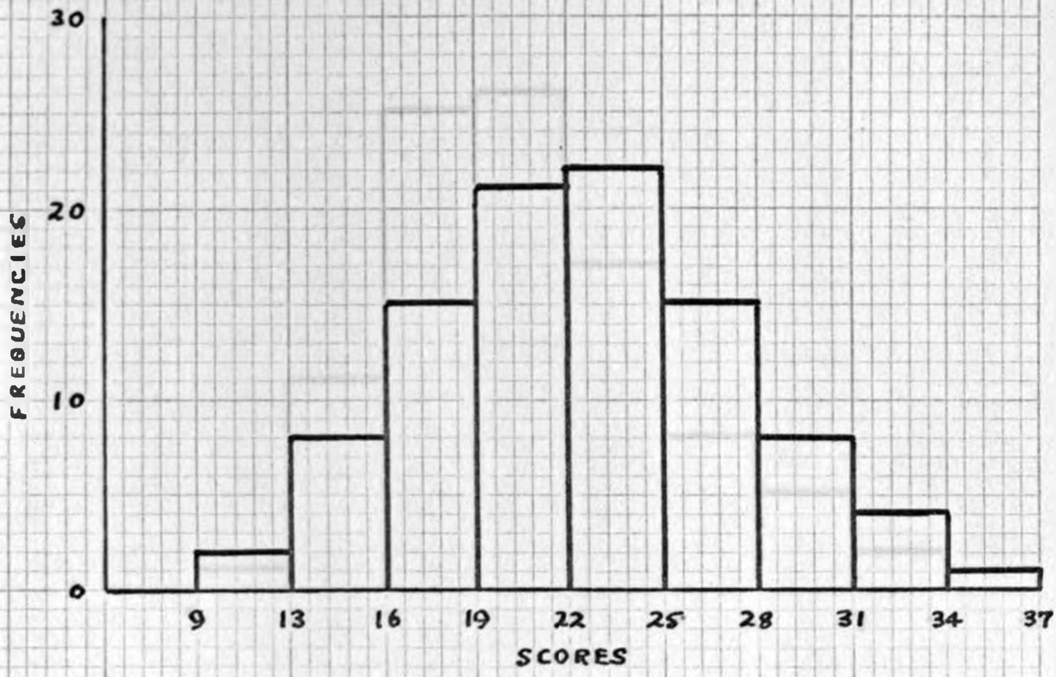
TEST 21LETT FIRST LETTERS



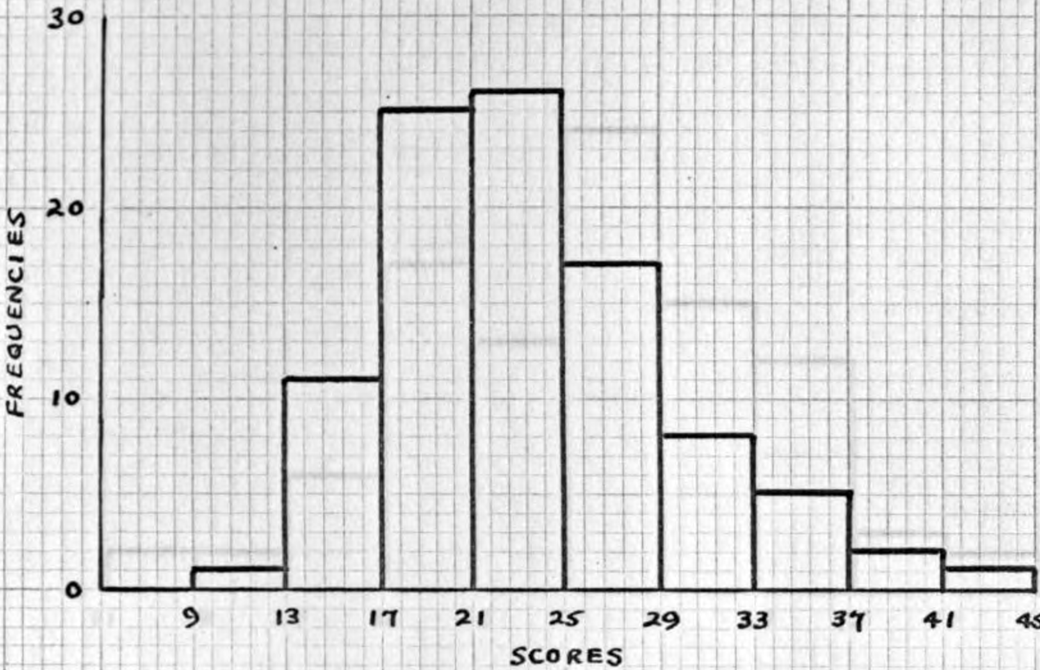
TEST 22PRFX PREFIXES



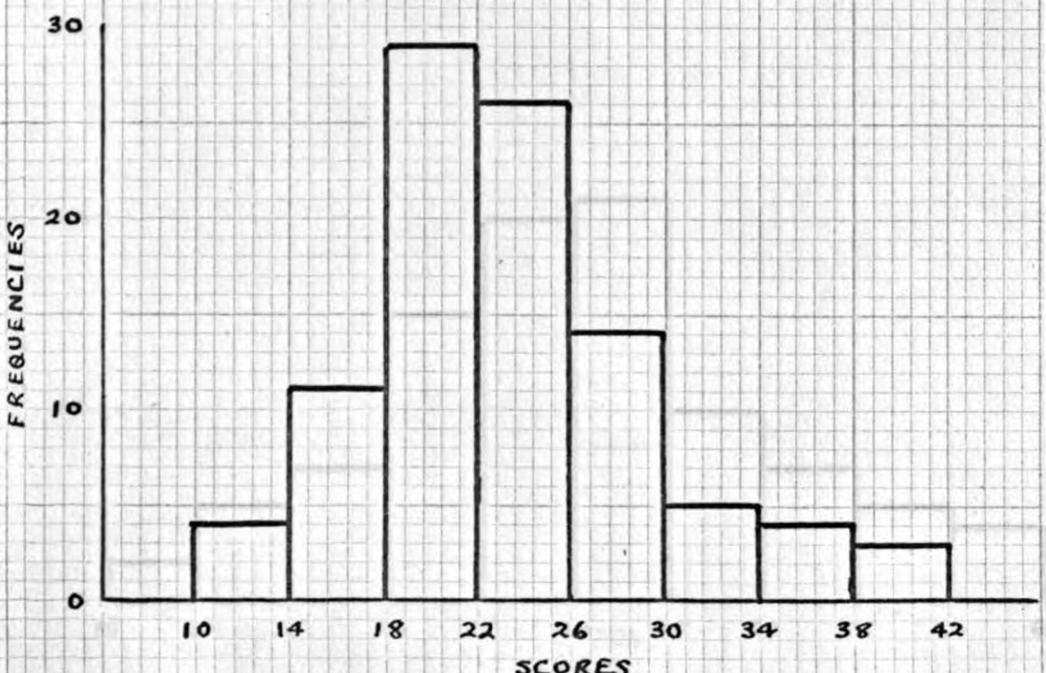
TEST 23SUFX SUFFIXES



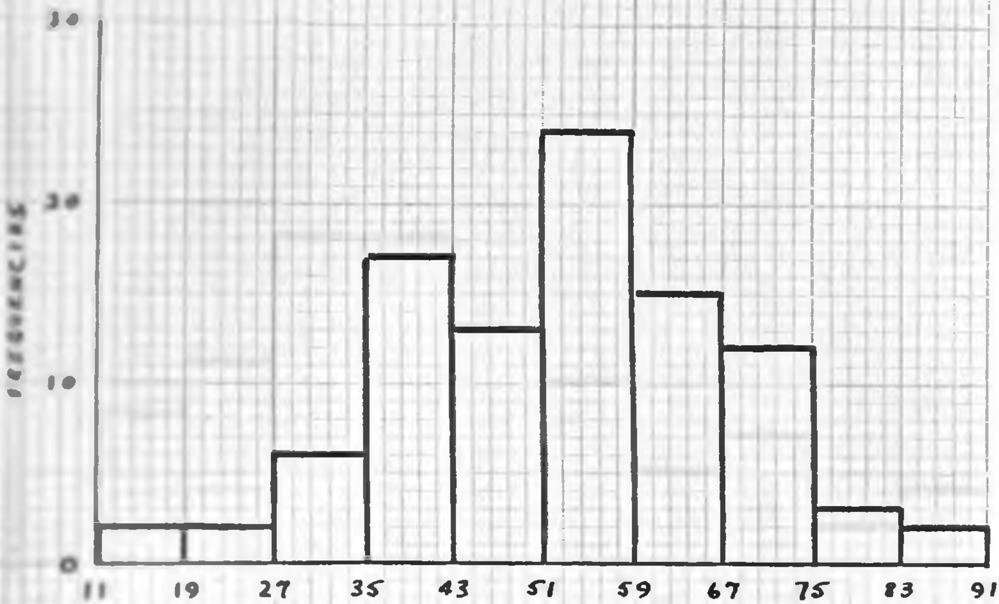
TEST 24THME THEME



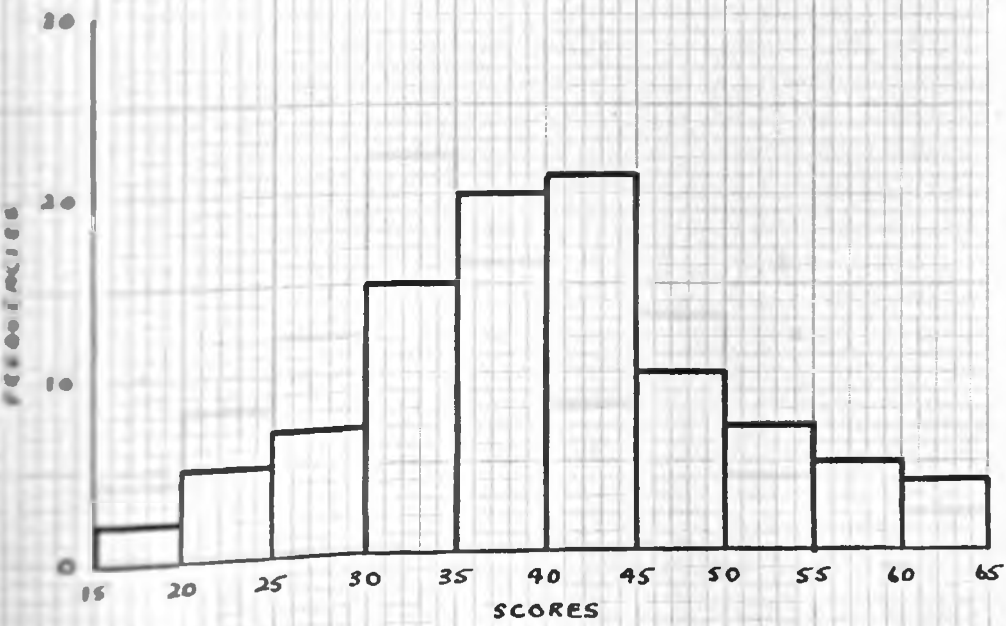
TEST 25CAT6 CATEGORIES



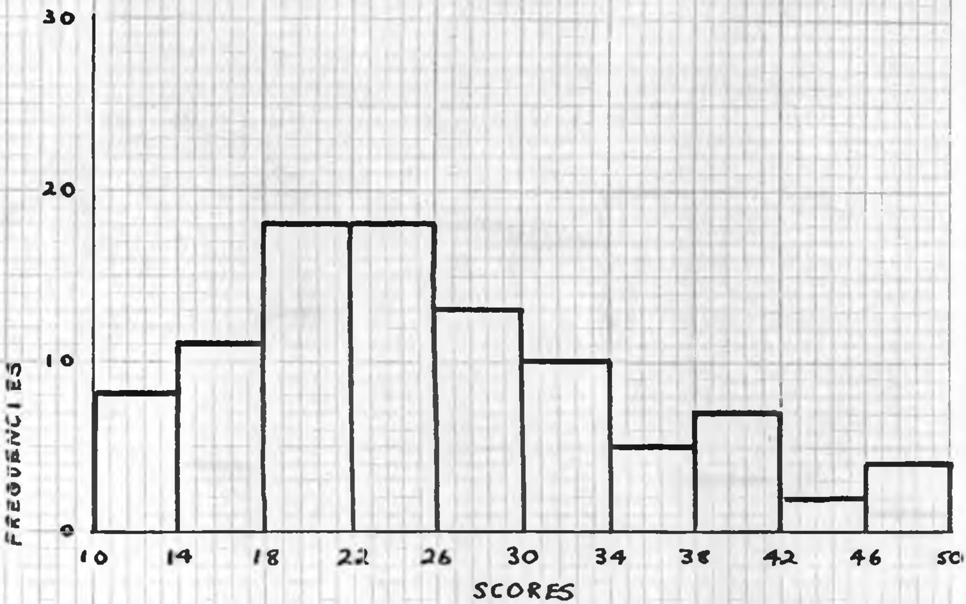
CHEMISTRY CONVENTIONAL



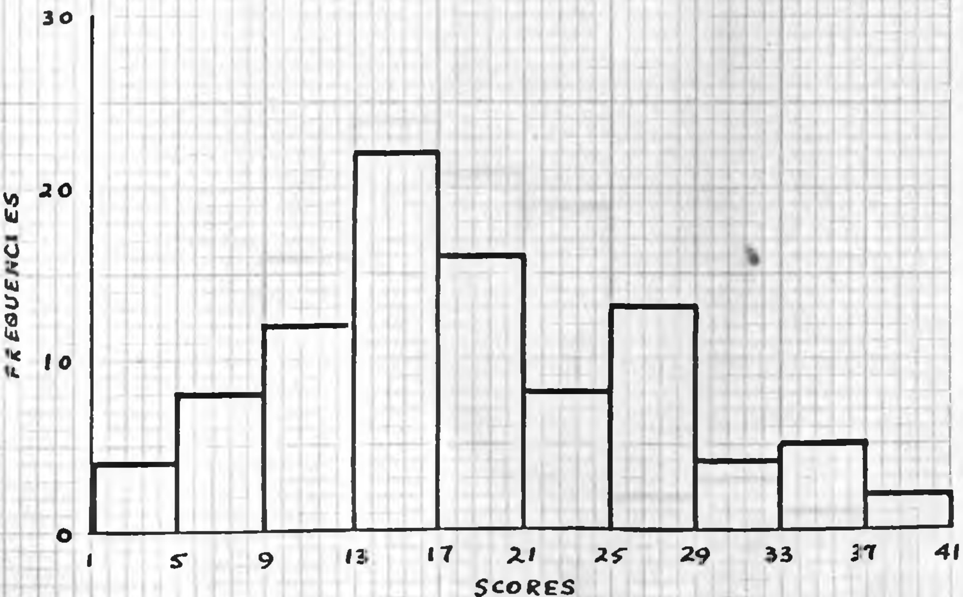
PHYSICS CONVENTIONAL



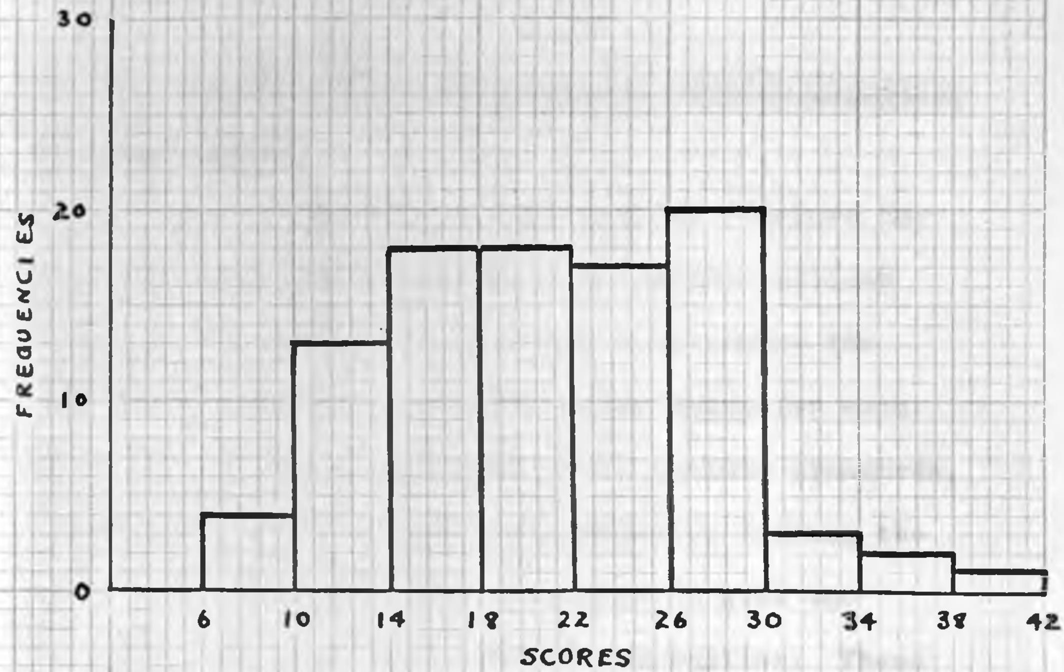
TEST 28CHOB CHEMISTRY OBJECTIVE - ORIGINAL



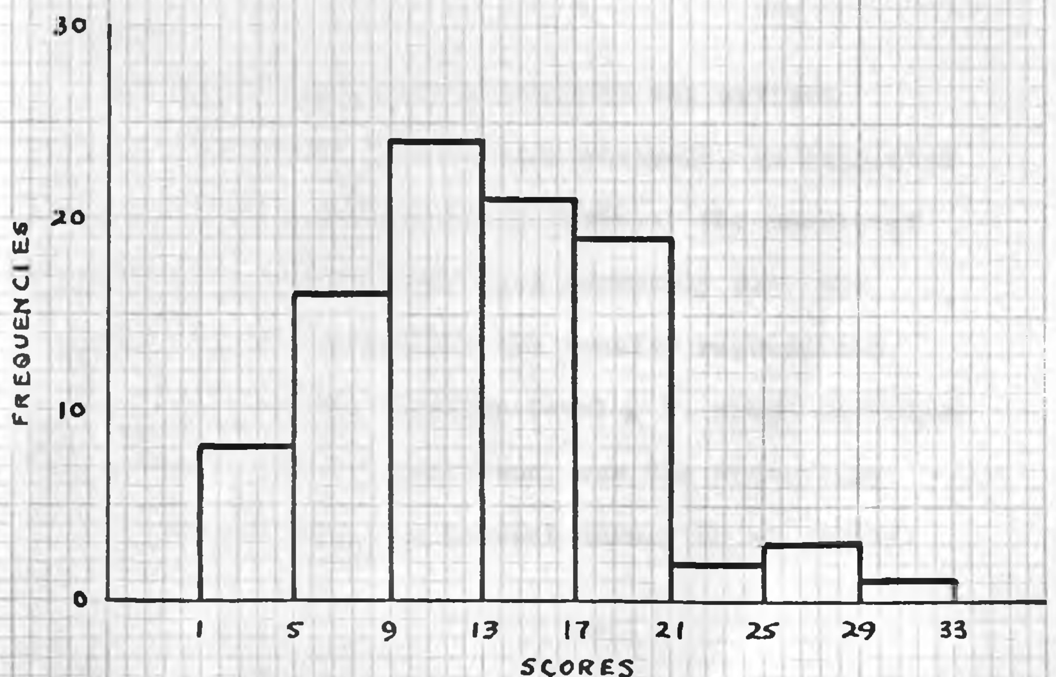
TEST 28CHOB CHEMISTRY OBJECTIVE - REVISED



TEST 29PHOB PHYSICS OBJECTIVE - ORIGINAL



TEST 29PHOB PHYSICS OBJECTIVE - REVISED



(c) <u>The analysis of the Chemistry and Physics objective examinations</u>

It was not possible to pre-test the items on the objective examinations, so an item analysis of each question was carried out in order to determine the facility level and the discrimination value for each question. If the item did not reach certain standards, the item was removed from the examination leaving the good items, which were then re-scored to give the subjects a new score on a revised examination. These new scores for the revised objective examination were those used in the analysis of the results.

<u>Chemistry</u>

The whole sample of 96 subjects was divided exactly into sixths for the item analysis, as suggested in Examinations Bulletin No. 3 (1964). The number of subjects who answered each item correctly i.e. the frequency, was counted and the results represented as in Figure 1. The facility level, F, which expresses the difficulty of the questions, was the percentage of subjects who gave the correct answer to the items.

The discrimination values, D, which express how effectively the items discriminate between the best and poorest subjects, were the difference between the proportion of correct answers in the top third and bottom third of the subjects.

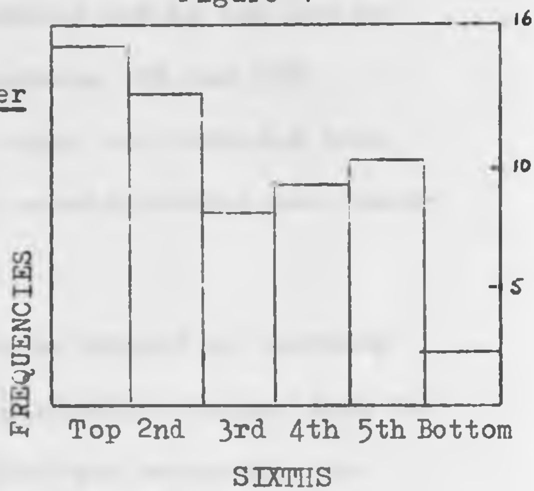
Question 2

		Frequency of correct answer
Top sixth	-	15
2nd sixth	-	13
3rd sixth	-	8
4th sixth	-	9
5th sixth	-	10
Bottom sixth	-	2

Facility Level(F) =60%

Discrimination Value (D)=0.50

Figure 1



Question 2 was considered to be a fairly good item especially in the view that only one in the top sixth answered wrongly and only two of the bottom sixth answered correctly. The Facility Level of 60% is good, as also is the Discrimination value of 0.50.

In order to decide which items to discard the following points were taken into consideration:

1. The general shape of the diagram, which should show a gradual diminishing of right answers from the top sixth to the bottom sixth. The diagram should not show any exaggerated results for any of the sixths.

2. The facility level should not be too low or too high. If the value was between 30% and 70% this was acceptable, but the range was extended down to 20% and up to 80% if other considerations were acceptable.

3. The discrimination value should be between 0.30 and 0.70, but again discrimination values down to 0.20 were acceptable if the item was acceptable in other considerations.

4. The item itself must not have shown any peculiarities, such as having alternatives which were in fact possible answers. If the item was considered to measure a valuable ability or skill, even though the facility level and discrimination value were low, provided the general shape of the diagram was consistent this item would be allowed to stand. e.g. Q16.

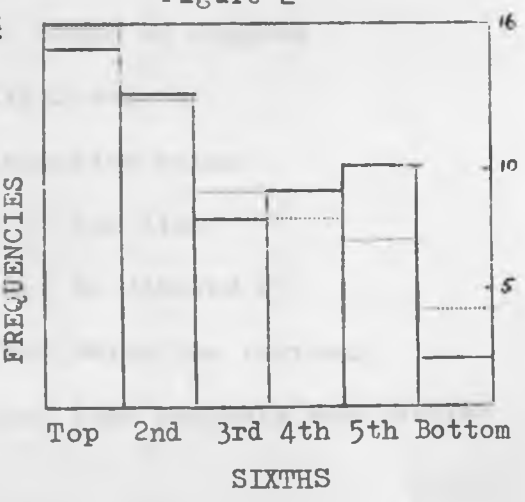
18 items on the Chemistry objective examination failed to measure up to this standard and therefore were discarded. A new score, based on the 42 'good' items, was calculated according to the formula: Score = No. right - $\frac{\text{No. Wrong.}}{3}$

The item analysis was repeated using these revised scores to divide the students into sixths and new discrimination values (D') were obtained, which are shown in the Table 3. Generally the discrimination values shows improved values, as would be expected when the poor items are eliminated. An example of the change in the diagram of item analysis is given for Question 2 in Figure 2.

Frequency of correct cnaswers

	Original	Revised
Top sixth	15	16
2nd sixth	13	13
3rd sixth	8	9
4th sixth	9	8
5th sixth	10	7
Bottom sixth	2	4

Figure 2



Facility Level (F)	=	60%
Original Discrimination Value (D)	=	0.50
Revised Discrimination Value (D')	=	0.56

The dotted line indicates the revised item analysis which shows a better gradation of correct answers. The discrimination value has increased slightly from 0.50 to 0.56.

Physics

An item analysis for the Physics Objective examination was carried out in a similar way to the Chemistry examination. The subjects were divided into sixths according to their scores in the Physics objective examination and the diagrams were drawn. From these were calculated the Facility Level and Discrimination Value of each item. The same consideration of

1. general shape of diagram
2. facility level
3. discrimination value
4. nature of the item

were considered and it was decided to discard 23 items leaving 32 'good' items from which the revised scores were calculated. A revised item analysis was carried

TABLE 3 F and D for Chemistry objective questions

F - Facility Level

D - Discrimination Value for item in original examination

D' - Discrimination Value for item in revised examination

x in the D' column - item not included in revised examination

Item	F	D	D'	Item	F	D	D'
1.	24	.41	.41	31.	47	.66	.72
2.	60	.50	.56	32.	78	.28	.25
3.	63	.38	.34	33.	21	.19	.12
4.	27	-.03	x	34.	26	.16	x
5.	41	.22	x	35.	82	.31	.25
6.	51	-.09	x	36.	77	.31	.28
7.	42	.38	.44	37.	42	.28	.31
8.	64	.19	.25	38.	70	.16	.22
9.	69	.44	.59	39.	80	.03	x
10.	73	.34	.38	40.	37	.12	.22
11.	80	.06	x	41.	75	.00	x
12.	48	.31	.31	42.	75	.19	.25
13.	50	.49	.38	43.	33	.44	.50
14.	52	.12	x	44.	47	.19	.22
15.	60	.38	.38	45.	22	.34	.28
16.	23	.31	.38	46.	82	.22	.28
17.	51	.47	.50	47.	83	.06	x
18.	49	.25	.28	48.	65	.22	.22
19.	13	.04	x	49.	45	.34	.28
20.	40	.25	.28	50.	44	.19	.19
21.	41	.50	.50	51.	60	.25	.22
22.	32	.15	x	52.	73	.41	.34
23.	64	.06	x	53.	60	.34	.34
24.	30	.00	x	54.	23	.06	x
25.	56	.50	.47	55.	79	.34	.34
26.	46	.06	x	56.	63	.44	.47
27.	75	.28	.25	57.	63	.47	.44
28.	38	.53	.53	58.	89	.13	x
29.	69	.13	x	59.	56	.28	.25
30.	66	.28	.44	60.	67	.13	x

TABLE 4 F and D for Physics objective questions

F - Facility Level

D - Discrimination Value for item in original examination

D' - Discrimination Value for item in revised examination

x in the D' column - item not included in revised examination

Item	F	D	D'	Item	F	D	D'
1.	75	.19	.19	29.	41	.53	.53
2.	61	.22	.25	30.	18	-.07	x
3.	44	.41	.38	31.	85	.19	x
4.	63	.16	x	32.	90	.19	x
5.	12	.12	x	33.	15	.03	x
6.	98	.06	x	34.	44	.38	.28
7.	81	.04	x	35.	18	.10	x
8.	38	.41	.34	36.	43	.03	x
9.	84	.22	.28	37.	79	.16	.19
10.	54	.10	.22	38.	36	.56	.63
11.	22	.28	.25	39.	41	-.07	x
12.	44	.12	x	40.	34	.16	.22
13.	51	.31	.31	41.	19	.03	x
14.	68	-.07	x	42.	70	.41	.47
15.	90	.08	x	43.	44	.44	.44
16.	20	.19	x	44.	14	-.03	x
17.	33	.34	.38	45.	40	.09	.03
18.	73	.34	.34	46.	28	.16	.22
19.	88	.12	x	47.	54	.41	.44
20.	70	.19	.19	48.	23	.16	x
21.	55	-.07	x	49.	46	.44	.44
22.	65	.22	.16	50.	67	.38	.44
23.	43	.59	.59	51.	54	.38	.41
24.	78	.19	.16	52.	19	-.03	x
25.	41	.19	.19	53.	52	.31	.34
26.	77	.25	.28	54.	37	.44	.38
27.	63	.10	x	55.	06	.00	x
28.	55	.50	.56				

out using the 32 good items and new discrimination values (D') were found. Table 4 shows the Facility Level (F), the original Discrimination Value (D) and the revised Discrimination Value (D') of each item.

<u>Effect of the revision on the science objective examinations</u>

When the poor items are discarded from a test the whole test should improve, for poor items do not adequately distinguish between the best and poorest students. The scores on the revised test should be a better reflection of achievement. To find out if the science examinations had improved overall in this revision, the facility levels and discrimination values of the whole examination, before and after revision, were calculated. This was done in two ways for both Chemistry and Physics; firstly using the average score calculated from the total number of items correctly answered (R), and secondly from the average score calculated from the correction for guessing formula, $S = R - \frac{W}{n - 1}$,

in which R = number of items right

W = number of items wrong

n = number of alternatives for the items.

Chemistry	Original Examination F	Original Examination D	Revised Examination F'	Revised Examination D'
(i) using scores R	55	0.26	55	0.34
(ii) using scores S	42	0.33	40	0.44
Physics				
(i) using scores R	50	0.21	53	0.33
(ii) using scores S	38	0.26	39	0.43

The revision has hardly affected the facility levels, which have values of about 50% when the average scores calculated from the total number of items answered correctly (R) are considered. This is the value usually recommended for science tests. The discrimination values of the original examinations were low, 0.20 to 0.33, but the revised tests show much better values. The discrimination values are over 0.40 when average scores after correction for guessing (S) are used. This value is slightly below the value of 0.50 generally recommended, but this may be accounted for by the homogeneity of the sample tested.

The diagrams for these item analysos are shown in Table 5. The revision has not changed the general

TABLE 5

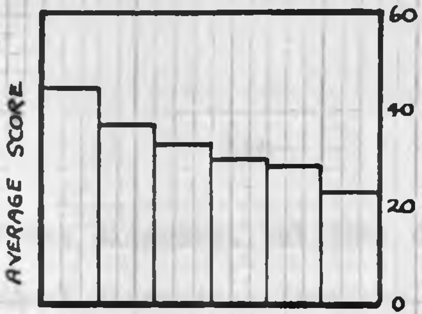
OVERALL ANALYSIS OF SCIENCE OBJECTIVE EXAMINATIONS

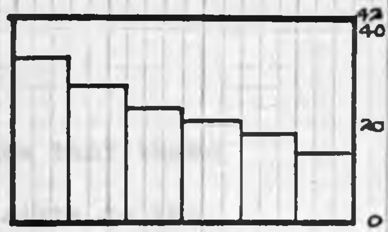
ORIGINAL EXAMINATION — REVISED EXAMINATION

TEST 28CHOB

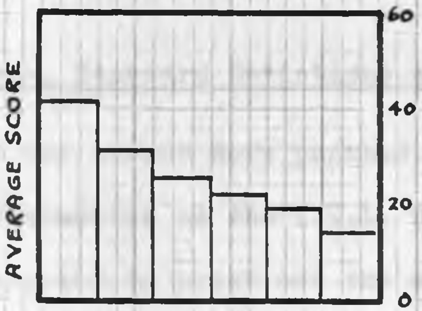
CHEMISTRY OBJECTIVE

(i) AVERAGE SCORE CALCULATED FROM TOTAL NUMBER CORRECTLY ANSWERED (R)





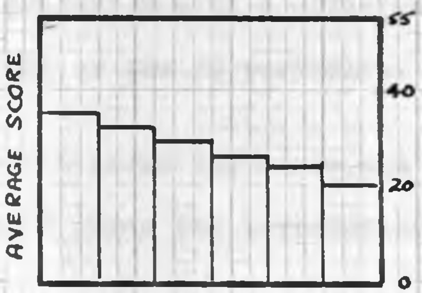
(ii) AVERAGE SCORE CALCULATED FROM FORMULA FOR CORRECTION OF GUESSING (S)



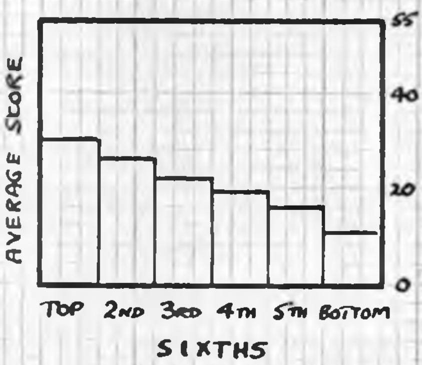
TEST 29PHOB

PHYSICS OBJECTIVE

(i) AVERAGE SCORE CALCULATED FROM TOTAL NUMBER CORRECTLY ANSWERED (R)



(ii) AVERAGE SCORE CALCULATED FROM FORMULA FOR CORRECTION OF GUESSING (S)



shape of the diagrams, but they do show that there is a gradual diminution from the top sixth to the bottom sixth in the average scores.

(d) Means, Standard Deviations and Correlation Matrix

The raw scores were punched on to cards and the 1500 IBM computor at the I.C.L. Building in Nairobi was instructed to print out the means and standard deviations for each of the 29 variables (tests) and the product-moment coefficients of correlation between all of the 29 variables.

Table 6 gives the means and standard deviations and Table 7 shows the correlation matrix.

Table 6

NAMES OF TESTS, MEANS AND STANDARD DEVIATIONS OF TESTS

Reference	Name	Mean	S.D.
01ADDT	ADDITION	42.7	11.7
02MULT	MULTIPLICATION	47.1	9.7
03AREA	ARITHMETICAL REASONING	64.9	10.1
04AROP	NECESSARY ARITHMETIC OPERATIONS	16.2	3.9
05LENO	LETTERS AND NUMBERS	23.7	5.2
06LEST	LETTER SETS	27.5	9.6
07SEEP	SEEING PROBLEMS	28.2	8.5
08FLGS	FLAGS	5.1	2.0
09CRDS	CARDS	21.6	11.7
10FIGS	FIGURES	5.1	1.8
11PERW	PERCEPTUAL WORDS	51.7	11.6
12PERN	PERCEPTUAL NUMBERS	36.5	6.1
13OBMR	OBJECT-NUMBER MEMORY	18.6	5.9
14PCMR	PICTURE MEMORY	14.8	2.4
15OTIS	GENERAL INTELLIGENCE	56.9	6.5
16EXPR	EXPRESSION AND COMPREHENSION	13.3	3.9
17COMP	COMPREHENSION	11.1	2.6
18ESSY	ESSAY	19.7	3.6
19SENT	SENTENCE STRUCTURE	14.8	3.4
20VOCB	VOCABULARY	31.2	6.1
21LETT	FIRST LETTERS	50.1	11.1
22PRFX	PREFIXES	26.0	5.6
23SUFX	SUFFIXES	21.8	5.0
24THME	THEME	22.7	6.0
25CATG	CATEGORIES	22.6	6.1
26CHCN	CHEMISTRY CONVENTIONAL	52.5	15.1
27PHCN	PHYSICS CONVENTIONAL	39.3	10.5
28CHOB	CHEMISTRY OBJECTIVE	17.9	8.4
29PHOB	PHYSICS OBJECTIVE	12.6	6.1

TABLE 7

TEST	01	02	03
01ADDT	-	62	30
02MULT	62	-	38
03AREA	30	38	-
04AROP	26	31	45
05LENO	11	20	46
06LEST	03	23	51
07SEEP	-04	03	30
08FLGS	00	10	19
09CRDS	04	16	29
10FIGS	09	15	25
11PERW	24	35	26
12PERN	39	44	27
13OBMR	25	25	18
14PCMR	11	14	13
15OTIS	-01	10	47
16EXPR	07	12	15
17COMP	-07	13	25
18ESSY	24	21	24
19SENT	-09	-16	25
20VOCB	-01	09	11
21LETT	08	10	08
22PRFX	27	17	15
23SUFX	17	16	08
24THME	12	06	06
25CATG	-07	-03	23
26CHCN	17	35	48
27PHCN	10	30	29
28CHOB	04	19	52
29PHOB	-07	02	41

04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
26	11	03	-04	00	04	09	24	39	25	11	-01	07	-07	24	-09	-01	08	27	17	12	-07	17	10	04	-07
31	20	23	03	10	16	15	35	44	25	14	10	12	13	21	-16	09	10	17	16	06	-03	35	30	19	02
45	46	51	30	19	29	25	26	27	18	13	47	15	25	24	25	11	08	15	08	06	23	48	29	52	41
-	38	35	27	20	26	09	33	25	13	-02	40	02	31	10	24	17	06	03	10	19	10	43	36	36	19
38	-	59	32	32	38	28	31	27	14	18	53	28	17	26	14	-08	11	-11	-07	11	18	40	29	52	35
35	59	-	23	19	27	11	24	17	03	18	51	13	20	22	20	10	14	-01	15	15	32	40	35	50	38
27	32	23	-	07	15	04	36	18	-01	10	35	11	22	12	34	12	20	06	12	40	39	28	07	29	27
20	32	19	07	-	64	58	12	11	12	01	18	15	25	09	06	-02	05	-29	00	-03	01	18	21	26	29
26	38	27	15	64	-	60	18	16	28	08	28	16	26	21	17	01	06	-23	-01	09	04	22	25	38	31
09	28	11	04	58	60	-	17	15	19	12	06	08	11	06	-01	-08	12	-23	04	01	05	15	34	33	27
33	31	24	36	12	18	17	-	57	24	28	25	17	22	17	21	11	12	-03	17	41	23	21	25	24	03
25	27	17	18	11	16	15	57	-	21	16	21	14	10	05	08	-04	06	-06	12	17	14	12	09	06	-05
13	14	03	-01	12	28	19	24	21	-	15	00	14	-06	22	-04	-10	14	09	04	-04	-01	02	03	03	01
-02	18	18	10	01	08	12	28	16	15	-	03	-13	-11	12	-16	-17	17	-08	05	19	10	01	06	00	08
40	53	51	35	18	28	06	25	21	00	03	-	10	44	23	26	27	14	-03	01	10	28	43	30	52	37
02	28	13	11	15	16	08	17	14	14	-13	10	-	10	24	10	-11	07	-19	-04	00	-05	05	14	25	14
31	17	20	22	25	26	11	22	10	-06	-11	44	10	-	07	32	29	15	-03	-03	05	14	24	22	35	28
10	26	22	12	09	21	06	17	05	22	12	23	24	07	-	10	10	18	03	09	08	04	26	15	32	17
24	14	20	34	06	17	-01	21	08	-04	-16	26	10	32	10	-	00	04	-04	06	24	18	23	07	35	35
17	-08	10	12	-02	01	-08	11	-04	-10	-17	27	-11	29	10	00	-	10	10	23	08	15	28	13	17	11
06	11	14	20	05	06	12	12	06	14	17	14	07	15	18	04	10	-	32	35	08	17	06	15	12	19
03	-11	-01	06	-29	-23	-23	-03	-06	09	-08	-03	-19	-03	03	-04	10	32	-	31	-04	11	07	13	-03	01
10	-07	15	12	00	-01	04	17	12	04	05	01	-04	-03	09	06	23	35	31	-	13	04	14	13	-01	00
19	11	15	40	-03	09	01	41	17	-04	19	10	00	05	08	24	08	08	-04	13	-	32	08	-10	15	09
10	18	32	39	01	04	05	23	14	-01	10	28	-05	14	04	18	15	17	11	04	32	-	08	06	21	34
43	40	40	28	18	22	15	21	12	02	01	43	05	24	26	23	28	06	07	14	08	08	-	37	70	44
36	29	35	07	21	25	34	25	09	03	06	30	14	22	15	07	13	15	13	13	-10	06	37	-	46	29
36	52	50	29	26	38	33	24	06	03	00	52	25	35	32	35	17	12	-03	-01	15	21	70	46	-	63
19	35	38	27	29	31	27	03	-05	01	08	37	14	28	17	35	11	19	01	00	09	34	44	29	63	-

(e) Reliabilities

There are various methods for finding the reliabilities of tests, (i) test re-test, (ii) alternate or parallel forms, (iii) split-half technique (iv) rational equivalence.

It was not possible to re-test the subjects or to set parallel test, so the method of rational equivalence was chosen to find reliabilities where the form of the test made possible this method, e.g. for objective tests in which the answers score either 1 or 0. The formula used to estimate reliabilities was that derived by Richardson and Kuder, Formular 20, which is given by Garrett (1966) as

$$r_{11} = \frac{n\sigma_t^2 - M\,(n-M)}{\sigma_t^2\,(n-1)}$$

in which

r_{11} = reliability of the whole test

n = number of items in test

σ_t = standard deviation of the test scores

M = mean of the test scores.

Rational equivalence formulae tend to underestimate the reliability coefficients as found by the other methods, so these are **minima** of reliability (Garrett, 1966). This formula assumes that all the items of the test are of equal difficulty, but in fact this formula provides a good index of reliability even when this assumption is not satisfied.

Test		Reliability
01ADDT	Addition	0.88
02MULT	Multiplication	0.84
03AREA	Arithmetical Reasoning	0.78
04AROP	Necessary Arithmetic Operations	0.51
05LENO	Letters and Numbers	0.64
06LEST	Letter Sets	0.68
09CRDS	Cards	0.91
13OBMR	Object-Number Memory	0.80
14PCMR	Picture Memory	0.33
15OTIS	General Intelligence	0.68
20VOCB	Vocabulary	0.68
28CHOB	Chemistry Objective	0.88
29PHOB	Physics Objective	0.82

CHAPTER 5

ANALYSIS OF THE RESULTS

(a) Comments on the science examinations with special reference to the correlation matrix

The abilities required for science examinations are discussed with particular reference to their correlations with the tests selected to measure these abilities.

Garrett (1966) states that for 92 observations (i.e. 92 subjects) the correlation coefficients must be at least 0.267 to be significant at the 1% level, and at least 0.205 to be significant at the 5% level. In the discussion which follows, correlation coefficients of 0.27 or greater will be regarded as significant at the **1% level** and are underlined, and correlation coefficients from 0.21 to 0.27 will be regarded as significant at the 5% level.

Number ability

Exams Tests	Chemistry Conv.	 Obj.	Physics Conv.	 Obj.
Addition	17	04	10	-07
Multiplication	35	19	30	02

It can be seen that only the correlations between the Multiplication test and the conventional science examinations are significant. It would be expected that the Addition test would have similar correlations because both tests have similar loadings on the number ability. That it is not so may be explained by the fact that the Multiplication test has higher correlations with the reasoning, induction and perceptual tests, indicating that the correlations with the conventional examinations are perhaps due to these other abilities rather than a pure number ability. This result does give support to Vernon's view (1961) that the number ability is linked to the scientific-methematical abilities, particulary in the conventional examinations, but the low correlations of the Addition test with science examinations agree with Lewis (1964, 1967), who found that achievement in science was almost independent of the number ability.

General Reasoning ability

Tests \ Exams	Chemistry		Physics	
	Conv.	Obj.	Conv.	Obj.
Arithmetical Reasoning	48	52	29	41
Necessary Operations	43	36	36	19

All the correlations are significant at the 1% level, except for that between the Necessary Arithmetic Operations test and Physics objective examination. The correlation between the two reasoning tests is .45 which is fairly high considering that one test requires number computation and the other requires only the selection of the correct method for solving an arithmetical problem.

The correlations show that the reasoning ability is necessary for all the science examinations, perhaps to a greater extent in Chemistry than in Physics. Berridge (1948), Chary (1948), Angus (1949) and James (1950) have all shown that the reasoning abilities play a large part in scientific achievement.

Tests \ Exams	Chemistry Conv.	Chemistry Obj.	Physics Conv.	Physics Obj.
Seeing Problems	28	29	07	27

The correlations are just significant at the 1% level except for that with the Physics conventional examination. The Seeing Problems test has highest correlations with the Theme and Categories tests, 0.40 and 0.39 respectively. This indicates that the Seeing Problems test requires ideational abilities. The Seeing Problems test has significant correlations with both reasoning tests. The correlations show that the Chemistry and the Physics objective examinations have a dependence on this test, suggesting that the abilities required for seeing problems are related to achievement in science, particularly in the objective examinations.

Induction ability

Tests \ Exams	Chemistry Conv.	Chemistry Obj.	Physics Conv.	Physics Obj,
Letters and Numbers	40	52	29	35
Letter Sets	40	50	35	38

All the correlations are significant at the 1% level showing that the induction ability is required in all science examinations as measured by the Letters and Numbers and Letter Sets tests. There is a slight increase in the correlation from conventional to objective, suggesting that the ability is more relevant in the objective examinations. The ability to find the rule or principle is more apparent in the objective paper, presumably because the subjects are required to eliminate alternatives, which is similar to the operatinns in the Induction tests. This confirms the work of Vernon (1961), Butt (1957) and Young (1948) who all suggested that induction was related to success in science courses. Up to the present time no clear induction factor has been isolated from investigations into science ability. This ability is probably absorbed by the reasoning and general factors and this can be appreciated from the inter-correlations between the tests of induction and the tests of reasoning and intelligence abilities.

Tests	03AREA	04AROP	15OTIS
Letters and Numbers	46	38	53
Letter Sets	51	35	51

All of these correlations are highly significant, showing that the abilities measured do overlap.

Spatial Ability

Exams / Tests	Chemistry Conv.	Chemistry Obj.	Physics Conv.	Physics Obj.
Flags	18	26	21	29
Cards	22	38	25	31
Figures	15	33	34	27

The spatial ability seems to be a fairly independent ability having low correlations with other ability tests. The only test to have a correlation of over .30 is the Letters and Numbers test of induction. This indicates that spatial tests require the same kind of ability to find the rule or principle in the configuration of the flags, cards and figures.

The objective science examinations all have correlations significant at the 1% level except for that between the Flags test and the Chemistry Objective, which just misses this significance level.

This indicates that the spatial ability is associated more with the objective examinations and only slightly with the conventional. Chemistry and Physics objective examinations have similar spatial content, but the Physics conventional examination is more highly correlated with the spatial tests, having two correlations significant at the 5% level and one at the 1% level. This agrees with the findings of previous investigations by Berridge (1948), Jog (1955), Lewis (1964) and Smith (1967) all of whom found spatial factors in Chemistry or Physics.

Perceptual ability

Exams / Tests	Chemistry		Physics	
	Conv.	Obj.	Conv.	Obj.
Perceptual words	21	24	25	03
Perceptual numbers	12	06	09	-05

None of these correlations is significant at the 1% level, although the perceptual words test has three correlations significant at the 5% level with the science examinations.

The perceptual ability, to appreciate the accuracy of letters and numbers at speed, does not seem to be particularly linked with success on science examinations, although the correlations with the Perceptual Words test does indicate that this ability may be slightly connected with success in the conventional examinations. It is interesting to note that the highest correlation of the Perceptual Words test is 0.41 with the Theme test, and this may indicate an ability to write words in a meaningful situation at speed, hence the link with the conventional examination.

The Perceptual Numbers test has correlations with of .39 and .44 with the Addition and Multiplication tests respectively, and as the number ability had only low correlations with the science examinations, the low correlations of the Perceptual numbers test would be expected as Denton and Taylor (1955) found that the number and perceptual factors were associated.

<u>Memory ability</u>

Tests \ Exams	Chemistry Conv.	Chemistry Obj.	Physics Conv.	Physics Obj.
Object-Number	02	03	03	01
Picture	01	00	06	08

The correlations are all nearly zero, indicating that this kind of 'intermediate' memory is not relevant to success in science examinations.

Small memory factors have been found in a number of previous investigations into scientific abilities, e.g. Berridge (1948) who found a small memory factor in Physics, Chary (1948) who found that Chemistry was more associated with memory than Physics, but Guildford (1967) states that there are numerous memory abilities. In fact the inter-correlation between the two memory tests is as low as 0.15 suggesting that these two types of memory are very different. If there is a memory ability relevant to science, it is probably the long-term type which requires associative recall, rather than the meaningless memory as in the Object-Number test and visual picture memory required in the Picture test.

General intelligence

Test \ Exams	Chemistry Conv.	Chemistry Obj.	Physics Conv.	Physics Obj.
General Intelligence	43	52	30	37

This test has fairly high correlations with all the science examinations and particularly with the Chemistry. The objective examinations are more highly correlated with the Otis test, showing that general and verbal reasoning abilities are an important part of this type of examination. The Otis test has high correlations with other ability tests, particularly with the tests of general reasoning and induction. It seems that general intelligence is an important factor in achievement in science, as was claimed by Angus (1949).

Verbal comprehension ability

Tests \ Exams	Chemistry Conv.	Chemistry Obj.	Physics Conv.	Physics Obj.
Expression	05	25	14	14
Comprehension	24	<u>35</u>	22	<u>28</u>
Essay	26	<u>32</u>	15	17
Sentence Structure	23	<u>35</u>	07	<u>35</u>
Vocabulary	<u>28</u>	17	13	11

The correlations of the verbal comprehension tests are generally higher with the objective examinations than with the conventional. It has been generally assumed by the critics of the essay-type questions that these questions depend too much on verbal ability and writing facility, but these tests do not support this view, for it is the objective examinations which correlate more highly with the comprehension, the essay and sentence structure tests.

There is a possibility that the higher correlations between the science objective examinations and the Comprehension test may be due to the objective multiple-choice form of question in the Comprehension test (Vernon, 1956), but this cannot explain the high correlations with the Essay and Sentence Structure tests which require the subjects to express themselves in writing.

The only correlation significant at the 1% level for the conventional tests is between the Chemistry conventional examination and the Vocabulary test. As this Vocabulary test is regarded as a reliable measure of verbal ability, Thurstone, (1938a) Zimmerman (1953), a reasonable importance should be attached to this correlation, which suggests that verbal ability is related particularly to the Chemistry conventional examination.

<u>Word fluency ability</u>

Tests \ Exams	Chemistry		Physics	
	Conv.	Obj.	Conv.	Obj.
First Letters	06	12	15	19
Prefixes	07	-03	13	01
Suffixes	14	-01	13	00

As there are no significant correlations with the word fluency tests, it seems that the ability to produce words with little or no reference to their meaning is not associated with science achievement.

The word fluency ability is generally independent of other abilities showing negative correlations with many tests and particularly with the spatial tests.

Ideational fluency ability

Tests \ Exams	Chemistry Conv.	Chemistry Obj.	Physics Conv.	Physics Obj.
Theme	08	15	-10	09
Categories	08	21	06	34

The only correlation significant at the 1% level is that between the Categories test and Physics Objective examination, although that with the Chemistry objective is significant at the 5% level. This suggests that the ability to classify and to relate ideas is more evident in the objective than the conventional examinations.

Science examinations

Exams \ Exams	Chemistry Conv.	Chemistry Obj.	Physics Conv.	Physics Obj.
Chemistry conventional	-	70	37	44
Chemistry objective	70	-	46	63
Physics conventional	37	46	-	29
Physics objective	44	63	29	-

As would be expected, all the correlations are significant at the 1% level, the highest correlation being between the Chemistry conventional and objective examinations, and the lowest between the Physics conventional and objective examinations. The Chemistry and Physics objective examinations are more highly correlated than the two conventional examinations.

The abilities required for the various examinations are obviously different and an attempt to discover the abilities are required for success in the science examination will be made in the section (b).

(b) <u>Significance of difference between means after grouping on the science score</u>

The aim of the research is to test the hypothesis that objective examinations test a wider range of abilities than conventional examinations. It seemed particularly relevant to attempt to find out what caused some students to do well in conventional examinations and poorly in objective examinations and vice versa. If two science examinations are reliable, one would expect that most candidates would do either well or poorly at both types of examinations, but in practice many students do well at one type and poorly in the other. Is it possible to relate these performances with performances in the ability tests, i.e. is it possible to find that if one group of students is better in conventional examinations it is also better at reasoning tests, for example, or those better at objective examinations are also better in spatial tests?

The subjects were divided into four groups based on the scores in the Chemistry examinations, in the following manner:

<u>Group A</u> - subjects with high conventional marks/high objective marks

<u>Group B</u> - subjects with high conventional marks/low objective marks

<u>Group C</u> - subjects with low conventional marks/high objective marks

<u>Group D</u> - subjects with low conventional marks/low objective marks.

The means of the scores on all the tests were calculated for each group and the difference between the means of Groups B and C and of Groups A and D was tested for significance. The same procedure was carried out with Groups based on scores in the Physics examinations.

Statistics

According to the Null Hypothesis (Garrett, 1966) there will be no significant difference between two means unless they differ from each other by a certain amount, which is determined by finding the Critical Ratio, CR, which is equal to the difference between the means, D, divided by its standard error, σ_D;

$CR = \frac{D}{\sigma_D}$. For large samples, if the CR is $\pm$ 1.96 or larger, the null hypothesis is rejected at the .05 level on the grounds that not more than once in 20 repetitions of the same experiment would a difference as large as, or larger than, that found arise - if the true difference were zero. If the CR = $\pm$ 2.58, or larger, the null hypothesis can be rejected at the .01 level.

When the N's of two independent samples are small (less than 30), the fraction $\frac{D}{SE_D}$ is equal to t, whose significance can be tested in a similar way, using the Table of t (Garrett, 1966, p.461). The standard error of difference (SE_D) is calculated for both samples combined.

The standard deviation (SD) when the two small independent samples are pooled $= \sqrt{\frac{\Sigma(X_1 - M_1)^2 + \Sigma(X_2 - M_2)^2}{(N_1 - 1)+(N_2 - 1)}}$

and the standard error of difference $SE_D = SD\sqrt{\frac{N_1+N_2}{N_1 N_2}}$

and $t = \frac{(M_1 - M_2) - 0}{SE_D}$

in which X_1 and X_2 are the scores in the two samples

M_1 and M_2 are the means of the two samples

N_1 and N_2 are the numbers in the two samples

It was decided that if the null hypothesis could be rejected at least at the .10 level, the levels of significance would be recorded, although it was thought that the .05 level would be needed to be really significant in this experiment.

Tables 8 and 10 give the means of the four groups for Chemistry and Physics, and Tables 9 and 11 give the standard error of difference SE_D, the t value, and level of significance for the test with means reaching the required level of difference.

<u>Chemistry grouping</u>

The subjects were divided into four groups according to their scores on the two examinations in Chemistry.

<u>Group A</u> consisted of 31 students, who scored 53 marks or more in the conventional examination and 18 marks or more in the objective examination. The means of the two examinations were 52.5 and 17.9 and it was found that these scores represented the median, dividing the top half of the students from the bottom half.

<u>Group B</u> consisted of 15 students, who came in the top half (scored 53 or more) in the conventional examination, but who came in the bottom half (score less than 18) in the objective examination.

<u>Group C</u> consisted of 9 students who came in the bottom half of the conventional, but who came in the top half of the objective examination.

Group D consisted of 39 students who came in the bottom half in both Chemistry examinations.

Group B and C are small owing to the high correlation of .70 between the two examinations.

TABLE 8 Means after grouping on Chemistry scores

TEST	GROUP A	GROUP B	GROUP C	GROUP D
01ADDT	44.1	41.9	40.9	42.3
02MULT	49.8	48.1	43.4	45.6
03AREA	70.1	62.3	71.7	60.4
04AROP	17.7	15.9	17.3	14.9
05LENO	26.8	20.9	25.1	22.1
06LEST	32.8	24.8	30.0	24.1
07SEEP	30.6	27.1	27.2	27.0
08FLGS	5.7	4.7	5.8	4.7
09CRDS	25.9	17.9	26.8	18.5
10FIGS	5.8	4.5	5.6	4.7
11PERW	54.6	50.5	49.3	50.1
12PERN	37.0	35.5	37.3	36.2
13OBMR	18.8	18.2	19.9	18.3
14PCMR	14.7	14.8	13.8	15.0
15OTIS	59.9	56.3	57.6	54.5
16EXPR	14.5	11.7	13.9	13.0
17COMP	11.7	11.4	10.9	10.5
18ESSY	21.1	18.3	18.7	19.5
19SENT	15.9	14.0	16.2	13.8
20VOCB	31.9	34.7	30.0	29.6
21LETT	51.2	51.1	45.6	49.5
22PRFX	26.2	26.3	27.7	25.4
23SUFX	21.8	24.4	19.7	21.1
24THME	23.3	22.4	22.8	22.4
25CATG	23.3	22.6	24.2	20.1
26CHCN	66.8	60.8	48.1	39.1
27PHCN	45.7	36.7	39.1	35.4
28CHOB	26.9	14.7	22.1	10.9
29PHOB	16.5	11.3	17.3	9.0

TABLE 9 Significance of difference between means CHEMISTRY

Table of t, (Garrett, 1966).

Where no value for SE_D has been given, the mean difference is not significant.

	Groups B and C			Groups A and D		
Test	SE_D	t	sig.level	SE_D	t	sig.level
01ADDT			-			-
02MULT			-	2.32	1.81	0.10
03AREA	3.81	2.47	0.05	2.17	4.47	0.01
04AROP			-	0.93	3.03	0.01
05LENO	1.59	2.64	0.02	1.20	3.90	0.01
06LEST			-	2.18	3.99	0.01
07SEEP			-	2.17	1.67	0.10
08FLGS			-	0.47	2.15	0.05
09CRDS	4.35	2.05	0.10	2.72	2.73	0.01
10FIGS			-	0.40	2.76	0.01
11PERW			-			-
12PERN			-			-
13OBMR			-			-
14PCMR			-			-
15OTIS			-	1.54	3.50	0.01
16EXPR			-	0.77	1.94	0.10
17COMP			-	0.65	1.92	0.10
18ESSY			-	0.89	1.79	0.10
19SENT			-	0.79	2.66	0.01
20VOCB	2.13	2,21	0.05			-
21LETT			-			-
22PRFX			-			-
23SUFX	1.94	2.43	0.05			-
24THME			-			-
25CATG			-	1.34	2.39	0.02
26CHCN	3.16	4.02	0.01	2.17	12.8	0.01
27PHCN			-	2.45	4.20	0.01
28CHOB	1.37	5.42	0.01	1.18	13.5	0.01
29PHOB	1.84	3.26	0.01	1.27	5.91	0.01

<u>Significance of difference between means of Groups B and C</u>

It would be expected that there would be a significance of difference between the means of Groups B and C in the tests of mental abilities which contribute more to achievement in the conventional examination than the objective examination, or vice versa.

The means of Group C are significantly better than the means in Group B in the following tests:-

		Level of significance
03AREA	Arithmetical reasoning	0.05
05LENO	Letters and Numbers	0.02
09CRDS	Cards	0.10
28CHOB	Chemistry objective	0.01
29PHOB	Physics objective	0.01

These results indicate that those subjects who do better at the objective examination in Chemistry, do better at the Physics Objective, Arithmetical Reasoning, Letters and Numbers and Cards tests. This suggests that the reasoning, induction and spatial abilities are required more for the objective examination than for the conventional.

The means of Group B are significantly better than the means of Group C in the following tests:

		Level of significance
20VOCB	Vocabulary	0.05
23SUFX	Suffixes	0.05
26CHCN	Chemistry conventional	0.01

Those subjects who do better in the conventional Chemistry examination also do better at the Vocabulary and Suffixes test, suggesting that the verbal and word fluency abilities are more associated with success in the essay-type paper.

It is interesting to note that there is no significance of difference between the means of any of the tests which measure number, perceptual, memory, or ideational abilities. These do not seem to be required for one particular type of examination.

<u>Significance of difference between means of Groups A and D</u>

Although the significance of difference between the means of Groups A and D would give no information about the different abilities required for conventional and objective examinations, it was thought that it might give some information about the abilities required for success in Chemistry examinations.

The means of Group A are significantly better than the means of Group D in the following tests:

<u>Significance level of .01</u>

03AREA	Arithmetical reasoning
04AROP	Necessary Operations
05LENO	Letters and Numbers
06LEST	Letter Sets
09CRDS	Cards
10FIGS	Figures
15OTIS	General intelligence
19SENT	Sentence Structure
26CHCN	Chemistry conventional
27PHCN	Physics conventional
28CHOB	Chemistry objective
29PHOB	Physics objective

<u>Significance level of 0.02</u>

25CATG	Categories

<u>Significance level of 0.05</u>

08FLGS	Flags

<u>Significance level of 0.10</u>

02MULT	Multiplication
07SEEP	Seeing Problems
16EXPR	Expression
17COMP	Comprehension
18ESSY	Essay

What is of interest is not the tests which are represented above, but those tests with difference of means which are not significant. It would be expected that the best students in science would be significantly better at ability tests than the poor students in science, but this is not the case in any of the tests for perceptual, memory, or word fluency abilities. Also the tests for verbal comprehension and number abilities are only represented at the 0.10 level of significance. Therefore it can be seen that the poorest students in Chemistry are just as good as the best students in some of the ability tests, and this suggests that success in science does not depend on these abilities.

Success in Chemistry must therefore be related to the abilities in general reasoning, induction, spatial, verbal reasoning and ideational fluency, and students who have these abilities are also good in Chemistry examinations.

Physics grouping

The students were divided into four groups according to their scores on the Physics examinations:

<u>Group A</u> consisted of 24 students who scored 40 marks or more on the conventional examination and 13 marks or more on the objective examination. The means for these two examinations were 39.3 and 12.9 respectively and were found to divide the students into approximately equal halves.

<u>Group B</u> consisted of 20 students, who came in the top half on the conventional but in the bottom half on the objective examination.

<u>Group C</u> consisted of 22 students who came in the bottom half on the conventional, but in the top half on the objective examination.

<u>Group D</u> consisted of 28 students who came in the bottom half on both examinations.

TABLE 10 Means after grouping on Physics scores

TEST	GROUP A	GROUP B	GROUP C	GROUP D
01ADDT	42.7	46.8	42.0	40.5
02MULT	49.2	51.2	45.7	43.4
03AREA	70.5	65.1	66.1	58.9
04AROP	17.7	18.0	15.9	14.0
05LENO	25.9	23.8	24.4	21.6
06LEST	32.0	28.5	29.9	21.2
07SEEP	28.0	26.6	32.2	26.4
08FLGS	5.8	5.2	5.4	4.5
09CRDS	23.4	23.1	23.0	17.6
10FIGS	5.8	5.2	4.9	4.7
11PERW	51.7	54.1	51.7	49.8
12PERN	35.6	38.3	37.0	35.5
13OBMR	18.2	18.9	18.7	18.8
14PCMR	14.5	15.3	15.4	14.1
15OTIS	60.4	57.2	56.7	54.1
16EXPR	14.0	13.0	14.0	12.5
17COMP	11.4	11.9	11.4	10.1
18ESSY	19.8	20.9	20.5	18.3
19SENT	15.1	14.1	16.4	13.8
20VOCB	31.2	32.6	31.7	30.1
21LETT	51.8	49.0	51.6	47.8
22PRFX	27.5	26.0	25.8	24.9
23SUFX	21.8	21.4	22.8	21.3
24THME	21.6	22.4	24.8	22.3
25CATG	23.8	20.2	24.8	21.6
26CHCN	57.3	53.9	60.2	41.5
27PHCN	50.0	45.8	33.6	30.2
28CHOB	22.5	17.7	21.0	11.6
29PHOB	17.8	8.7	17.8	7.1

TABLE 11 Significance of difference between means
Physics

Table of t, (Garrett, 1966).

Where no value for SE_D has been given, the mean difference is not significant.

	Groups B and C			Groups A and D		
	SE_D	t	sig.level	SE_D	t	sig.level
01ADDT			-			-
02MULT	3.16	1.74	0.10	2.41	2.40	0.02
03AREA			-	2.39	4.86	0.01
04AROP	1.11	1.90	0.10	0.98	3.78	0.01
05LENC			-	1.25	3.45	0.01
06LEST			-	2.33	4.65	0.01
07SEEP	2.77	2.02	0.05			-
08FLGS			-	0.62	2.07	0.05
09CRDS			-	3.36	1.73	0.10
10FIGS			-	0.49	2.27	0.05
11PERW			-			-
12PERN			-			-
13OBMR			-			-
14PCMR			-			-
15OTIS			-	1.67	3.78	0.01
16EXPR			-			-
17COMP			-	0.76	1.72	0.10
18ESSY			-			-
19SENT	1.08	2.18	0.05			-
20VOCB			-			-
21LETT			-			-
22PRFX			-	1.54	1.69	0.10
23SUFX			-			-
24THME			-			-
25CATG	1.82	2.44	0.02			-
26CHCN			-	3.88	4.07	0.01
27PHCN	1.38	8.83	0.01	2.00	9.90	0.01
28CHOB			-	1.76	6.18	0.01
29PHOB	1.16	7.86	0.01	0.89	13.9	0.01

Significance of difference between means of Groups B & C

The means of Group C are significantly better than the means of Group B in the following tests:

		Level of significance
07SEEP	Seeing Problems	0.05
19SENT	Sentence Structure	0.05
25CATG	Categories	0.02
29PHOB	Physics objective	0.01

It will be noted that the mental ability tests which have significant differences of means for the Physics grouping are different from those found in the Chemistry grouping, suggesting that different abilities are required for achievement in Physics. All three tests, Seeing Problems, Sentence Structure and Categories all have something in common in that all three tests require the subject to think about a problem. This suggests that the Physics objective examination requires the students to have the ability to see and solve problems which require the production of ideas.

The means of Group B are significantly better than the means of Group C in the following tests:

		Level of significance
02MULT	Multiplication	0.10
04AROP	Necessary Operations	0.10
27PHCN	Physics conventional	0.01

The Multiplication and Necessary Arithmetic Operations tests have only low levels of significance, showing that the students who are better at the conventional Physics examination are only slightly better at the number and reasoning abilities.

There are no significant differences between means of the tests which measure the induction, spatial, perceptual memory, verbal comprehension (except Sentence Structure) or word fluency abilities, showing that differences in achievement are not due to these abilities.

Significance of difference between means of Groups A & D

As with the Chemistry results, it would be expected that the means of the ability tests for Group A would be significantly better than for Group D. This is so for the following tests:

Significance level of .01

03AREA Arithmetic reasoning

04AROP Necessary Operations

05LENO Letters and Numbers

06LEST Letter Sets

150TIS General Intelligence

26CHCN Chemistry conventional

27PHCN Physics conventional

28CHOB Chemistry objective

29PHOB Physics objective

Significance level of .02

02MULT Multiplication

Significance level of 0.05

08FLGS Flags & 10 FIGS Figures

Significance level of 0.10

09CRDS Cards

17COMP Comprehension

22PRFX Prefixes.

It is seen that the abilities which clearly distinguish the students who are good at Physics examinations from those who have poor results are abilities such as general reasoning, induction, general intelligence, spatial and number.

There are some abilities which do not seem to affect ability at science, for abilities of perception, memory and ideational fluency are not represented in the list above. Of the verbal and fluency abilities, only the Comprehension and the Prefixes tests show any significant difference of means. The lack of importance of verbal, fluency and memory abilities may be due to the fact that the original selection of the students for secondary school was based solely on their ability at English and Mathematics, which require high levels of achievement in these abilities, so that the sample is fairly homogeneous in respect to verbal and fluency abilities. This does not mean that verbal and fluency abilities are not important in achievement in science examinations, but that this particular sample showed an even distribution in these abilities.

A comparison of the tests which have means which are significantly different for Groups A and D in both Chemistry and Physics groupings show striking similarities. The tests with levels of significance of difference at the 0.05 level or better, include both tests of general reasoning, both induction tests, the Otis general intelligence test, and two of the three spatial tests. This suggests that overall achievement in Chemistry and Physics requires good abilities in general reasoning, induction and space, associated with a higher general intelligence in verbal reasoning.

The numerical, perceptual, memory, verbal comprehension, and fluency abilities may contribute to success in science, but the presence of them does not predict success.

(c) Factor Analysis

The scores of the tests and examinations were punched on to cards and the principal components were extracted according to the Statistical Analysis for Principal Components programme on the IBM computer at the Treasury in Nairobi.

Table 12 gives the values of the first ten components, which covered 70.5% of the total variance. The variance of component 10 falls below 1.0 which is less than 3% of the total variance and appears therefore not to be significant (Harman 1967). An attempt was made to analyse the first nine principal components, and it was thought accordingly that a varimax solution of seven components would cater for the psychological interpretation of the twenty nine variables.

TABLE 12 Principal Components

TEST	COMPONENTS 1	2	3	4	5	6	7	8	9	10
01ADDT	10	45	06	12	13	00	05	22	15	04
02MULT	17	40	09	18	16	-05	-07	-02	05	-01
03AREA	28	06	-03	11	10	16	-07	24	-08	12
04AROP	24	07	-06	07	24	-18	-12	17	-06	02
05LENO	27	-05	12	-08	10	29	-06	-11	-16	-04
06LEST	26	-05	-07	01	01	26	-18	-17	-12	-10
07SEEP	19	-05	-24	-30	-06	-03	10	08	01	-01
08FLGS	17	-15	37	-01	-17	-27	-04	02	02	02
09CRDS	22	-11	34	-05	-16	-20	02	08	10	17
10FIGS	16	-05	39	-01	-30	-19	-13	13	06	-11
11PERW	21	24	-03	-32	09	-18	03	-16	-03	-11
12PERN	15	31	07	-24	21	-16	-02	-04	-25	-06
13OBMR	08	25	22	-03	-14	08	24	17	-09	47
14PCMR	07	18	08	-27	-24	30	-37	-17	11	02
15OTIS	26	-14	-13	02	13	05	-07	-23	-19	24
16EXPR	11	-02	17	-04	13	14	59	-27	-13	-28
17COMP	18	-17	-09	06	09	-37	10	-13	-25	22
18ESSY	15	09	03	08	-07	25	37	-27	41	25
19SENT	15	-21	-18	-16	09	-11	33	39	01	-14
20VOCB	08	-03	-28	21	-01	-37	-08	-38	26	29
21LETT	10	12	-14	04	-53	-01	20	-16	-25	-01
22PRFX	00	24	-32	29	-23	08	06	30	-21	06
23SUFX	06	22	-20	10	-35	-22	07	-09	09	-36
24THME	11	08	-20	-44	-02	-10	00	08	41	-11
25CATG	14	-07	-26	-27	-19	08	-15	07	-16	20
26CHCN	26	-03	-10	24	13	05	-10	06	32	-10
27PHCN	21	01	05	28	-07	-04	-13	-12	-17	-37
28CHOB	30	-18	-02	14	04	14	04	05	19	-12
29PHOB	23	-25	-05	08	-20	17	01	22	08	-01

COMPONENT	1	2	3	4	5	6	7	8	9	10
VARIANCE	6.45	2.58	2.38	1.87	1.53	1.40	1.25	1.04	1.00	0.94
ACCUMULATED % OF TOTAL VARIANCE	22.3	31.2	39.4	45.8	51.1	55.9	60.2	63.8	67.3	70.5

The extraction of factors was re-worked by the Uganda Treasury Computer using the principal component method. Unity was used in the diagonal cells as a communality estimate and no extractions were repeated to adjust the communalities. The principal component matrix is typical of what is reported in Table 12. Furthermore a Varimax solution of seven factors was obtained by the computer and the Varimax Rotated Factors are given in Table 13. No further rotation of the Varimax solution was conducted as such rotation was not necessary.

The interpretation of the Varimax factors for psychological meaning was attempted taking into consideration the content of the tests and previous factorial analyses. The interpretation of the factorial loadings rests solely upon those tests of known content with positive loadings of .30 or higher, utilizing the conventional agreement among psychologists that such a loading is of significant value. If there are significant loadings of tests on other factors, these are indicated in brackets. The signs of the loadings on Factors II and VII of all tests concerned are reversed for convenience in interpretation.

TABLE 13

VARIMAX ROTATED FACTOR LOADINGS

(Decimal point omitted in body of table)

Test	Factor I	II	III	IV	V	VI	VII	Communality h^2
01 Addition	08	-75	-08	-11	20	10	15	66
02 Multiplication	27	-77	05	-13	15	03	04	72
03 Arithmetical Reasoning	69	-29	07	10	06	01	12	59
04 Necessary Arith. Op.	48	-42	09	17	-04	-29	-10	53
05 Letters and Numbers	66	-14	21	20	-19	20	24	67
06 Letter Sets	72	-06	05	21	01	15	02	60
07 Seeing Problems	28	02	00	67	12	11	09	57
08 Flags	17	-01	82	-02	-07	-09	05	71
09 Cards	26	-08	78	07	-04	-05	16	71
10 Figures	15	-07	83	-04	06	12	01	74
11 Perceptual Words	12	-55	16	58	02	-02	08	69
12 Perceptual Numbers	04	-69	13	36	-11	03	06	64
13 Object-Number Memory	-04	-34	24	-02	18	23	42	43
14 Picture Memeory	12	-14	12	26	07	71	-14	64
15 General Intelligence	68	-03	05	27	-05	-20	00	58
16 Expression and Comp.	09	-06	10	03	-13	-13	75	63
17 Comprehension	30	-02	24	21	02	-58	-04	52
18 Essay	30	-12	00	01	21	06	55	45
19 Sentence Structure	22	17	00	45	-05	-42	27	54
20 Vocabulary	19	-05	05	06	32	-51	-32	51
21 First Letters	07	06	14	19	73	08	18	63
22 Prefixes	09	-12	-39	-12	67	-01	-04	64
23 Suffixes	-04	-18	04	13	68	-10	-07	53
24 Theme	-01	-14	-02	73	03	03	-03	55
25 Categories	29	16	-03	59	17	13	-14	51
26 Chemistry Conventional	73	-19	03	-02	09	21	-01	62
27 Physics Conventional	53	-17	26	-17	21	-09	-05	47
28 Chemistry Objective	79	04	20	10	02	-17	21	75
29 Physics Objective	64	32	24	14	16	-02	13	63
Total Variance	4.65	2.68	2.56	2.47	1.90	1.70	1.51	17.47
Proportion of Total Variance (%)	16.0	9.2	8.8	8.5	6.6	5.9	5.2	60.0
Proportion of Common Variance (%)	26.5	15.3	14.6	14.1	10.8	9.4	8.6	100.0

Interpretation of Factors

I. Gen.ral Science Reasoning Achievement Factor

Reference	Test	Loading
28CHOB	Chemistry Objective	79
26CHCN	Chemistry Conventional	73
06LEST	Letter Sets	72
03AREA	Arithmetical Reasoning	69
15OTIS	General Intelligence	68
05LENO	Letters and Numbers	66
29PHOB	Physics Objective	64 (II : 32)
27PHCN	Physics Conventional	53
04AROP	Necessary Arithmetic Operations	48 (II : 42)
17COMP	Comprehension	30 (VI : 58)
18ESSY	Essay	30 (VII : 55)

The Chemistry Objective examination has the highest loading on this factor, followed by the Chemistry Conventional examination. The Physics examinations also have their primary loading on this factor. The tests which measure the abilities of general reasoning and induction have primary loadings on this factor. Such a factor may be called a General Science Reasoning Achievement Factor.

This finding fits into Vernon's (1961) diagram of "Structure of Educational Abilities", which portrays the relationship between scientific subjects with the k:m factor on one hand and the arithmetical reasoning factor on the other.

Berridge (1948) found a factor of general intelligence and reasoning in his Physics tests and Lewis (1967) identified a scholastic, including scientific achievement factor, in tests on Physics, Chemistry and Biology, although the loadings on the reasoning tests were low.

Tests 17COMP and 18ESSY have minimum loadings of .30 each on this factor. This might indicate that reasoning ability requires the ability to write an essay or comprehend a piece of literature, which is necessary to answer science questions. Muthulingham (1963) identified a verbal scientific factor in tests on Physics and Chemistry.

The objective examinations for both Physics and Chemistry have higher loadings on this factor than the conventional examinations. It appears, therefore, that responding to an objective science test, if constructed with care, would require the subject to reason, inductively and deductively, as much as, if not more than, he would when dealing with essay-type conventional examinations.

II Numerical Perceptual Factor

Reference	Test	Loading
02MULT	Multiplication	77
01ADDT	Addition	75
12PERN	Perceptual Numbers	69 (IV : 36)
11PERW	Perceptual Words	55 (IV : 58)
04AROP	Necessary Arithmetic Operations	42 (I : 48)
13OBMR	Object-Number Memory	34 (VII : 42)
29PHOB	Physics Objective	-32 (I : 64)

This factor is a mixture of numerical facility and perceptual discrimination with a small memory ability for numbers. The tests of numerical facility, Tests 01ADDT and 02MULT, head the loadings on this factor and have no secondary loadings on other factors. Furthermore, tests of perceptual speed, Tests 11PERW and 12PERN, have significant saturations on this factor; the perceptual number test has its primary loading on this factor, whereas the perceptual word test has its primary loading on Factor IV. Although El-Abd (1966) reported the existence of a numerical facility factor using an East Africa sample, the present factor is identified as a numerical-perceptual factor, presumably similar to that found by Taylor(1955).

The Perceptual Numbers test is presumably linked with the tests of numerical facility because of its number content, requiring the ability to deal with numbers at speed. The Necessary Arithmetic Operations test has a secondary loading on this factor because this test is known to have loadings on the numerical factor (Guildford, 1967). The Object-Number test for memory has a significant loading on this factor, presumably because the subject is required to memorize numbers in relation to objects. Coombs (1941) found that this type of test had loadings on the numerical as well as the memory ability.

The fact that the Physics Objective examination has a significant negative loading on this factor suggests that the numerical - perceptual facility is not apparant in the Physics Objective examination. Although one might not expect this result, it does support the findings of Lewis, (1964, 1967) who found that the numerical factor was generally not related to success in science.

III Spatial Orientation Factor

Reference	Test	Loading
10FIGS	Figures	83
08FLGS	Flags	82
09CRDS	Cards	78
22PRFX	Prefixes	-39 (V : 67)

This is a spatial orientation factor which has been reported in previous researches (e.g. Thurstone, 1938a; Vernon, 1961; EL-Abd, 1966). In order to solve the problems in the spatial tests the subject is required to identify, from a group of five or six drawings of an object shown rotated or turned over, the ones which show the object rotated but not turned over. The Prefixes test asks the subject to produce as many words as possible from the given prefix. The Prefixes test requires an activity of the mind which involves productive thinking, whereas the spatial tests require a cognitive activity. Also the content of the spatial tests is figural whereas the content of the Prefixes test is symbolic. Hence it is not unexpected that the Prefixes test has a negative loading on this factor.

IV **Verbal,Ideational, Perceptual Judgement Factor**

Reference	Test	Loading
24THME	Theme	73
07SEEP	Seeing Problems	67
25CATG	Categories	58
11PERW	Perceptual Words	58(II : 55)
19SENT	Sentence Structure	45(VI : 42)
12PERN	Perceptual Numbers	36(II : 69)

The two tests of ideational fluency served their purpose in distinguishing this factor to some extent. The Perceptual Words test has its primary loading on this factor and the Perceptual Numbers has a small loading. The Seeing Problems test, which requires the subject to think of different problems associated with common objects, has its only significant loading on this factor. Accordingly this factor has been named as verbal ideational, perceptual judgement. The common feature about the Theme, Categories, Perceptual Words, Seeing Problems tests is perhaps the ability of the person to judge a word, name an idea, a difficulty in relation to a given word, topic, or object in a limited period of time. All these tests are verbal. The Sentence Structure has its primary saturation on this factor presumably because this is a test in which the subject has to re-write sentences according to instructions, but has to keep the same idea and meaning of the sentences.

V <u>Word Fluency Factor</u>

Reference	Test	Loading
21LETT	First Letters	73
23SUFX	Suffixes	68
22PRFX	Prefixes	67 (III : - 39)
20VOCB	Vocabulary	32 (VI : 51; VII : -32)

This factor is identified as a word fluency factor. All three reference test have their primary significant loadings on it. The presence of Vocabulary on this factor does not contradict the findings of previous research (Thurstone 1938a) as the word fluency factor was originally isolated from the verbal factor as measured by the vocabulary test. Vocabulary is a test of verbal comprehension whereas the word fluency tests require verbal production.

VI Verbal Comprehension

Reference	Test	Loading
17COMP	Comprehension	58 (I : 30)
20VOCB	Vocabulary	51 (V : 32; VII : -32)
19SENT	Sentence Structure	42 (IV : 45)
14PCMR	Picture Memory	-71

This appears to be a verbal comprehension factor despite the high negative loading of the Picture Memory test. In comparing the content material involved in the verbal tests 17COMP, 20VOCB and 19SENT with the Picture Memory test, one finds that the former tests consist of words and sentences that need verbal understanding and interpretation, whereas the Picture Memory test requires the subject to memorize certain objects presented in figural form. Here again as suggested in the interpretation of Factor III, there are two different activities of mind (cognition vs memory) and two different contents of material (verbal vs non-verbal).

VII Expressional Fluency

Reference	Test	Loading
16EXPR	Expression and Comprehension	75
18ESSY	Essay	55 (I : 30)
13OBMR	Object-Number Memory	42 (II : 34)
20VOCB	Vocabulary	-32 (V : 32; VI : 51)

Expression and Comprehension and Essay tests have their highest loadings on this factor. In the former the subject is asked to write three sentences and a short paragraph in answer to questions about a given paragraph taken from a certain book. In both the Expression and Comprehension test and the Essay test the subject writes sentences in which the organization of meanings over-shadows the organization of syntactical structures. Guildford (1967) identifies sentence-construction tests with the expressional fluency ability.

The presence of the Object-Number Memory test on this factor strengthens the idea that in writing an essay, or in expressing himself, the subject has to depend on his memory to recall facts and ideas related to the topic concerned.

The Vocabulary test has a negative loading which is difficult to interpret, but which might be due to the fact that the Vocabulary test is a very selective measure of cognition of semantic units (Guildford, 1967) in which the subject has to identify meanings of given words in terms of alternative word responses.

Calgary Promax Second-Order Solution

When the programmers at the Kampala Treasury were first approached to obtain the Varimax solution from the data, they were unable to do so, as the programme was not available. The Calgary Department of Educational Psychology, Canada was approached by the Makerere Educational Psychology Department to get the writer's data factorized. However, whilst Calgary were processing the data, the Kampala Treasury Computer was able to perform the operation in co-operation with the Computer Centre at Makerere University College. Therefore, the interpretation of the Varimax Rotated Factor Loadings is based on the Kampala Treasury Computer analysis.

The Calgary Computer supplied a Varimax solution with eight factors, which appear to be similar to the Kampala solution. In addition the Calgary Computer supplied the Promax rotations which allow the calculation of two second-order factors. Table 14 gives the correlations between the Promax factors and Table 15 gives the variable loadings on the second-order factors.

It is found that the first second-order factor has significant loadings on all but six variables and this factor could be labelled as a general science scholastic intelligence factor, which is similar to Vernon's (1961) general factor g, and similar to that found by Lewis (1961, 1964). This factor has 25.4% of the total variance. Tests 20VOCB, 21LETT, 22PRFX and 23SUFX are not loaded significantly on this factor. All these tests are related to the meaning and production of words at speed and the low loadings on these tests may be due to the fact that the subjects are using a language (English) which is not their mother tongue.

The second factor seems to be a mixture of numerical facility, rote memory and word fluency with a variance of 15% of the total. Rote memory was not identified in the first-order factorial analysis but this factor seems to be associated with a memory for words and numbers. Test 19SENT, Sentence Structure, has a significant loading opposing this factor and the objective science examinations have smaller loadings opposing this factor, suggesting that the objective science examinations do not depend on the number, memory and word fluency abilities as much as the conventional examinations.

Table 14

CORRELATIONS BETWEEN PROMAX FACTORS

FACTOR	1	2	3	4	5	6	7	8
1	1.00	-.14	.35	.37	.06	.14	-.23	.25
2	-.14	1.00	-.14	-.07	-.04	.11	.14	-.18
3	.35	-.14	1.00	.23	-.13	.02	-.30	.11
4	.37	-.07	.23	1.00	-.13	.03	-.22	.19
5	.06	-.04	-.13	-.13	1.00	-.09	.05	.05
6	.14	.11	.02	.03	-.09	1.00	.11	.02
7	-.23	.14	-.30	-.22	.05	.11	1.00	-.01
8	.25	-.18	.11	.19	.05	.02	-.01	1.00

TABLE 15

SECOND-ORDER FACTORS DERIVED FROM THE PROMAX FACTORS

(Decimal points omitted from body of table)

No.	Test	Factor I	Factor II		Significant Loadings I	Significant Loadings II
01ADDT	Addition	17	-54			-54
02MULT	Multiplication	35	-55		35	-55
03AREA	Arithmetical Reasoning	58	-13		58	
04AROP	Necessary Arith. Op.	53	-04		53	
05LENO	Letters and Numbers	65	03		65	
06LEST	Letter Sets	55	-08		55	
07SEEP	Seeing Problems	50	12		50	
08FLGS	Flags	51	15		51	
09CRDS	Cards	64	09		64	
10FIGS	Figures	44	-02		44	
11PERW	Perceptual Words	61	-23		61	
12PERN	Perceptual Numbers	44	-26		44	
13OBMR	Object-Number Memory	32	-44		32	-44
14PCMR	Picture Memeory	15	-44			-44
15OTIS	General Intelligence	64	08		64	
16EXPR	Expression and Comp.	37	20		37	
17COMP	Comprehension	51	22		51	
18ESSY	Essay	42	-25		42	
19SENT	Sentence Structure	38	49		38	49
20VOCB	Vocabulary	25	-22			
21LETT	First Letters	22	-41			-41
22PRFX	Prefixes	-20	-47			-47
23SUFX	Suffixes	08	-44			-44
24THME	Theme	33	03		33	
25CATG	Categories	32	-02		32	
26CHCN	Chemistry Conventional	52	-04		52	
27PHCN	Physics Conventional	39	-16		39	
28CHOB	Chemistry Objective	67	17		67	
29PHOB	Physics Objective	48	20		48	
	Variance (%)	25.4	15.1			

CHAPTER 6

SUMMARY AND CONCLUSIONS

(a) Correlations between ability testsand science examinations

One of the main aims of this work was to discover if the objective type examinations measured a wider range of abilities than conventional examinations or vice versa. Table 16 lists the ability tests which have correlations with the science examinations, significant at the 1% and 5% level.

The memory and word fluency abilities are the only abilities which do not have at least one test with a significant correlation with a science examination. The objective examinations have more significant correlationsat the 1% level with the tests of the other eight mental abilities than do the conventional examinations. Thus it would seem that the objective type science examinations measure mental abilities better than do the conventional examinations.

Both types of examination measure well the general reasoning, induction and general intelligence abilities.

The objective examinations measure the spatial, verbal comprehension and ideational fluency abilities better.

The conventional examinations measure the number and perceptual abilities better.

These results show that both types of examination require the general reasoning and inductive abilities at this academic level. It is interesting that the objective examinations measure the verbal comprehension and ideational fluency abilities better than the conventional examinations, although the subjects do not express themselves verbally, showing that these abilities are required to understand the written material in order to select the correct alternative.

TABLE 16

Significant correlations between mental ability tests and science examinations

Ability	Test	Chemistry Conv.	Chemistry Obj.	Physics Conv.	Physics Obj.
Number	01ADDT	-	-	-	-
	02MULT	1%	-	1%	-
General Reasoning	03AREA	1%	1%	1%	1%
	04AROP	1%	1%	1%	-
	07SEEP	1%	1%	-	1%
Induction	05LENO	1%	1%	1%	1%
	06LEST	1%	1%	1%	1%
Spatial	08FLGS	-	5%	5%	1%
	09CRDS	5%	1%	5%	1%
	10FIGS	-	1%	1%	1%
Perceptual	11PERW	5%	5%	5%	-
	12PERN	-	-	-	-
Memory	13OBMR	-	-	-	-
	14PCMR	-	-	-	-
General Intelligence	15OTIS	1%	1%	1%	1%
Verbal Comprehension	16EXPR	-	5%	-	-
	17COMP	5%	1%	5%	1%
	18ESSY	5%	1%	-	-
	19SENT	5%	1%	-	1%
	20VOCB	1%	-	-	-
Word Fluency	21LETT	-	-	-	-
	22PRFX	-	-	-	-
	23SUFX	-	-	-	-
Ideational Fluency	24THME	-	-	-	-
	25CATG	-	5%	-	1%

Number of significant correlations:

Chemistry Conventional - 8 at 1% level; 5 at 5% level

Chemistry Objective - 11 at 1% level; 4 at 5% level

Physics Conventional - 7 at 1% level; 4 at 5% level

Physics Objective - 11 at 1% level.

(b) <u>Comparison of abilities required for success in objective and conventional science examinations</u>

This work set out to discover if different abilities are needed for success in conventional and objective science examinations. Table 17 gives a summary of the tests which, after grouping the subjects according to their scores in science, had means which showed significant differences at the 0.01, 0.02, 0.05 and 0.10 levels.

There are surprisingly few tests which have means which are significantly different. This suggests that students at this level of academic achievement are generally equally proficient at both types of examinations.

Students who are better at the conventional examinations than they are at the objective examinations show particular ability in one of the tests designed to measure verbal, word fluency, number and general reasoning abilities. The general reasoning test, O4AROP Necessary Arithmetic Operations, may be based to a large extent on numerical and verbal reasoning abilities.

Students who are better at the objective examinations than they are at conventional examinations show particular ability in at least one of the tests designed to measure general reasoning, induction, spatial ability, verbal comprehension and ideational fluency.

TABLE 17

Significance of difference between means

Conventional vs Objective examinations

(1) - mean of Group B significantly better than mean of Group C

(2) - mean of Group C significantly better than mean of Group B

(Groups B and C refer to science groups as on p. 129 and 140)

Ability	Test	Chemistry (1)	Chemistry (2)	Physics (1)	Physics (2)
Number	01ADDT	-	-	-	-
	02MULT	-	-	0.10	-
General Reasoning	03AREA	-	0.05	-	-
	04AROP	-	-	0.10	-
	07SEEP	-	-	-	0.05
Induction	05LENO	-	0.02	-	-
	06LEST	-	-	-	-
Spatial	08FLGS	-	-	-	-
	09CRDS	-	0.10	-	-
	10FIGS	-	-	-	-
Perceptual	11PERW	-	-	-	-
	12PERN	-	-	-	-
Memory	13OBMR	-	-	-	-
	14PCMR	-	-	-	-
General Intelligence	15OTIS	-	-	-	-
Verbal Comprehension	16EXPR	-	-	-	-
	17COMP	-	-	-	-
	18ESSY	-	-	-	-
	19SENT	-	-	-	0.05
	20VOCB	0.05	-	-	-
Word Fluency	21LETT	-	-	-	-
	22PRFX	-	-	-	-
	23SUFX	0.05	-	-	-
Ideational Fluency	24THME	-	-	-	-
	25CATG	-	-	-	0.02
Science	26CHCN	0.01	-	-	-
	28CHOB	-	0.01	-	-
	27PHCN	-	-	0.01	-
	29PHOB	-	0.01	-	0.01

(c) <u>Abilities required for achievement in Chemistry and Physics</u>

Those students who are good at both types of science examination would be expected to have significantly better scores in the mental ability tests than those students who are relatively poor at both types of examination. Table 18 indicates that this is not so, suggesting that achievement in science at this academic level depends on certain abilities.

Both top and bottom groups in science have similar abilities in the perceptual and memory abilities, showing no significant differences between the means for these tests. Only one test for word fluency and one for ideational fluency show significant differences between means. Tests for verbal comprehension and number abilities have means which show only low significant differences for these science groupings.

It can therefore be concluded that the abilities of number, perceptual, memory, verbal comprehension, word fluency and ideational fluency are all fairly much the same for those students with good science achievement and those with poor science achievement.

This does not infer that these abilities are not required for science achievement, for science examinations require verbal expression, numerical calculation and recall capabilities, but it does indicate that the presence of these abilities does not necessarily lead to science achievement.

The fact that the verbal, numerical and memory abilities are apparantly very similar for all students may be due to the type of primary school education which concentrates on the verbal and numerical aspects of education, encouraging rote memory,so that the student may do well in the Certificate of Primary Education. The sample had received this type of education, therefore all the subjects would have achieved high standards in these abilities to be selected for secondary education.

The students, who were good at both kinds of examination, were significantly better in the tests designed to measure the general reasoning, induction, spatial and general intelligence abilities, so it can be concluded that it is the presence of these abilities which affects scientific achievement. These are the abilities which were not particularly encouraged by the kind of primary school education which the subjects received before coming to Alliance High School.

TABLE 18

Significance of difference between means

Good vs Poor students

Groups A and D refer to science groups on pages 129 and 140.

Ability	Test	Means of Group A significantly better than means of Group D	
		Chemistry	Physics
Number	01ADDT	-	-
	02MULT	0.10	0.02
General Reasoning	03AREA	0.01	0.01
	04AROP	0.01	0.01
	07SEEP	0.10	-
Induction	05LENO	0.01	0.01
	06LEST	0.01	0.01
Spatial	08FLGS	0.05	0.05
	09CRDS	0.01	0.10
	10FIGS	0.01	0.05
Perceptual	11PERW	-	-
	12PERN	-	-
Memory	130BMR	-	-
	14PCMR	-	-
General Intelligence	150TIS	0.01	0.01
Verbal Comprehension	16EXPR	0.10	-
	17COMP	0.10	0.10
	18ESSY	0.10	-
	19SENT	0.01	-
	20VOCB	-	-
Word Fluency	21LETT	-	-
	22PRFX	-	0.10
	23SUFX	-	-
Ideational Fluency	24THME	-	-
	25CATG	0.02	-
Science	26CHCN	0.01	0.01
	28CHOB	0.01	0.01
	27PHCN	0.01	0.01
	29PHOB	0.01	0.01

(d) Factor Analysis

A Varimax solution of seven components was obtained from the data using standard statistical procedures. The seven components were given a psychological interpretation and were identified as factors of mental ability. Table 19 shows the significant loadings of the Varimax Rotated Factors.

Factor I General Science Reasoning Achievement

A science achievement factor in Chemistry and Physics, particularly related to verbal, non-verbal and arithmetical reasoning.

Factor II Numerical Perceptual

A numerical factor associated with perceptual speed and a memory for numbers. The Physics objective examination has a negative loading on this factor.

Factor III Spatial Orientation

A spatial factor particularly related to the orientation of objects and drawings.

Factor IV Verbal, Ideational, Perceptual Judgement

An ideational fluency factor associated with the verbal manipulation of verbal material concerning ideas and problems, within a limited time.

Factor V Word Fluency

A straightforward word fluency factor requiring the production of words at speed under easy restrictions.

Factor VI Verbal Comprehension

A verbal factor related to the meaning of words and understanding of written verbal material.

Factor VII Expressional Fluency

An expressional fluency factor associated with the verbal expression of ideas with a small memory loading.

Second-order Factors

Two second-order factors were obtained from a Promax solution.

I General Science Scholastic Intelligence

This had significant loadings on most of the ability tests and science examinations.

II Numerical, Memory, Word Fluency Facility

A factor related to memory for numbers and words.

TABLE 19

THE SIGNIFICANT LOADINGS OF
THE VARIMAX ROTATED FACTORS
(Decimal points omitted from body of table)

No.	Test	Factor						
		I	II*	III	IV	V	VI*	VII
01ADDT	Addition		75					
02MULT	Multiplication		77					
03AREA	Arithmetical Reasoning	69						
04AROP	Necessary Arith. Op.	48	42					
05LENO	Letters and Numbers	66						
06LEST	Letter Sets	72						
07SEEP	Seeing Problems				67			
08FLGS	Flags			82				
09CRDS	Cards			78				
10FIGS	Figures			83				
11PERW	Perceptual Words		55		58			
12PERN	Perceptual Numbers		69		36			
13OBMR	Object-Number Memory		34					42
14PCMR	Picture Memory						-71	
15OTIS	General Intelligence	68						
16EXPR	Expression and Comp.							75
17COMP	Comprehension	30					58	
18ESSY	Essay	30						55
19SENT	Sentence Structure				45		42	
20VOCB	Vocabulary					32	51	-32
21LETT	First Letters					73		
22PRFX	Prefixes			-39		67		
23SUFX	Suffixes					68		
24THME	Theme				73			
25CATG	Categories				59			
26CHCN	Chemistry Conventional	73						
27PHCN	Physics Conventional	53						
28CHOB	Chemistry Objective	79						
29PHOB	Physics Objective	64	-32					

* signs are reversed

(e) Discussion

The measurement of abilities using conventional and objective type science examinations has important implications for the setting of examinations in schools. For too long it has been assumed that objective type multiple choice questions are unable to measure the 'higher' abilities, which are necessary for achievement in science.

The administration of a battery of mental tests alongside typical conventional and objective examinations in science enabled a comparison between the abilities required for the different types of examination to be made, and also for group factors of ability to be extracted.

Students who have similar levels of general intelligence perform equally as well on both types of examination. From the results it appears that success in the objective type examination depends on as wide a range of abilities as success on the conventional type examination, and in fact the objective examinations have higher correlations with tests which measure spatial, reasoning, verbal comprehension and ideational abilities. There is only slight evidence, in the Chemistry examination, that verbal ability contributes to success in the conventional rather than the objective examination. This suggests that there would be no real loss if science examinations were all of the objective type, for all abilities required for conventional are also required, and more so, for objective examinations.

Generally all the analyses gave similar results for Chemistry and Physics suggesting that, at this level of academic achievement, there are no particular 'Chemistry' or 'Physics' abilities.

The existence of the general science reasoning achievement factor has important implications for science teaching. A comparison of the significance of difference between the means of those students good at both types of examinations and those poor at both types showed clearly that the reasoning and inductive abilities, the spatial ability and general intelligence were most influential on achievement in science. Students who enter secondary schools in Kenya have high standards in verbal and numerical abilities and have a high average general intelligence, but there is no evidence that standards are equally high in the reasoning and spatial abilities. This work has shown that there is a wider range in the reasoning and spatial abilities than there is in the verbal and numerical abilities. Thus it would be a great help in the teaching of science if the reasoning and spatial abilities could be encouraged, just as verbal and numerical abilities are encouraged.

It is commonly said that Africans in Kenya find science harder to understand than the arts subjects, and the reason usually given is that they have little 'scientific' background. Perhaps one way of helping this situation is to positively assist by setting a series of tests in reasoning, both verbal and non-verbal, and in spatial orientation. If two groups of students could be taught science over a period of a year, whilst one of the groups receives special instruction in the reasoning and spatial abilities, tests in science could then be given at the beginning and end of the year, and with reference to tests of mental ability, it might be observed whether or not the group receiving special instruction in the reasoning and spatial abilities had improved more than the other group.

Seven factors of ability have been identified, but only the first two had significant loadings on the science examinations. Many of these factors are probably required for success in science, but the general science achievement factor absorbs these other factors in the kind of examinations set in this work. Lewis (1967) classified science questions into three categories, knowledge, comprehension and evaluation, and identified factors with significant loadings on these categories. It might be useful to set science examinations classifying the questions according to abilities such as numerical, numerical reasoning, verbal reasoning, space, ideational fluency and so on, and with a reference battery of mental tests undertake a factor analysis to find out whether or not these abilities are being measured by such science questions. This could be done with both conventional and objective type questions.

This work has produced no evidence as to how memory fits into science achievement, probably because it is a more complex ability that originally realized, so it would be fruitful, especially for a comparison of the two types of examination, to construct a series of memory tests, incorporating memory for scientific knowledge, as well as rote memory.

It has been pointed out by Lewis (1965) that there has been a recognition that students' abilities develop and change, so it would be of value to follow the pattern of abilities over a period of years, right through to Higher School Certificate.

In conclusion, it has been shown that the general pattern of abilities with secondary school students in a school in Kenya follows a similar pattern to that which has been found in Britain.

BIBLIOGRAPHY

AHMANN, J. S. (1962), Testing Student Achievements and Attitudes.
Library of Education.

ANGUS, L. (1949), A Comparative Study of the Methods of Measuring Interest in Science and its Relation to Ability and Achievement. M. Ed. Thesis, Durham. Brit. J. Educ. Psychol., 20, p 63.

BAIR, J.T. (1951), Factor Analysis of Clerical Aptitude Tests. J. Appl. Psychol., 35, p 245.

BALLARD, P. B. (1923), The New Examiner. University of London Press.

BERRIDGE, A. R. (1948), A Factorial Analysis of Ability in School Physics. M.A. Thesis. University of London.

BLOOM, B.S. (1956), Taxomony of Educational Objectives: Cognitive Domain. New York: Longmans, Green.

BURT, C. (1917), The Distribution and Relations of Educational Abilities. Edinburgh: Oliver & Boyd.

BURT, C. (1949), The Structure of the Mind: A Review of the Results of Factor Analysis. Brit. J. Educ. Psychol., 19. p 100.

BUTT, A.S. (1957), The Differentiation of Reasoning Abilities at Adolescence. Ph.D. Thesis. University of London.

CARROLL, J. B. (1941), A Factor Analysis of Verbal Abilities Psychometrika, 6, p 279.

CHARY, K.V. (1948), A Statistical Analysis of the Performance of Boys and Girls in Science. M.A. Thesis. University of London.

CHEMISTRY HANDBOOK FOR TEACHERS, (1964), The Nuffield Foundation.

COOK, F.S. (1936), The Value of the New-type Examination for Assessing Attainment in Biology. M.A. Thesis, University of London.

COOMBS, C.C. (1941), A Factorial Study of Number Ability. Psychometrika, 6, p 161.

COX, J.W. (1928), Mechanical Aptitude. London: Methuen.

DEMPSTER, J.J. B. (1948), Symposium on the Selection of Pupils for Different Types of Secondary Schools: V - The Selector's Point of View. Brit. J. Educ. Psychol., 18, p 121.

DENTON, J.C. & TAYLOR, C.W. (1955), A Factor Analysis of Mental Abilities and Personality Traits. Psychometrika, 20, p 75.

EARLE, F.M. (1936), Tests of Ability for Secondary School Courses. University of London Press.

EBEL, R.L. (1965), Measuring Educational Achievement. New Jersey: Prentice-Hall.

EDUCATION IN CHEMISTRY, (1965), 2, p 283, True or False: Some Thoughts on Examination Questions. Jennings, K.R. and Leisten, J.A.

EDUCATION IN CHEMISTRY, (1967), 4, p 2, The Nuffield 'O' Level Chemistry Examinations. Matthews, J.C.

EDUCATION IN CHEMISTRY, (1967), 4, p 112, New Examinations in School Chemistry. Neuff, A.T.

EDUCATION IN CHEMISTRY, (1969), 6, p 78, Measuring Attainment of Educational Objectives in Chemistry. Hoare, D.E. & Revans, M.N.

EDUCATION IN CHEMISTRY, (1969),6, p 88, Increasing the Efficiency of the University Examinations System. Walkley, G. H.

EDUCATIONAL TESTING SERVICE, (1963), Multiple-Choice Questions: A Close Look. E. T. S. Princeton, New Jersey.

EGGLESTON, J. F. (1965), A Critical Review of Assessment Procedures in Secondary School Science. University of Leicester.

EL-ABD, H. (1966), Three Facets of Mental Ability: B.Ed. II Structure of Intellect. Res. Rep. No. 2 Makerere University College, Uganda.

EL KOUSSY, A. A. H. (1935), The Visual Perception of Space. Brit. J. Psychol. Monogr. Suppl., 20.

ELLIS, A. G. (1948), The Relations between Abilities in Grammar School Subjects and their Bearing on School Organization. M.Ed. Thesis, Durham. Brit. J. Educ. Psychol., 19, p 166.

EMMETT, W.G. (1949), Evidence of a Space Factor at 11+ and Earlier. Brit. J. Psychol. Statist. Sec., 2, p 3.

EXAMINATIONS BULLETIN No. 3. (1964), The Certificate of Secondary Education: An Introduction to Some Techniques of Examining. H.M.S.O. Secondary School Examinations Council.

EXAMINATIONS BULLETIN No. 8. (1965), The Certificate of Secondary Education: Experimental Examinations: Science. The Schools Council. H.M.S.O.

FRENCH, J. W. (1951), The Description of Aptitude and Achievement Tests in Terms of Rotated Factors. Psychometr. Monogr. No. 5.

FRENCH, J. W. (1957), The Factorial Invariance of Pure-Factor Tests. J. Educ. Psychol., 48, p 93.

FURST, E. J. (1958), Constructing Evaluation Instruments. New York: Longmans.

GARRETT, H. E. (1966), Statistics in Psychology and Education. 6th Edition. Longmans.

GREEN, R. F., GUILDFORD, J. P., CHRISTENSEN, P.R. & COMREY, A. L., (1953), A Factor-Analytic Study of Reasoning Abilities. Psychometika, 18, p 135.

GREENE, H. A., JORGENSEN, A. N. & GERBERICH, J. R. (1953), Measurement and Evaluation in the Secondary School. New York: Longmans.

GUILDFORD, J. P. (1947), Army Air Forces Aviation Psychology. Report No. 5. Washington, D. C. Government Printing Office.

GUILDFORD, J.P. (1956a), The Structure of Intellect. Psychol. Bull. 53, p 267.

GUILDFORD, J.P. (1956b), The Nature of the General Reasoning Factor. Psychol. Rev. 63, p169.

GUILDFORD, J.P. (1956c), Fundamental Statistics in Psychology and Education. 3rd Edition. McGraw-Hill.

GUILDFORD, J.P. (1967), The Nature of Human Intelligence. McGraw-Hill.

HARMAN, H. H. (1967), Modern Factor Analysis. University of Chicago.

HARTOG, P. & RHODES, E. C. (1935), An Examination of Examinations. London: Macmillan.

HAWKES, H. E. (1936), The Construction and Use of Achievement Examinations. Harrap.

HEINONEN, V. (1963), Differentiation of Primary Mental Abilities. Jyvaskyla Studies in Education, Psychology and Social Research 2.

IRVINE, S. H. (1966), Towards a Rationale for Testing Attainments and Abilities in Africa. Brit. J. Educ. Psychol., 36, p 24.

JAMES, E. (1950), An Investigation into the Factors Entering into the Ability to Learn Biology at the School Certificate Stage. M.A. Thesis, University of London.

JOG, R. N. (1955), A Study of the Factors Underlying the Ability of Grammar School Boys to Learn Physics at the G.C.E. Stage. M.A. Thesis, University of London.

KELLEY, H. P. (1954), A Factor Analysis of Memory Ability. Princeton, New Jersey: Educational Testing Service.

KELLEY, T. L. (1928), Crossroads of the Mind of Man. Stanford, Calif: Stanford University Press.

KESSEN, W. (1964), Statement of Purposes and Objectives of Science Education in School. J. Res. in Science Teaching, 2, p 3.

KHAN, M. A. (1951), A Study of Ability and Interest in Secondary School Pupils in Science. M.A. Thesis. University of London.

LEWIS, D.G. (1961), Group Factors of Attainment in Grammar School Subjects. Brit. J. Educ. Psychol., 31, p 241.

LEWIS, D. G. (1964), The Factorial Nature of Attainment in Elementary Science. Brit. J. Educ. Psychol., 34, p 1.

LEWIS, D. G. (1965), Objectives in the Teaching of Science. Educ. Res. V11, 3, p 186.

LEWIS, D. G. (1967), Ability in Science at 'O' Level G.C.E. Brit. J. Educ. Psychol., 37, p 361.

LINDQUIST, E. F. (1951), Educational Measurement. Washington D.C.: American Council on Education.

MEYER, G. (1936), An Experimental Study of the Old and New Type of Examination. J.Educ. Psychol., 26, p 30.

MICHAEL, W. D., GUILDFORD, J.P. et al (1957), The Description of Spatial Visualization Abilities. Educ. Psychol. Measmt., 17, p 185.

MORGAN, G.A.V. (1956), Verbal Abilities in Primary School Children. Durham Res. Rev., 7, p 97.

MUTHULINGHAM, S. (1963), An Investigation of Certain Factors in the Physical Science Course of Secondary Schools in Relation to Aspects of the Achievement, Attitudes and Interests of Fifth Year Pupils. M.A. Thesis, University of London.

NELSON, C. H. (1958), Let's Build Quality into our Science Tests. National Science Teacher Association.

NOLL, V.H. (1957), Introduction to Educational Measurement. Boston: Houghton Mifflin.

PAWLEY, G.C. (1937), A Factor Analysis of the Abilities Involved in Learning School Chemistry. M.A. Thesis, University of London.

PEEL, E.A. (1948), Assessment of Interest in Practical Topics. Brit. J. Educ. Psychol., 18, p 41.

REPORT, (1960), Secondary School Examinations other than the G.C.E. Report of a Committee: Chairman, Beloe, R. Ministry of Education, H.M.S.O.

ROE, Anne, (1953), A Psychological Study of Eminent Psychologists and Anthropologists and a comparison with Biological and Physical Scientists. Psychol. Monogr. 67, No. 2.

ROGERS, C.A. (1953), The Structure of Verbal Fluency. Brit. J. Psychol., 44, p 368.

SCHOOL SCIENCE REVIEW, (1967), 49, No.167, p 21. O-Level Chemistry Examinations. Matthews, J.C.

SCHOOL SCIENCE REVIEW, (1968), 49, No. 170, p 19.
Objective Testing. Daniels, D.J.

SCHOOL SCIENCE REVIEW, (1968), 50, No. 171, p 315.
An Electronic Approach to Organic Chemistry.
Whitfield, R.C.

SCHWAB, J. J. (1963), Biology Teachers' Handbook.
Wiley.

SCIENCE MASTERS' ASSOCIATION, (1938), The Teaching of
General Science, Part II. Murray.

SHOUSMITH, G. (1958), Fluency and Essay Writing. Brit.
J. Educ. Psychol., 28, p 266.

SMITH, I. MacFarlane, (1964), Spatial Ability. University
of London Press.

SMITH, I. MacFarlane, (1967), A Factorial Study
of an Hypothesis about the Nature of Spatial
Ability. Durham. Res. Rev., 18, p 149.

SMITH, M. & McDOUGALL, W. (1919), Some Experiments in
Learning and Retention. Brit. J. Psychol., 10,
p 199.

SPEARMAN, C. (1904), 'General Intelligence', Objectively
Determined and Measured. Amer. J. Psychol., 15,
p 201.

SPEARMAN, C. (1927), The Abilities of Man. London: Macmillan.

STEPHENSON, W. (1931), Tetrad Differences for Verbal Subtests relative to Non-verbal Subtests. J. Educ. Psychol., 22, p 334.

SULTAN, E.E. (1962), A Factorial Study in the Domain of Creative Thinking. M.A. Thesis, University of London. Brit. J. Educ. Psychol., 32, p 78.

SUTHERLAND, J. (1941), An Investigation into some Aspects of Problem Solving in Arithmetic. Brit. J. Educ. Psychol., 11, p 215.

TAYLOR, C.W. (1947), A Factorial Study of Fluency in Writing. Psychometrika, 12, p 239.

THOMSON, G.H. (1916), A Hierarchy without a General Factor. Brit. J. Psychol., 8, p 271.

THURSTONE, L.L. (1938a), Primary Mental Abilities. University of Chicago Press.

THURSTONE, L.L. (1938b), Primary Mental Abilities. Psychometr. Monogr., 1.

THURSTONE, L.L. (1948), Psychological Implications of Factor Analysis. Amer. Psychol., 3, p 402.

THURSTONE, L.L. (1950), Some Primary Abilities in Visual Thinking. Chicago: University of Chicago Psychometric Laboratory Report No. 59.

THURSTONE, L.L. (1951), An Analysis of Mechanical Aptitude. University of Chicago, Psychometric Laboratory.

VALENTINE, J.A. (1969), The Unbearable Burden on External Examinations in England and the United States. Comparative Educ., 5, No. 2, p 139.

VERNON, P.E.(1939), Educational Abilities of Training College Students. Brit. J. Educ. Psychol., 9, p 233.

VERNON, P.E. (1947), Research on Personnel Selection in the Royal Navy and the British Army. Amer. Psychologist, 2, p 35.

VERNON, P.E. (1950), An Application of Factorial Analysis to the Study of Tests Items. Brit. J. Psychol. Statist. Sec., 3, p 1.

VERNON, P.E. (1956), The Measurement of Abilities. 2nd Edition. London: University of London Press.

VERNON, P.E. (1961), The Structure of Human Abilities. 2nd Edition.London: Methuen.

VERNON, P.E. (1962), The Determinants of Reading Comprehension. Educ. Psychol. Measmt., 22, p 269.

VERNON, P.E. (1964), Examinations Bulletin No. 4. The Certificate of Secondary Education. An Introduction to Objective-Type Examinations. H.M.S.O.

VERNON, P.E. (1967), Administration of Group Intelligence Tests to East African Pupils. Brit. J. Educ. Psychol., 37, p 282.

WISEMAN, S. (1956), The Use of Essays in Selection at 11+. Brit. J. Educ. Psychol., 26, p 172.

WOODROW, H. (1939), The Common Factors in Fifty-Two Mental Tests. Psychometrika, 4, p 99.

WRIGLEY, J. (1958), The Factorial Nature of Ability in Elementary Mathematics. Brit. J. Educ. Psychol., 28, p 61.

YOUNG, J.E. (1948), The Ability to Draw Inferences from Science Experiments. Ed.B. Thesis, Glasgow. Brit. J. Educ. Psychol., (1951) 21, p 74.

ZIMMERMAN, W.S. (1953), A Revised Orthogonal Rotational Solution for Thurstone's Original Primary Mental Abilities Tests Battery. Psychometrika, 18, p 77.

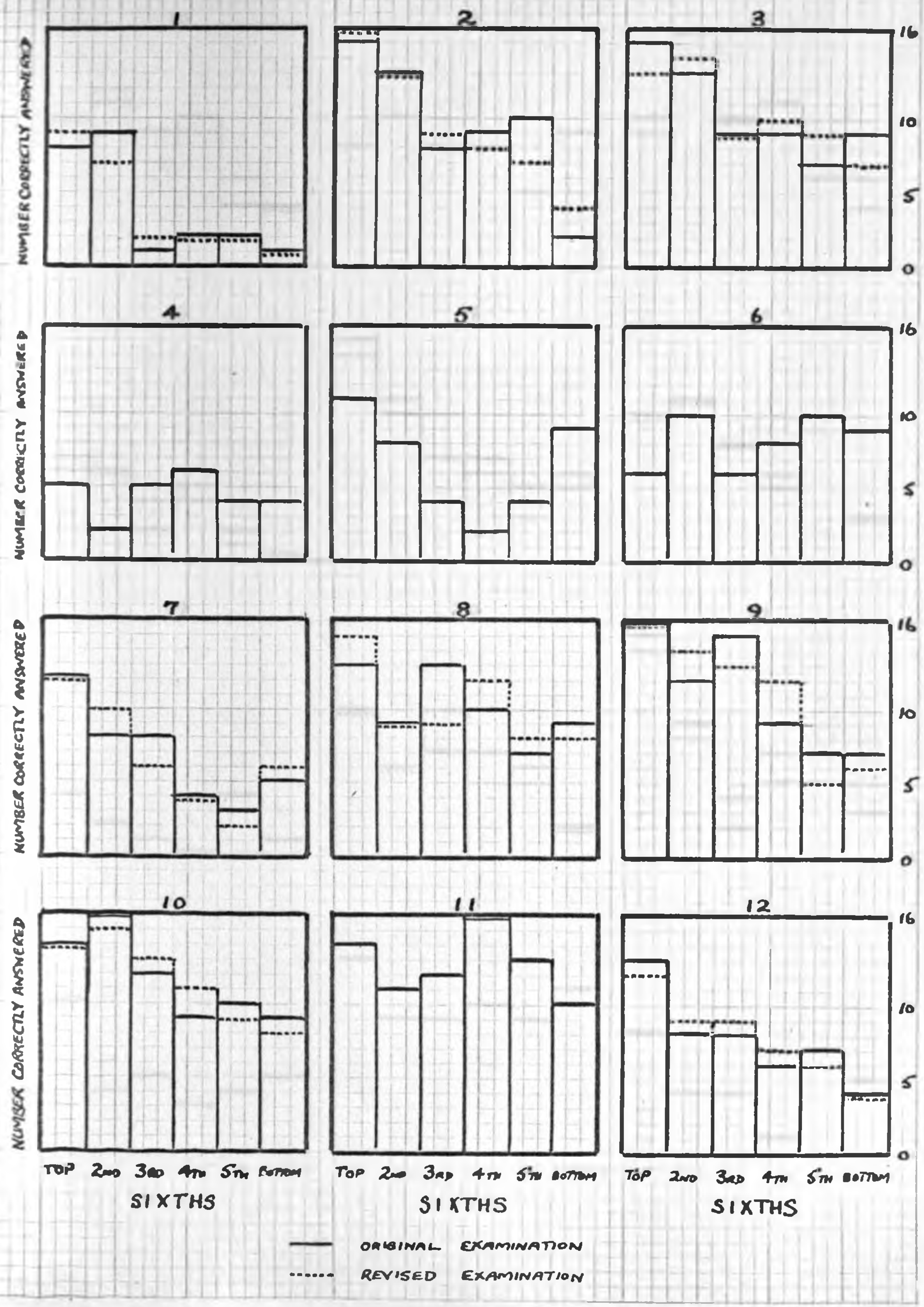
ZYVE, D.L. (1927), A Test of Scientific Aptitude. J.Educ. Psychol., 17, p 525.

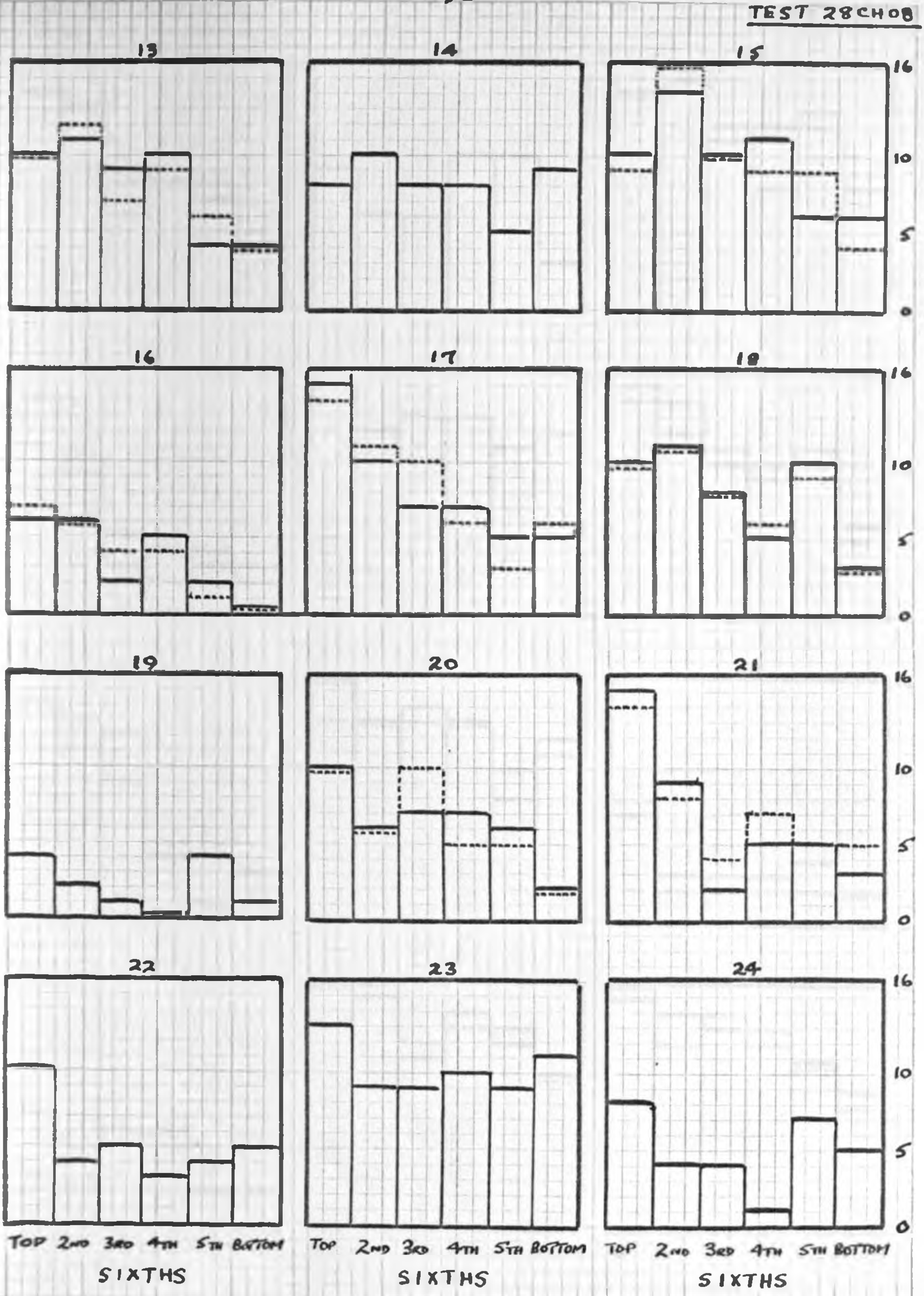
APPENDIX

(a) Item Analysis of the Chemistry and Physics objective examinations

(b) The Tests and Examinations

ITEM ANALYSIS : TEST 28 CHOB CHEMISTRY OBJECTIVE




TEST 28CHOB
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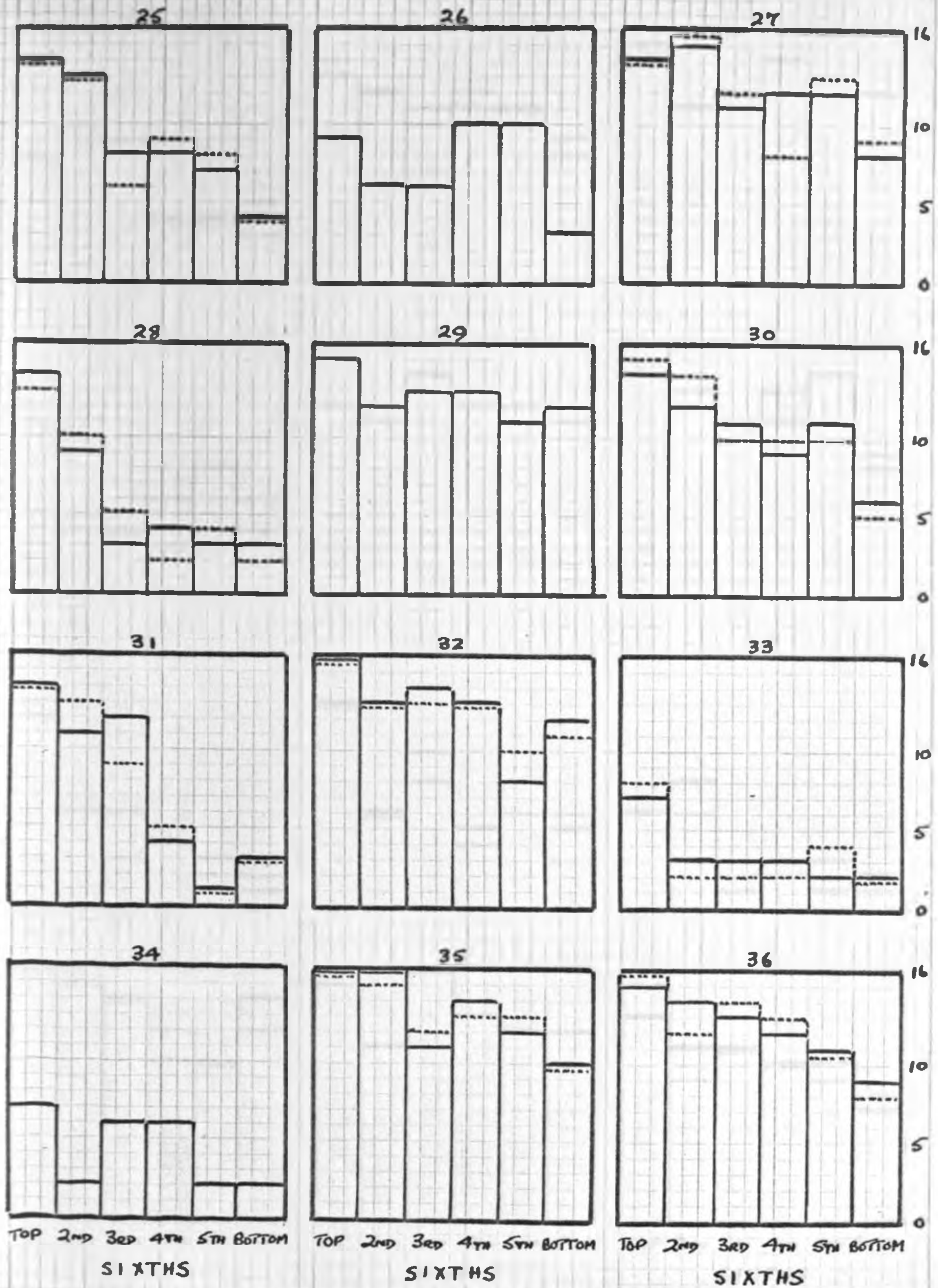
TEST 28 CHOB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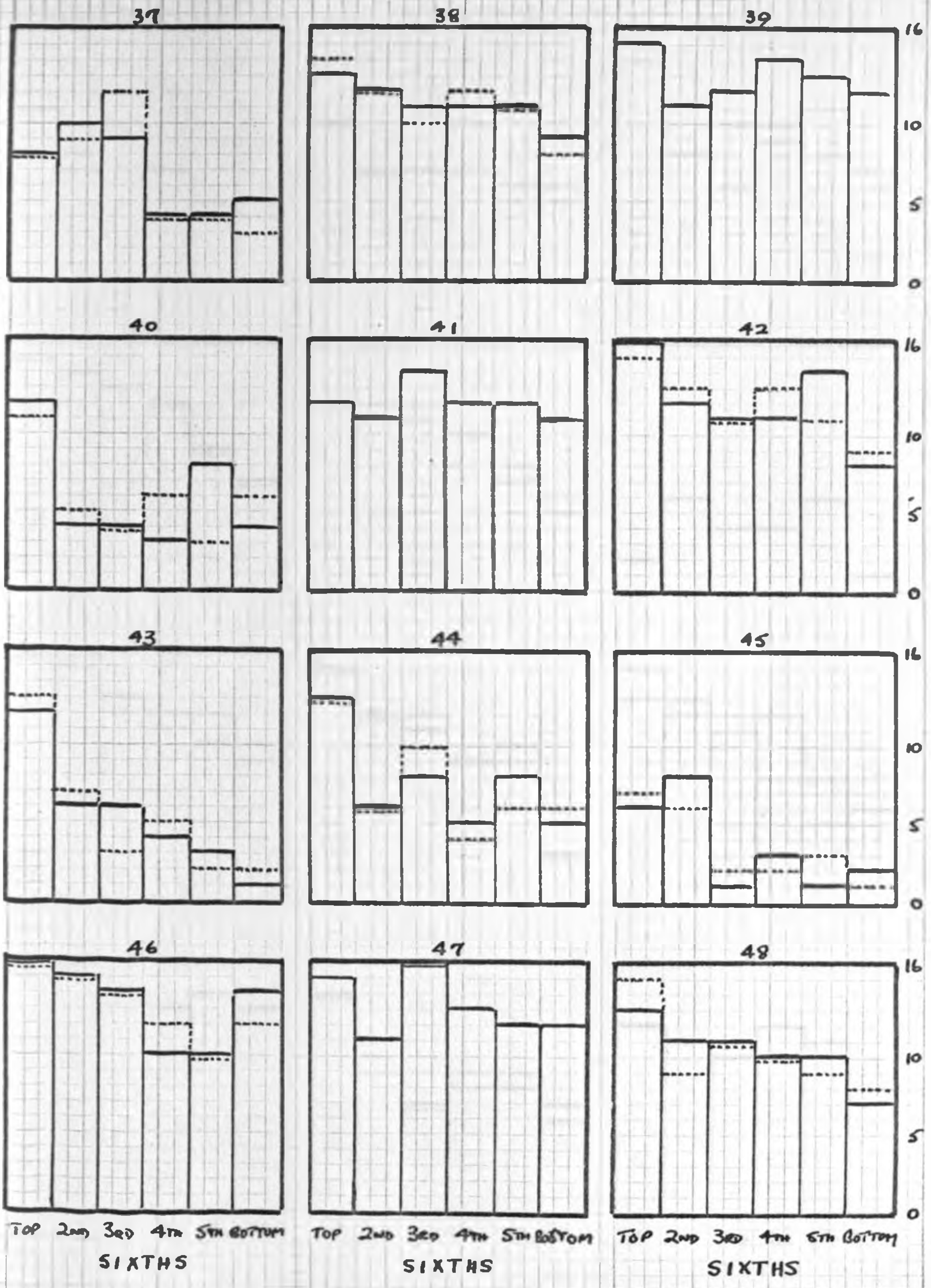
TEST 28CH08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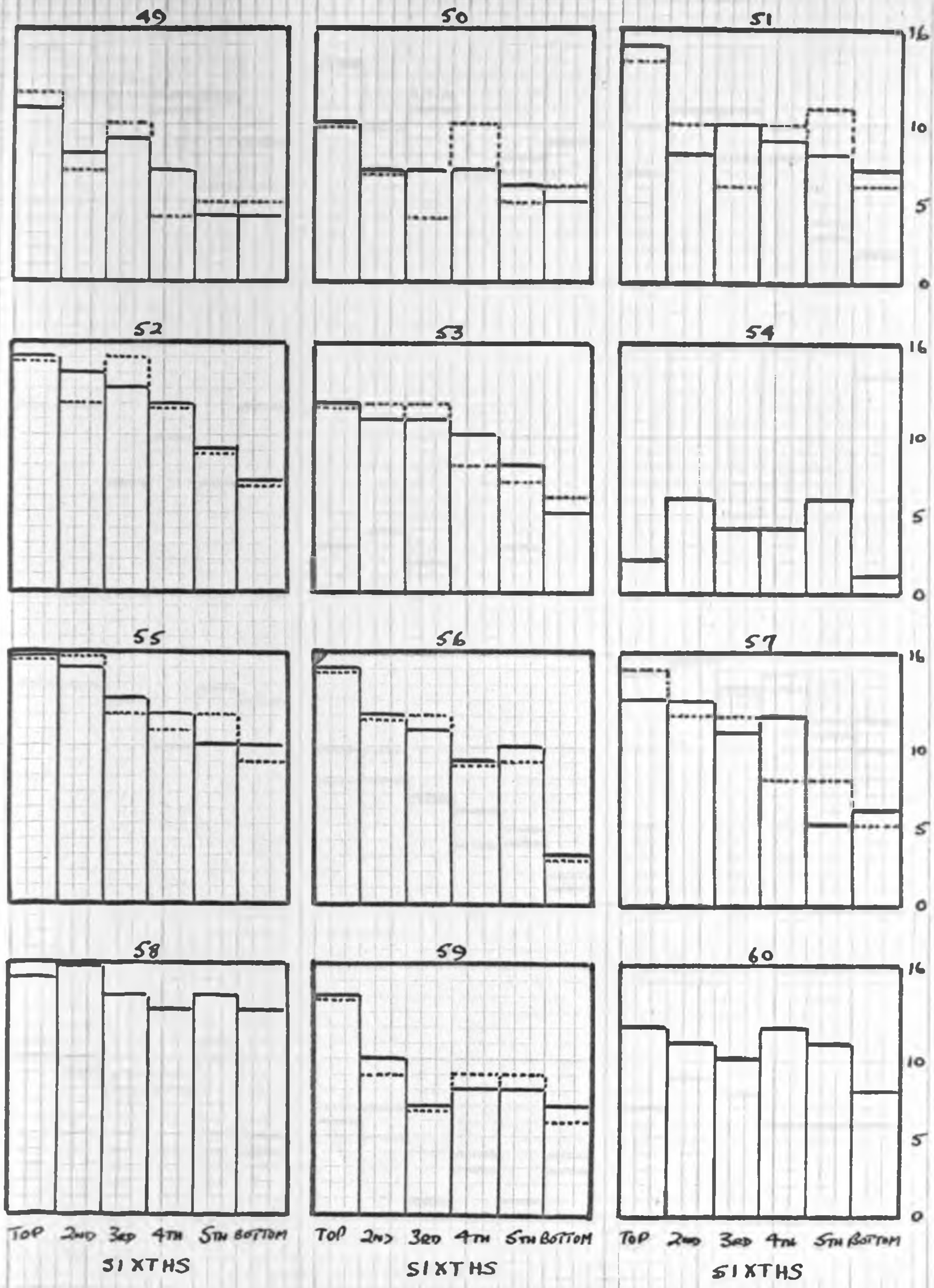
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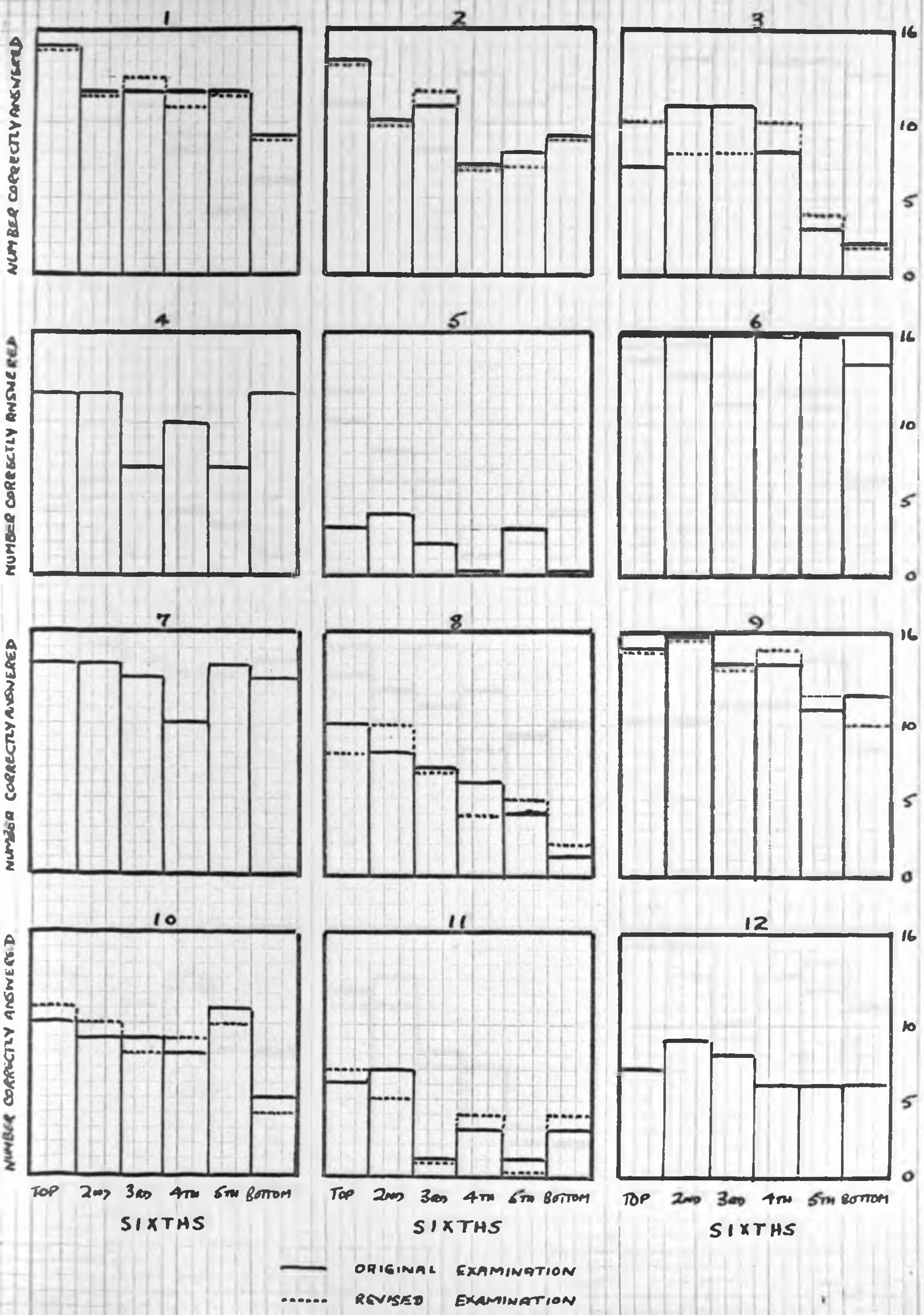
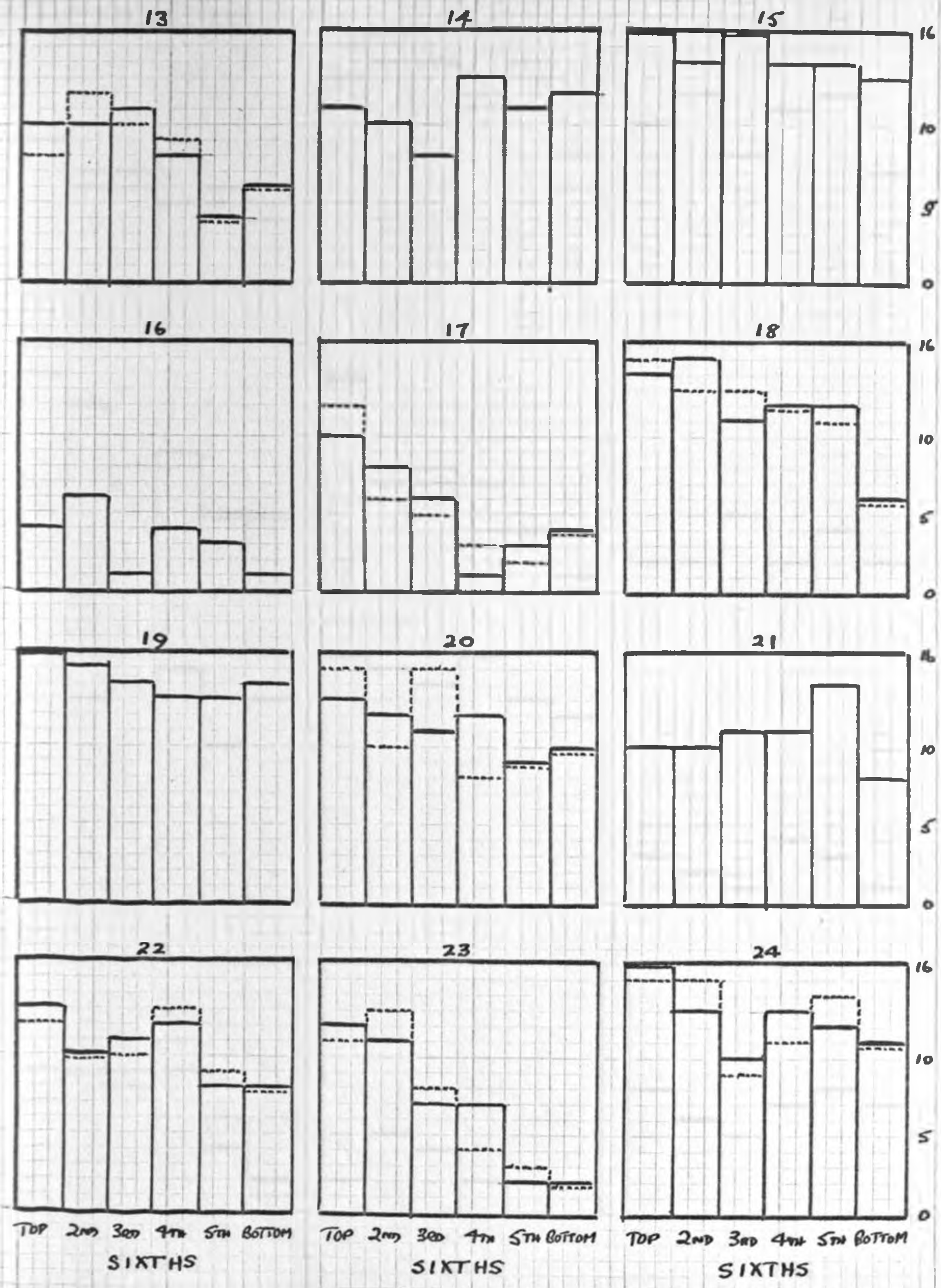
ITEM ANALYSIS : TEST 29 PHOB PHYSICS OBJECTIVE



TEST 29PHOB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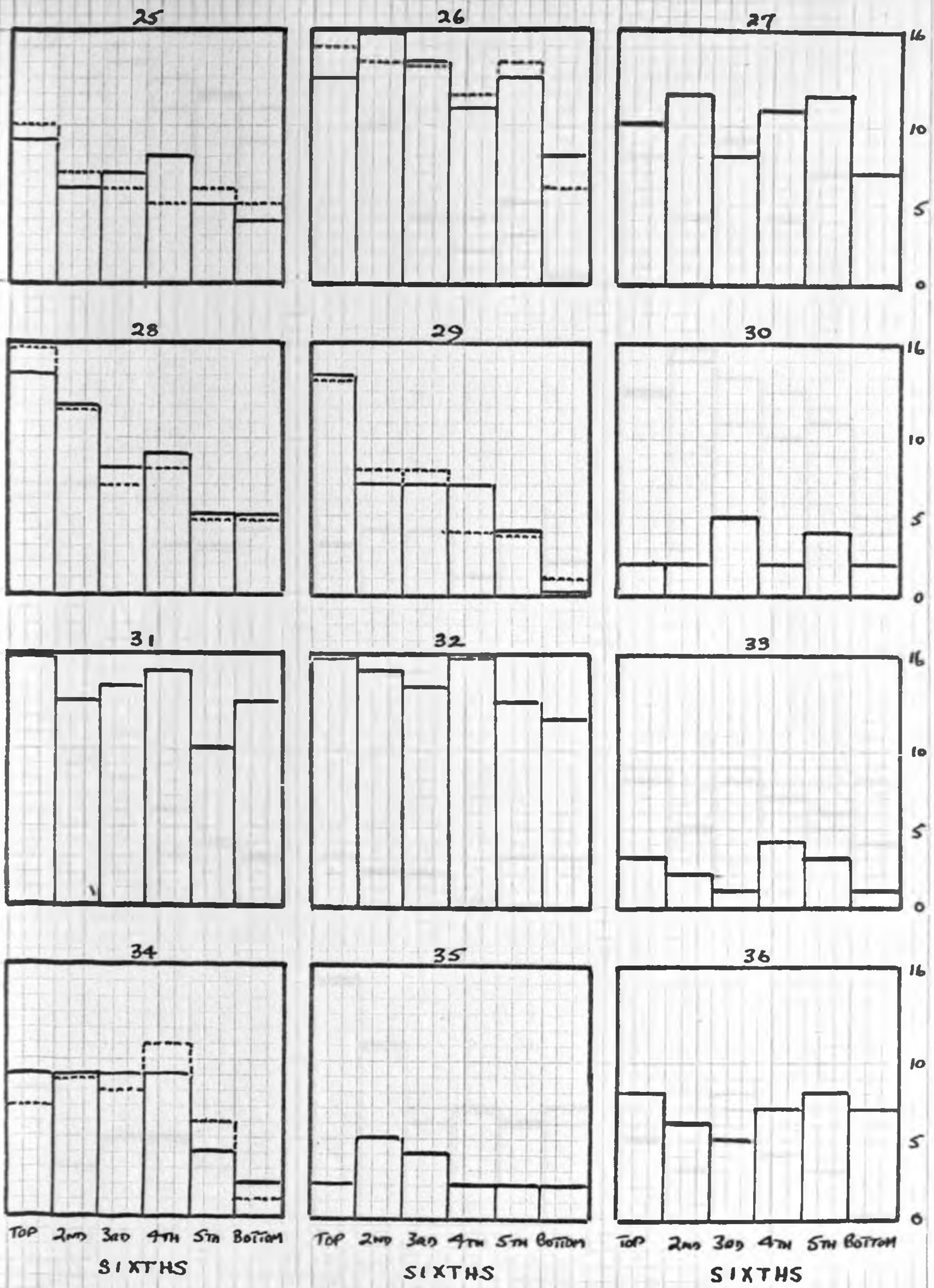
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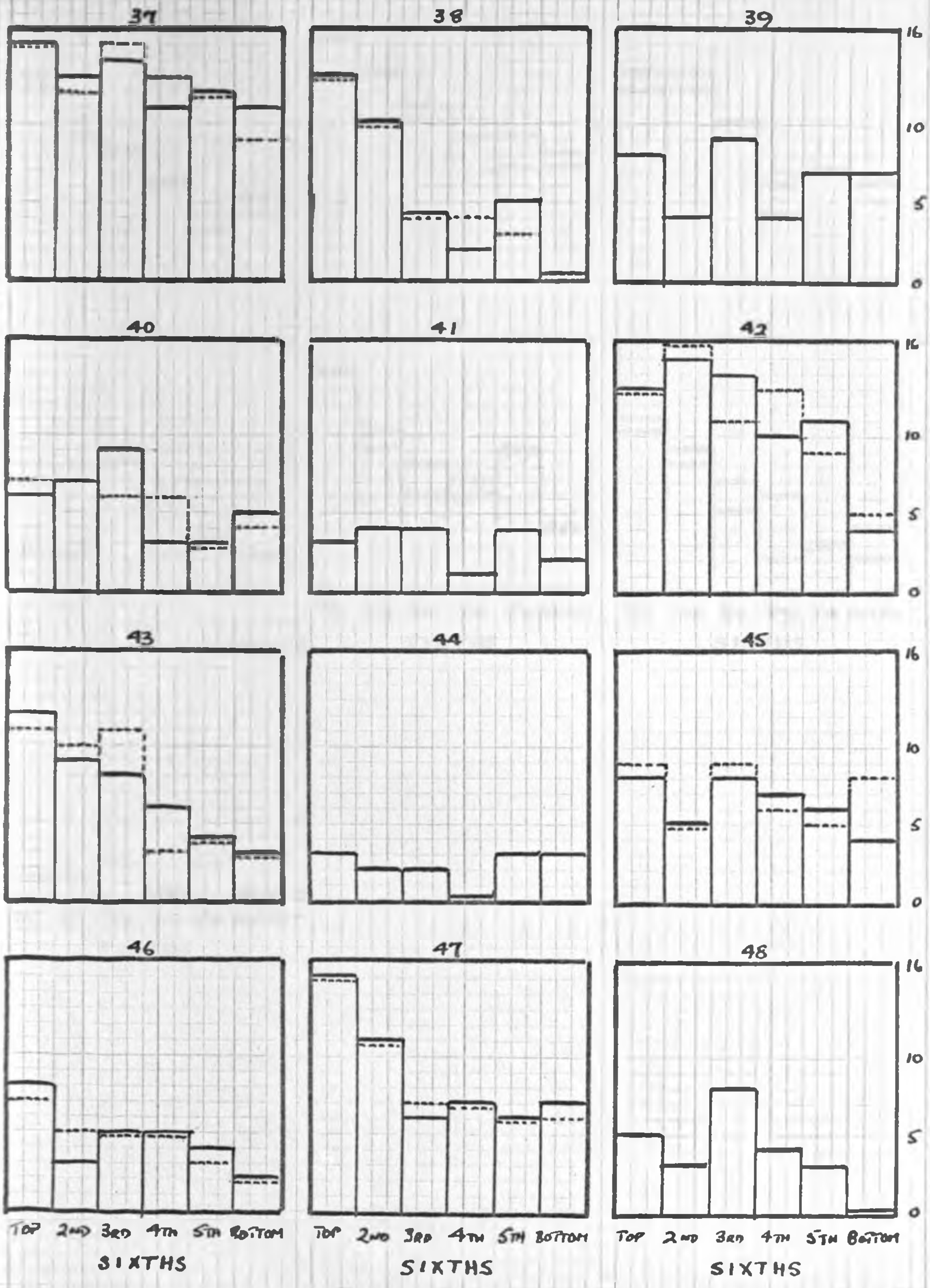
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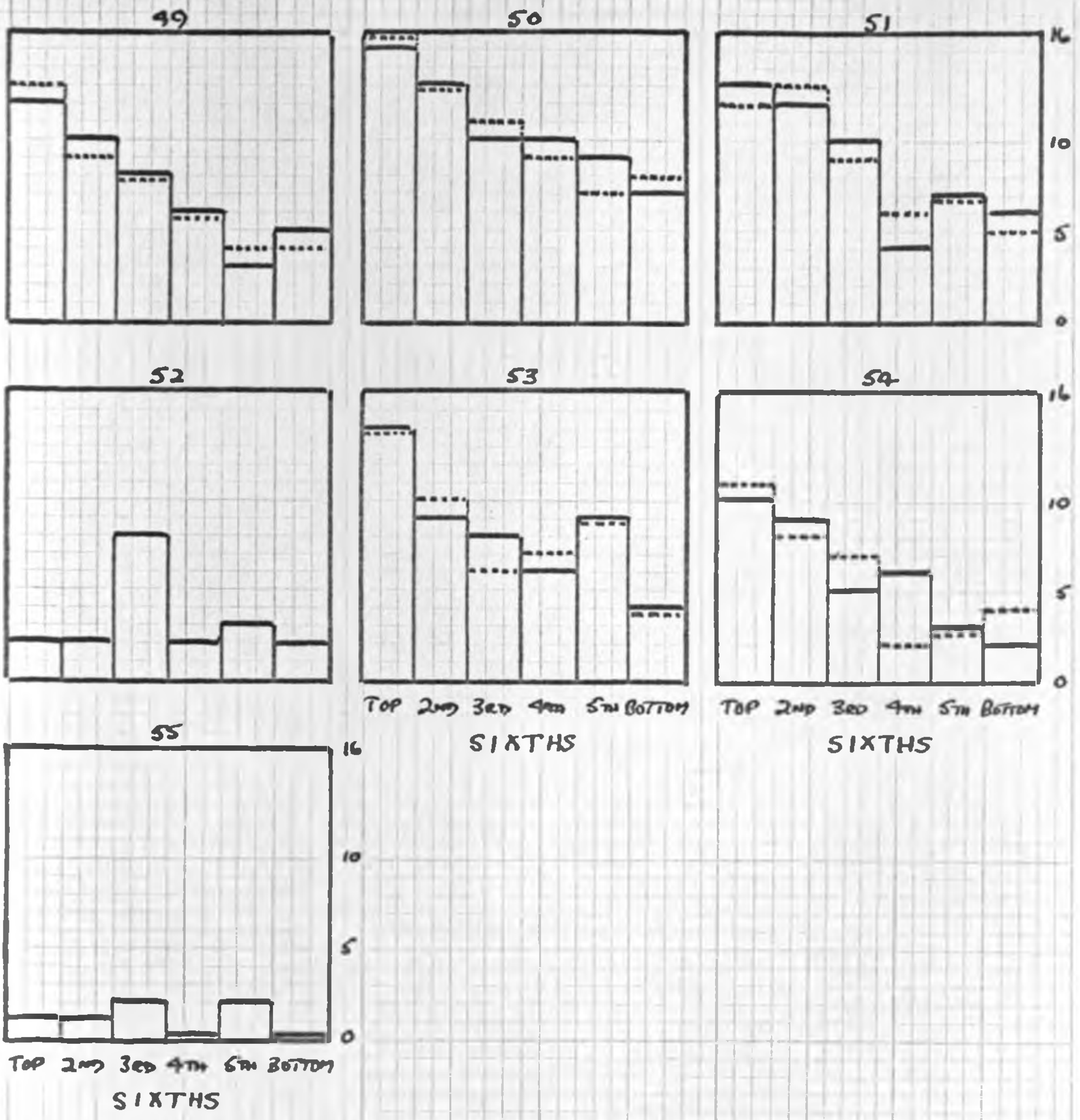
SIXTHS

TEST 29PHOB



(b) THE TESTS AND EXAMINATIONS

Reference	Name of tests	Source *
01ADDT	Addition	L.L.T.
02MULT	Multiplication	L.L.T.
03AREA	Arithmetical Reasoning	Ballard
04AROP	Necessay Arithmetic Operations	E.T.S.
05LENO	Letters and Numbers	P.E.V.
06LEST	Letter Sets	E.T.S.
07SEEP	Seeing Problems	E.T.S.
08FLGS	Flags	L.L.T.
09CRDS	Cards	L.L.T.
10FIGS	Figures	L.L.T.
11PERW	Perceptual Words	A.C.E.S.
12PERN	Perceptual Numbers	A.C.E.S.
13OBMR	Object-Number Memory	E.T.S.
14PCMR	Picture Memory	A.C.E.S.
15OTIS	General Intelligence	Otis
16EXPR	Expression and Comprehension	A.H.S.
17COMP	Comprehension	A.H.S.
18ESSY	Essay	A.H.S.
19SENT	Sentence Structure	A.H.S.
20VOCB	Vocabulary	L.L.T.
21LETT	First Letters	L.L.T.
22PRFX	Prefixes	L.L.T.
23SUFX	Suffixes	L.L.T.
24THME	Theme	E.T.S.
25CATG	Categories	E.T.S.
26CHCN	Chemistry Conventional	A.C.E.S.
27PHCN	Physics Conventional	A.C.E.S.
28CHOB	Chemistry Objective	A.C.E.S.
29PHOB	Physics Objective	A.C.E.S.

* L.L.T. – L. L. Thurstone, Chicago

E.T.S. – Educational Testing Service, Princeton

P.E.V. – Professor P. E. Vernon

A.C.E.S. – The writer

Otis – Otis Intermediate Examination

A.H.S. – Alliance High School English Department

TEST O1ADDT

Name ....

A D D I T I O N - N

Below are two columns of numbers which have been added. Add the numbers for yourself to see if the sums are correct.

	16	42
	38	61
	45	83
	99	176
R	▬	:::
W	:::	▬

The first sum is right so the space in the R row is marked.
The second sum is wrong so the space in the W row is marked.

Check the sums of the columns below. If the sum is right, mark the space in the R row. If the sum is wrong, mark the space in the W row.

	17	35	63
	84	28	17
	29	61	89
	140	124	169
R	:::	:::	:::
W	:::	:::	:::

STOP HERE

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

A D D I T I O N

Add each column.

If the sum is right, mark the space in the R row.
If the sum is wrong, mark the space in the W row.

	61	31	66	73	13	48	88	86	69	71	
	34	59	73	29	39	45	29	49	44	37	
	78	52	15	56	99	17	69	54	89	66	
	53	68	38	33	32	82	98	22	84	55	
	226	200	202	211	183	192	284	111	286	129	
R	:::	:::	:::	:::	:::	:::	:::	:::	:::	:::	R
W	:::	:::	:::	:::	:::	:::	:::	:::	:::	:::	W

	44	75	26	99	25	43	31	59	52	68	
	49	54	44	77	46	34	73	29	56	33	
	23	36	75	82	92	89	13	39	99	32	
	48	17	51	68	57	32	48	45	17	82	
	164	162	196	316	220	198	185	192	124	225	
R	:::	:::	:::	:::	:::	:::	:::	:::	:::	:::	R
W	:::	:::	:::	:::	:::	:::	:::	:::	:::	:::	W

	78	95	79	89	97	13	26	44	97	13	
	56	49	22	64	35	92	99	77	92	99	
	76	44	84	61	66	31	26	86	26	86	
	35	37	55	34	73	36	62	68	86	79	
	245	205	240	258	271	172	213	275	201	367	
R	:::	:::	:::	:::	:::	:::	:::	:::	:::	:::	R
W	:::	:::	:::	:::	:::	:::	:::	:::	:::	:::	W

	26	44	75	51	81	32	97	23	71	48	
	77	82	68	39	46	98	63	36	46	59	
	32	84	39	92	43	22	76	41	67	17	
	99	32	57	32	48	91	57	65	62	16	
	234	232	339	314	208	243	303	165	236	150	
R	:::	:::	:::	:::	:::	:::	:::	:::	:::	:::	R
W	:::	:::	:::	:::	:::	:::	:::	:::	:::	:::	W

	24	89	26	81	75	18	59	64	83	32	
	85	95	86	39	47	15	44	61	34	97	
	94	55	24	84	55	57	78	34	41	23	
	47	79	99	79	19	96	89	19	16	71	
	250	218	345	293	196	186	280	188	174	243	
R	:::	:::	:::	:::	:::	:::	:::	:::	:::	:::	R
W	:::	:::	:::	:::	:::	:::	:::	:::	:::	:::	W

	98	22	91	28	81	89	75	51	43	31	
	63	76	57	63	39	86	82	68	73	29	
	36	41	65	62	67	69	99	32	39	99	
	46	67	62	87	52	71	87	23	17	82	
	243	196	295	260	239	315	243	174	182	251	
R	:::	:::	:::	:::	:::	:::	:::	:::	:::	:::	R
W	:::	:::	:::	:::	:::	:::	:::	:::	:::	:::	W

	59	52	68	31	59	42	68	75	78	23	
	56	33	47	43	73	29	56	33	47	56	
	32	55	56	92	43	13	39	45	32	55	
	19	33	58	79	57	32	48	99	17	82	
	146	173	239	245	232	106	201	242	154	216	
R	:::	:::	:::	:::	:::	:::	:::	:::	:::	:::	R

TEST O2MULT

Page 3

M U L T I P L I C A T I O N

Below are two multiplication problems. Multiply the numbers for yourself to see if the products are correct.

	64	39
	7	4
	448	166
R	▬	:::
W	:::	▬

The first answer is right so the space in the R row is marked. The second answer is wrong so the space in the W row is marked.

Check the answers in the problems below. If the answer is right, mark the space in the R row. If the answer is wrong, mark the space in the W row.

	57	46	29
	6	8	7
	342	358	193
R	:::	:::	:::
W	:::	:::	:::

STOP HERE.

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

 209

MULTIPLICATION

If the answer is <u>right</u>, mark the space in the <u>R row</u>.
If the answer is <u>wrong</u>, mark the space in the <u>W row</u>.

	68	82	72	57	65	92	58	81	47	84	
	3	3	9	4	9	4	7	3	8	3	
	204	236	658	208	585	368	406	233	376	242	
R											R
W											W
	48	68	47	46	42	78	76	54	63	87	
	8	3	7	9	8	4	6	4	6	3	
	384	194	329	404	336	312	446	206	368	241	
R											R
W											W
	97	73	92	32	64	58	86	67	52	38	
	6	8	3	8	7	7	4	6	8	4	
	582	604	276	246	448	406	344	402	406	142	
R											R
W											W
	67	73	89	32	73	89	69	43	26	26	
	3	7	6	7	6	6	4	9	6	8	
	201	491	524	214	458	534	286	387	146	198	
R											R
W											W
	73	29	98	36	59	95	37	54	76	78	
	4	8	4	6	3	6	9	4	8	7	
	292	252	382	236	177	570	353	236	608	566	
R											R
W											W
	56	72	24	42	94	89	36	82	98	38	
	9	8	8	6	9	6	8	7	6	7	
	504	586	182	272	846	534	268	574	598	286	
R											R
W											W
	36	98	93	65	79	56	52	34	87	76	
	9	6	7	6	8	6	7	8	7	4	
	304	588	641	390	632	316	344	292	589	304	
R											R
W											W

Name ______________________ 210

TEST 03AREA

ARITHMETICAL REASONING
Ballard Form A

This is a test of arithmetical reasoning. You will have 15 minutes.

Write your answers in the space provided on the right-hand side of each question. You can do rough work on this paper. Only the answer in the box will be marked. There are 33 questions.

1/7 There are 20 beads on a string. 7 are red, 8 are blue, and the rest are yellow. How many are yellow? 1

2/10 Among how many boys can I share Sh.5/- so that each gets 50 cents? 2

3/4 A boy was given 12 apples. 3 of the apples were bad and had to be thrown away. After eating 4 of the good ones how many were left? 3

4/52 What is the least number that must be added to 53 to make it exactly divisible by 7? 4

5/22 Shakespeare died in 1616 at the age of 52. When was he born? 5

6/23 What is the length of the stick which I can cut up into 8 pieces, each of 6 in. long, and have 4 in. left over? 6

7/12 If I write the word 'giraffe' 8 times, how many letters do I use? 7

8/40 If $1\frac{1}{2}$ lb. of cheese costs Sh.3/-, what will 1 lb. cost? 8

9/8 A plank 20 ft. long is laid on the top of one which is 14 ft. long so that it is 2 ft. over at one end. How much is it over at the other? 9

10/50 I entered a shop at 5 p.m. and stayed till 5.30 p.m. I bought two ties at Sh.2/- each and two handkerchiefs at Sh.3/50 each. What change did I get from Sh.20/-? 10

11/15 Mary is twice as old as Jane, Jane is twice as old as Ann, Ann is as old as Ruth, Ruth is 3. How old is Mary? 11

12/39 A man has 5 children. It costs him Sh.50/- to feed them. What will be the expense for a month (4 weeks)? 12

13/54 How many oranges at 4 for 25 cents can I buy for Sh.2/-? 13

14/14 Two similar taps fill a bath in 20 minutes. How long will one take? 14

GO STRAIGHT ON TO NEXT PAGE.

15/43 A half and a quarter of a man's money added together make Sh.9/-. How much has he? 15

16/2 What number is half-way between 12 and 16? 16

17/47 How many days are there from noon on January 28th to noon on February 2nd of the same year? 17

18/51 A boy sold a knife for Shs.1/50. His gain was 30 cents. What fraction of the cost price did he gain? 18

19/80 If I share 60 cents among two boys, so that one gets 20 cents more than the other, how much does the less fortunate boy get? 19

20/58 In the 3 class-rooms of a school there are 120 children. Half of them are in the first room, one-third in the second room, and the rest in the third room. How many are there in the third room? 20

21/64 What is the greatest number that will divide 62 and 74 and leave a remainder of 2 in each case? 21

22/29 How many twos must be multiplied together to make thirty-two? 22

23/37 A runs a hundred yards race with B, giving him 5 yards start. A beats B by 6 yards. How many yards has B run when A reaches the winning post? 23

24/66 What is the profit on 120 articles bought at 80 cents a dozen and sold at Sh.1/- a dozen? 24

25/59 A bag contained nuts. David was given half of them and Samuel a quarter. It was found that David had 9 nuts more than Samuel. How many nuts were there in the bag at first? 25

26/41 A man of 35 is 7 times as old as his son; how many times as old as his son will he be 25 years hence? 26

27/76 How many times as fast as the hour hand does the minute hand of a clock move? 27

28/94 The sum of two numbers is 24 and their difference is 10. What is the larger of the two numbers? 28

29/99 If in secretly sending numbers to a friend I agree to write 7 when I mean 3 and 11 when I mean 7, what should I write when I mean 10? 29

GO STRAIGHT ON TO THE NEXT PAGE.

30/96 A brick weighs 7 lb. plus half its own weight. What is the weight of the brick? 30

31/92 If a man's salary is reduced by 10 percent. and then increased by 10 per cent., state whether he loses or gains and by what percentage? 31

32/88 A rectangular plot of grass 6 ft. long and 5 ft. broad is surrounded by a path 2 ft. wide. What is the area of the path in square feet? 32

33/65 A 5-storey house has 4 equal flights of stairs with a total of 52 stairs. How many stairs must I go up to get to the fourth storey? 33

STOP.

Name ______________________________

ARITHMETICAL REASONING
Ballard Form B

This is a test of arithmetical reasoning. You will have 15 minutes

Write your answers in the space provided on the right-hand side of each question. You can do rough work on this paper. Only the answer in the box will be marked. There are 33 questions.

1/18 A bookseller bought some books for Sh.20/- and sold them for Sh.22/-, gaining 50 cents on each book. How many did he buy? 1

2/16 There are 40 nuts on a plate. How many will be left after 5 people have eaten 7 each? 2

3/27 How many numbers between 19 and 30 are exactly divisible by 4? 3

4/3 A man is taller than his wife by 3 inches. His wife is taller than his daughter by 5 inches. The daughter is 60 inches tall. How tall is the man? 4

5/6 Fred has 15 marbles when he starts playing. He loses 8 marbles and then wins 6 marbles. How many marbles has he? 5

6/28 If it takes 3 minutes to boil an egg, how long will it take to boil 10 eggs together? 6

7/19 There are 35 boys in the first class and 40 in the second class. For the arithmetic lesson 5 boys go down from the first class to the second class and 7 go up from the second to the first. How many boys are in the first class for the arithmetic lesson? 7

8/33 If I buy two books at 90 cents each and three pencils at 40 cents each, what change shall I have left from a five shilling note piece? 8

9/53 How many eggs at 3 for 40 cents can I buy for Sh.2/80? 9

10/67 A bookseller bought some books for Sh.30/- and sold them for Sh.35/-, gaining 20 cents on each book. How many did he buy? 10

GO STRAIGHT ON TO THE NEXT PAGE.

11/70 If 1 man eats 1 apple in 1 day, in how many days will 10 men eat 10 apples at the same rate? 11

12/11 I make as many separate triangles as I can with 29 whole matches. How many matches are not used? 12

13/13 In one pan of a balance there are 15 lb. of rice and in the other 7 lb. of apples. How much rice must I take from one pan and place in the other to make them balance? 13

14/77 The area of a square is 144 sq.in. What is the distance in inches round it? 14

15/78 What is the distance round a rectangular table top 5 ft. long and 4 ft. broad? 15

16/32 A paper boy buys a dozen newspapers at Sh.2/- and sells them at 15 cents each. What profit does he make on the whole? 16

17/84 A boy said "In 10 years' time I shall be twice as old as I am now". How old was he? 17

18/55 It takes three men two days to paint the inside of a house. How many men would be needed to do it in half a day working at the same rate? 18

19/69 A man 6 ft. tall stands in the sunlight near a telegraph pole 30 ft. high and casts a shadow of 9 ft. How long is the shadow of the telegraph pole? 19

20/21 The bottom of a hill is 200 ft. above sea-level and the top 400 ft. above sea-level. How high above the sea is a house which is half-way up the hill? 20

21/56 Two men start rowing down a river from the same place at the same time. One rows at the rate of 4 miles per hour, and the other at $3\frac{1}{4}$ miles per hour. How far apart are they after 3 hours? 21

22/61 What two whole numbers multiplied together will make 7? 22

23/45 A boy spent a quarter of his money on sweets and twice as much on fruit. Half of what he had left was 15 cents. How much had he at first? 23

24/55 A boy has 3 miles to walk to get to school. He can cycle 4 times as fast as he can walk. How far has he to go when he cycles to school? 24

25/60 What fraction lies midway between $\frac{1}{4}$ and $\frac{1}{3}$? 25

26/89 5 per cent of A's income is the same as 15 per cent of B's. A's income is £300 a year. What is B's? 26

27/93 A box and its key cost Sh.1/20. The box costs Sh.1/- more than the key. What does the key cost? 27

28/100 The first even number is 2, the second is 4, and so on. What is the hundredth even number? 28

29/86 John and Henry start walking to meet one another from places $10\frac{1}{2}$ miles apart. If John walks at the rate of 3 miles an hour and Henry at 4 miles an hour, how long will it be before they meet? 29

30/57 My watch gains 4 minutes every day. It is set right at noon on Monday. What time will it show on the following Wednesday when the right time is 6 p.m.? 30

31/71 A man can dig his garden in 2 days, and his son can do it in 4 days. How long will it take them if they work together? 31

32/25 What is the cost of 50 cents worth of eggs at 7 for 90 cents? 32

33/95 A man rows with the stream at the rate of 3 miles an hour and against it at the rate of 1 mile an hour. What is the rate of the stream? 33

<u>STOP</u>.

Name ______________________________

ARITHMETICAL REASONING
Ballard Form C

This is a test of arithmetical reasoning. You will have 15 minutes.

Write your answers in the space provided on the right-hand side of each question. You can do rough work on this paper. Only the answer in the box will be marked. There are 34 questions.

1/26	If I pay Sh.6/- for 3 lb. of butter, what shall I have to pay for 2 lb.?	[ ]	1
2/24	How much must be added to Sh.4/50 to make Sh.10/-?	[ ]	2
3/30	On January 4th a man bought 10 lb. of potatoes for Sh.3/-. On January 6th he sold them in the market to 30 people for Sh.5/-. How much profit did he make?	[ ]	3
4/44	If half a cake costs 25 cents, what will 5 cakes cost?	[ ]	4
5/20	What is the number which is a quarter of five?	[ ]	5
6/62	Find the distance round a square whose sides are 8 in.	[ ]	6
7/46	Among how many boys may 35 apples be divided so that each gets $2\frac{1}{2}$ apples?	[ ]	7
8/42	Two-thirds of a class consists of 24 children. How many are there in the class?	[ ]	8
9/35	A boy was given three shillings. He gave half to his brothers and with the rest bought oranges at 10 cents each. How many did he buy?	[ ]	9
10/75	A man works a day, then rests a day, then works a day, then rests a day, and so on. For each day he works he earns Sh.15/-. How much will he earn from Monday morning to Friday night?	[ ]	10
11/73	The average of 5 numbers is 4. Four of the numbers are 2, 1, 5 and 5. What is the fifth number?	[ ]	11

GO STRAIGHT ON TO THE NEXT PAGE.

12/1 Jane is 18 years old. If Sarah were 5 years older she would be as old as Jane. How old is Sarah? 12

13/49 After spending half of my money and then half the remainder I had 20 cents left. How much did I have at first? 13

14/48 If five-eigths of my money is 10 cents, how much have I? 14

15/17 Five separate equilateral triangles of equal size are made from 60 in. of wire. How long is each side? 15

16/9 John has 30 oranges and James has 15 oranges. James gives John six of his oranges. How many more oranges has John than James? 16

17/38 If a train goes 12 miles in 10 minutes, how long will it take to go 1 mile? 17

18/36 A butcher in selling $3\frac{1}{4}$ lb. of meat gave 5 oz. short weight. What did the meat really weigh? 18

19/63 Mary and Margaret together earn Sh.10/- by making button-holes. Mary sews 3 while Margaret sews 2. What share of the Sh.10/- should Mary receive? 19

20/31 A boy measured a piece of string with a ruler and found that it was 6 ft. long. He then measured the ruler and found that it was only 11 in. long. What was the real length of the string? 20

21/97 How many times can one-third be taken away from twelve? 21

22/83 Seven posts 3 ft. apart are fixed in a row. How far is the first post from the last? 22

23/79 A rectangle is twice as long as it is broad. Its area is 200 sq.ft. What is its breadth? 23

24/81 If I share a shilling among two boys so that one gets ten cents more than the other, how much does the more fortunate boy get? 24

25/85 If telegraph poles stand 50 yards apart in a straight row, what is the distance from the first to the eighth? 25

26/34 What is the smallest sum of money that can be paid in either five shilling notes or ten shilling notes? 26

27/74 There are two numbers, one of which is larger than the other by 2. When multiplied together they make 143. What is the smaller number? 27

28/98 A man walks 5 yards north, 5 yards to the east, 5 yards to the south, and then 5 yards to the west. How far is he then from the starting point? 28

29/72 How much is three times the third of three and a third? 29

30/90 A street 30 yards long is planted on each side with trees 6 yards apart. How many trees are there? 30

31/87 A man walking at the rate of 4 miles an hour pursues another man who had an hour's start and walks at the rate of 3 miles an hour. How long will it take the pursuer to catch up the other man? 31

32/69 A man 5 ft. tall stands in the sunlight near a tree 40 ft. tall and casts a shadow of 6ft. How long is the shadow of the tree? 32

33/91 If a man's salary is increased by 10 per cent, and then reduced by 10 per cent, state whether he loses or gains and by what percentage. 33

34/82 A flower-bed 6 ft. square is surrounded by a path a foot wide. What is the areaof the path in square feet? 34

STOP.

Namo: TEST 04AROP

NECESSARY ARITHMETIC OPERATIONS TEST — R-4

This test consists of problems in mathematics. However, instead of solving the problems and finding an answer, your task will be merely to indicate which arithmetic operations could be used, if you solved the problems. Put an X through the number in front of the option that you select.

Example I

If a man earns Shs.2.75 an hour, how many hours should he work each day in order to make an average of Shs.22.50 per day?

1-subtract
2-divide
3-add
4-multiply

In order to solve the problem you should divide Shs.22.50 by Shs.2.75; therefore, you should have put an X through 2.

Example II

Desks priced at Shs.40 each are being sold in lots of 4 at 85% of the original price. How much would 4 desks cost?

1-divide and add
2-multiply and multiply
3-subtract and divide
4-multiply and divide

One way to solve the problem would be to multiply Shs.40 by ·85 and then multiply this product by 4; therefore, you should have put an X through number 2. (Although some problems may be solved in more than one way, as with Example II, only the operations for one of these ways will be given among the options).

When 2 operations are given, they are always given in the order in which they should be performed.

Your score on this test will be the number marked correctly minus a fraction of the number marked incorrectly. Therefore, it will not be to your advantage to guess unless you are able to eliminate one or more of the answer choices as wrong.

You will have 5 minutes for each of the 2 parts of this test. Each part has 3 pages. When you have finished Part 1, STOP. Please do not go on to Part 2 until you are asked to do so.

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

Part 1 (minutes)

1. There are 4 quarts in a gallon and 4 cups in a quart. How many cups are there in a gallon?

   1-add
   2-subtract
   3-multiply
   4-divide

2. An electric planing machine is set to remove .02 of an inch each time a piece of wood is passed through it. If a board is put through 7 times, how much wood will have been removed?

   1-multiply
   2-subtract
   3-divide
   4-add

3. There are 54 children at a small summer camp. If there are 33 boys attending the camp, how many campers are girls?

   1-add
   2-multiply
   3-subtract
   4-divide

4. A man wants to seed a lawn around his new house. His plot is 120 feet by 90 feet (10.800 sq.feet). His house is centred on the plot and occupies 2,785 sq.feet. How many square feet of ground may he sow with grass seed?

   1-add
   2-divide
   3-multiply
   4-subtract

5. A wholesale meat dealer sells beef for Shs.1.44 per pound and goats' meat for Shs.0.62 per pound. One day he sold 79 pounds of each. How much money was taken in?

   1-add and divide
   2-add and multiply
   3-multiply and subtract
   4-divide and divide

Part 1 (continued)

6. A cyclist in an international bicycle race has covered an average of 9 miles every 20 minutes. If he can maintain the same average speed, how long will it take him to cycle the remaining 84 miles of the race?

   1-divide and multiply
   2-subtract and divide
   3-add and subtract
   4-divide and add

7. A grocer sells oranges for Shs.1.18 per dozen. The oranges cost him Shs.0.66 a dozen. How much profit is there on each orange?

   1-subtract and multiply
   2-divide and subtract
   3-add and divide
   4-subtract and divide

8. A boy works in a shop after school for a total of 10 hours from Monday to Friday. He also works 8 hours on Saturdays. How much is he being paid per hour, if he earns Shs.20.70 per week?

   1-multiply and subtract
   2-add and divide
   3-divide and subtract
   4-add and multiply

9. A woman took a job which pays Shs.130 per week. After taxes have been deducted she is left with 76% of her salary, and each week she spends a total of Shs.6.00 on lunches and bus fares. How much does her job increase her family's income?

   1-divide and subtract
   2-subtract and multiply
   3-add and divide
   4-multiply and subtract

10. A rectangular underground reservoir is 15 feet deep and contains 2,000,000 gallons of water, when it is full. The Long Rains filled the reservoir, but the following drought caused the water level to drop 8 feet. Approximately how many gallons of water were consumed during the drought?

   1-subtract and divide
   2-add and subtract
   3-divide and multiply
   4-subtract and multiply

Part 1 (continued)

11. A certain cut of beef costs Shs.1.50 per pound. How much beef could a housewife serve to each of 5 people, if she could only afford to spend Shs.4.00 for the beef?

1-divide and divide
2-multiply and add
3-subtract and multiply
4-divide and multiply

12. A coat marked Shs.40.00 was sold for Shs.29.95 during a sale. What was the per cent reduction?

1-divide and add
2-subtract and divide
3-multiply and subtract
4-add and divide

13 At the beginning of the month, a car rental organization rented 37 cars. During the month, 32 of these cars were returned. If, at the end of the month, 43 of their cars were being rented, how many new rentals had been made?

1-subtract and divide
2-subtract and subtract
3-add and subtract
4-multiply and add

14. A Corporation doubled its assets by selling 1,000 shares of stock at Shs.75.00 per share. What were the Corporation's total assets after the stock had been sold?

1-multiply and divide
2-add and multiply
3-add and subtract
4-multiply and multiply

15. A certain housewife generally squeezes $1\frac{1}{2}$ oranges for a glass of orange juice. The average cost of the oranges she bought during one year was Shs.0.40 per orange. Approximately how much did it cost the family for the 827 glasses of juice that they drank during the year?

1-multiply and subtract
2-add and divide
3-multiply and multiply
4-divide and multiply

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

Part 2 (minutes)

16. If chocolate bars are sold by the dozen at a cost of 45 cents, how much does each bar cost?

1-multiply
2-divide
3-add
4-subtract

17. If a woman can weave a small rug in three days, what is the least number of days that she would need to complete 6 of these rugs?

1-add
2-subtract
3-multiply
4-divide

18. A book club is giving its members a discount of Shs.2.00 on each book. If the members buy a total of 1,721 books in a certain month, how much is the total discount for that month?

1-divide
2-multiply
3-subtract
4-add

19. If 2 inches are added to the length of a rectangle, its area is increased by $\frac{1}{2}$ sq.inch. What is the breadth of the rectangle?

1-divide
2-add
3-multiply
4-subtract

20. A salesman needed to drive the 300 miles from Nairobi to Mombasa. If he left Nairobi at 7:30 A.M. and arrived in Mombasa at 12:30 P.M., what was his average speed in miles per hour?

1-add and subtract
2-divide and multiply
3-multiply and add
4-subtract and divide

GO ON TO THE NEXT PAGE.

Part 2 (continued)

21. A particular television set can be purchased with cash for Shs.680, or it can be purchased on the installment plan for Shs.44 a month for 18 months. How much more would the television set cost on the installment plan?

1-multiply and add
2-add and divide
3-subtract and divide
4-multiply and subtract

22. A newspaper seller buys newspapers for 30 cents each and sells them for 50 cents each. How many papers must be sold to make a profit of Shs.4.00 per day?

1-subtract and divide
2-multiply and subtract
3-divide and multiply
4-add and divide

23. At the first day of the year, a shop's inventory showed goods worth Shs.31,250. During February the shop purchased goods worth Shs.29,834. In March a fire completely destroyed the shop. If the owner claimed a goods loss of Shs.47,420, how much goods had been sold before the fire occurred?

1-multiply and subtract
2-subtract and add
3-multiply and add
4-add and subtract

24. A clothing store took in Shs.93,752 in cash from one year's sales. At the end of the year there was also Shs.7,952 outstanding in uncollected accounts. If the store expects to collect 95% of these accounts, how much will it eventually take in for the year's sales?

1-subtract and multiply
2-divide and add
3-subtract and divide
4-multiply and add

25. A topographical map on which 1 inch equals 50 miles shows that a point 1 inch from the seacoast is 1,500 feet above sea level. What is the average number of feet that the ground must climb every 5 miles in order to reach that height?

1-multiply and subtract
2-divide and divide
3-add and divide
4-multiply and multiply

GO ON TO THE NEXT PAGE.

Part 2 (continued)

26. A farmer has his home and cattle insured for Shs.52,000. The yearly premium rate is Shs.2.05 per Shs.100. How much does this insurance cost him each year?

1-divide and add
2-add and multiply
3-divide and multiply
4-subtract and divide

27. John, who is eight years old, has been given an allowance of 25 cents per week. Each year he will get a rise of 20 cents per week. How much will his weekly allowance be 10 years from now?

1-multiply and add
2-subtract and divide
3-divide and subtract
4-add and multiply

28. A man who owns a motor boat which uses 54 gallons of petrol every 6 hours when it is cruising at $\frac{1}{4}$ speed. If the same boat uses 20 gallons an hour when it is running at $\frac{3}{4}$ speed, how many fewer gallons are used per hour at $\frac{1}{4}$ than at $\frac{3}{4}$ speed?

1-multiply and multiply
2-add and divide
3-divide and subtract
4-subtract and add

29. At present, Mr. Mwangi receives an annual interest of Shs.42 from a Shs.910 investment. He wants to increase his investment so that he will get Shs.437 interest annually. What is the total amount that he must have invested at the same rate of interest?

1-divide and divide
2-subtract and divide
3-multiply and subtract
4-add and multiply

30. A motorist spent Shs.31.20 for petrol in the first 4 days of a 20 day trip. At this rate what will his petrol expenditure be for the entire trip?

1-multiply and add
2-divide and multiply
3-add and divide
4-subtract and multiply

DO NOT GO BACK TO PART 1

STOP.

Name . . . . .TEST 05LENO. . . . .

LETTERS AND NUMBERS TEST

In this test, wherever you see a dot, there is one letter or number missed out. Write the missing letters or numbers just above the dot.

e.g. A B C D E

1. hot cold wet dry fast slow down . .

3. ACBD EGFH IKJL . . . .

4. 2 8 18 32 . .

5. AZ CX EV . .

6. 212 323 434 545 . . .

7. grass green sky blue soot . . . . . .

8. than an thought ought think . . .

9. Sunday 1 Monday 2 Saturday .

10. peat pea note not bowl . . .

11. 1 inch 12 foot 36 . . . .

12. shark hark ark spill pill . . .

13. no on ten net deer . . . .

14. C 18 D 16 E 14 F 12 . . .

15. head hat foot shoe hand . . . . .

16. she he sill ill slow . . .

17. A Z B Y C X D W .

18. January March May . . . .

GO STRAIGHT ON TO THE NEXT PAGE.

19. finger hand arm toe foot . . .

20. we our she her he . . .

21. bag beg big . . . bug

22. he ha end and rein . . . .

23. 864 753 642 531 . . .

24. Wednesday Tuesday Friday Thursday Saturday . . . . . .

25. great get tarry try blind bid chain . . .

26. RZKT TRZK KTRZ . . . .

27. beneath bath swallow slow torrent . . . .

28. sheathe heath eat .

29. sloops pool unity tin zone . .

30. bread dread ham jam nail . . . .

31. umpire rum pie search she car estate . . . tea

32. dough cough bough teal seal . . . .

33. B C E H L .

34. rain into tone . . . . atom

35. ALZ DMX CNV . JOT . . .

36. sleet hail greet animal bear carry
recline lie falsehood bag . . . . dismiss

37. DeF HiJ LmN . . .

38. 100 baa 201 cab 106 bag 543 . . .

39. dare case fate h . . .

40. TOWN VQYP CITY . . . .

41. 396 584 772 . . .

STOP HERE.

TEST 06LEST

Name: ____

LETTER SETS TEST — I-1

Each problem in this test has five groups of letters with four letters in each group. Four of the groups of letters are alike in some way. You are to find the rule that makes these four groups alike. The fifth group is different from them and will not fit this rule. Draw an X through the group of letters that is different.

NOTE: The rules will not be based on the sounds of groups of letters, the shapes of letters, or whether letter combinations form words or parts of words.

Examples:

A.	NOPQ	~~DEFL~~	ABCD	HIJK	UVWX
B.	NLIK	PLIK	QLIK	~~THIK~~	VLIK

In example A, four of the groups have letters in alphabetical order. An X has therefore been drawn through DEFL. In example B, four of the groups contain the letter L. Therefore, an X has been drawn through THIK.

Your score on this test will be the number of problems marked correctly minus a fraction of the number marked incorrectly. Therefore, it will not be to your advantage to guess unless you are able to eliminate one or more of the letter groups.

You will be allowed 7 minutes for each of the two parts of this test. Each part has 1 page. When you have finished Part 1, STOP. Please do not go on to Part 2 until you are asked to do so.

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

The Alphabet:

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

Part 1 (7 minutes)

1.	QPPQ	HGHH	TTTU	DDDE	MLMM
2.	BCDE	FGHI	JKLM	PRST	VWXY
3.	PABQ	SEFT	VIJW	COPD	FUZG
4.	LNLV	DTFL	CLNL	HRLL	LLWS
5.	BDCE	FHGI	JLKM	PRQS	TVWU
6.	BCCB	GFFG	LMML	QRRQ	WXXW
7.	DCDD	HGHH	MMLM	QQQR	WWVW
8.	ABCX	EFGX	LJKX	OPQX	UVWZ
9.	GFFG	DCCD	STTS	RQQR	MLLM
10.	DEGF	KLHJ	NOQP	PQSR	TURS
11.	CERT	KMTV	FHXZ	BODQ	HJPR
12.	CFCR	JCVC	CGCS	CLXC	KCWC
13.	PXCC	EEQX	RXGG	IISX	TXLL
14.	VEBT	XGDV	ZIFX	KXVH	MZXJ
15.	AFBG	EJFK	GKHM	PSQT	RWSX

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

STOP.

The Alphabet:

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

Part 2 (7 minutes)

16.	BDBB	BFDB	BHBB	BBJB	BBLB
17.	NABQ	PEFS	RIJV	GOPK	CUWH
18.	CAEZ	CEIZ	CIOZ	CGUZ	CAUZ
19.	BDEF	FHIJ	HJKL	NPQR	SVWX
20.	BVZC	FVZG	JVZK	PWXQ	SVZT
21.	ABDC	EGFH	IJLK	OPRQ	UVXW
22.	AAPP	CCRR	QQBB	EETT	DDSS
23.	ABCE	EFGI	IJKM	OPQT	UVWY
24.	XDBK	TNLL	VEGV	PFCC	ZAGZ
25.	FEDC	MKJI	DCBA	HGFE	JIHG
26.	BCEF	FGIJ	STWX	CDFG	PQST
27.	BEPW	HJTX	KNRZ	KOSV	WRPM
28.	RRBR	QQAR	FTEF	JXIJ	SSCS
29.	AOUI	CTZR	JHTN	PBRL	RTVH
30.	WOGD	BFOP	GHUZ	XSIH	POLF

DO NOT GO BACK TO PART 1 and

DO NOT GO ON TO ANY OTHER TEST UNTIL ASKED TO DO SO.

STOP.

TEST 07SEEP

Name: ____

SEEING PROBLEMS — Sep-2

In this test you will be given names of common objects. You will be asked to write down problems that you think of when you think about each of these objects. You do not have to think of any answers to the problems. All you have to do is think of the problems and write them down.

For example, if you were given the word "candle" you might see the following problems:

1. How to light it
2. Keeping it from falling over
3. Keeping it burning steadily
4. How long will it burn
5. What to do with the dripping wax

Your problems should deal with the use of the object, its shape, or what it is made of. Do not waste your time thinking of ways to get the object or ways to get rid of it, as these will not be counted. You will have minutes for each page (there are three objects on each page)

In the test you are to write as many as <u>five</u> different problems for each object named. You need not write more than five problems for any one object. If you cannot think of five, write as many as you can, then go on to the next object.

If you have questions, ask them now.

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

Part 1 (minutes)

Write different problems for each of these objects. If you cannot think of any more problems, go on to the next object.

Tree

1. ____________________

2. ____________________

3. ____________________

4. ____________________

5. ____________________

Hammer

1. ____________________

2. ____________________

3. ____________________

4. ____________________

5. ____________________

Wind

1. ____________________

2. ____________________

3. ____________________

4. ____________________

5. ____________________

STOP HERE.

Part II (minutes)

Write different problems for each of these objects. If you cannot think of any more problems, go on to the next object.

Paint

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________

Box

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________

Lake

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________

STOP HERE.

Part III (minutes)

Write different problems for each of these objects. If you cannot think of any more problems, go on to the next object.

Envelope

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

Curtain

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

Sun

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

STOP HERE.

Part IV (minutes)

Write different problems for each of these objects. If you cannot think of any more problems, go on to the next object.

Glue

1. ______
2. ______
3. ______
4. ______
5. ______

Rope

1. ______
2. ______
3. ______
4. ______
5. ______

Potato

1. ______
2. ______
3. ______
4. ______
5. ______

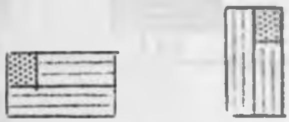
STOP HERE.

TEST 08FLGS

Name . . . .

F L A G S

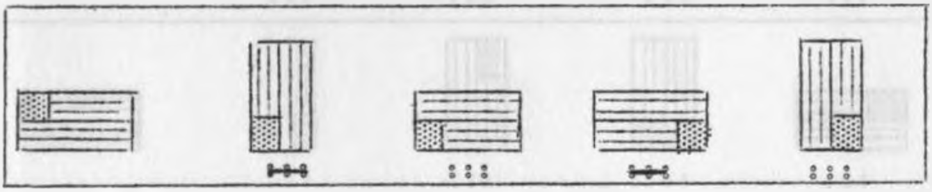
The two flags below are alike. You can slide one around on the page to fit the other exactly.



Now look at the next two flags. They are different. You cannot make them fit by sliding around on the page.

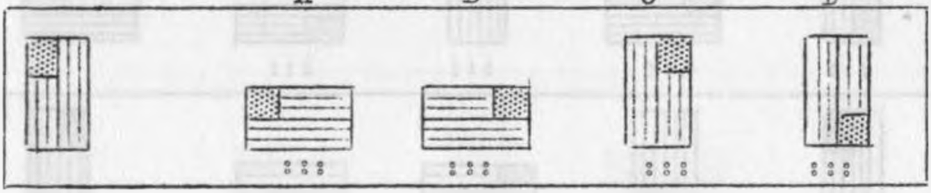
Here are more flags. Some of the flags are marked. The flags that are like the first flag in this row are marked.

A B C D



Below is another row of flags. Mark all the flags that are like the first flag in the row.

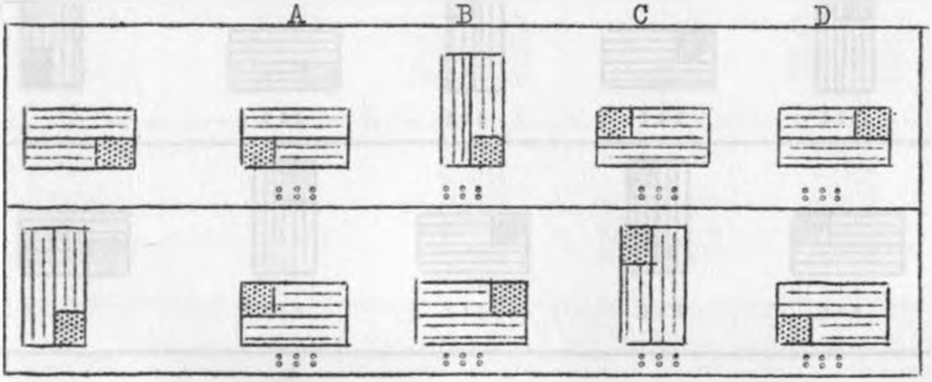
A B C D



You should have marked the flags B and D.

Here are more flags for you to mark. In each row mark every flag that is like the first flag in the row.

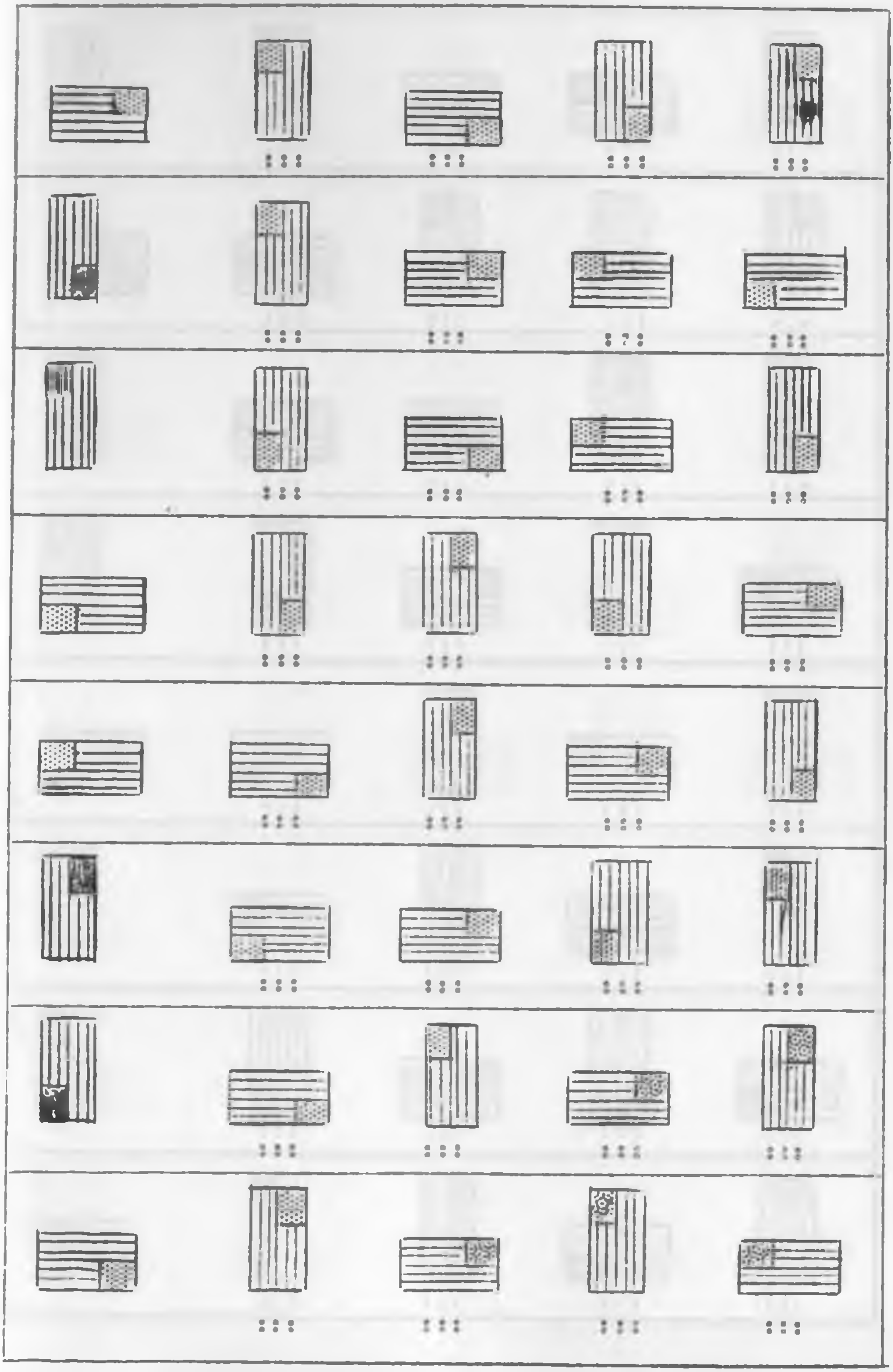
A B C D



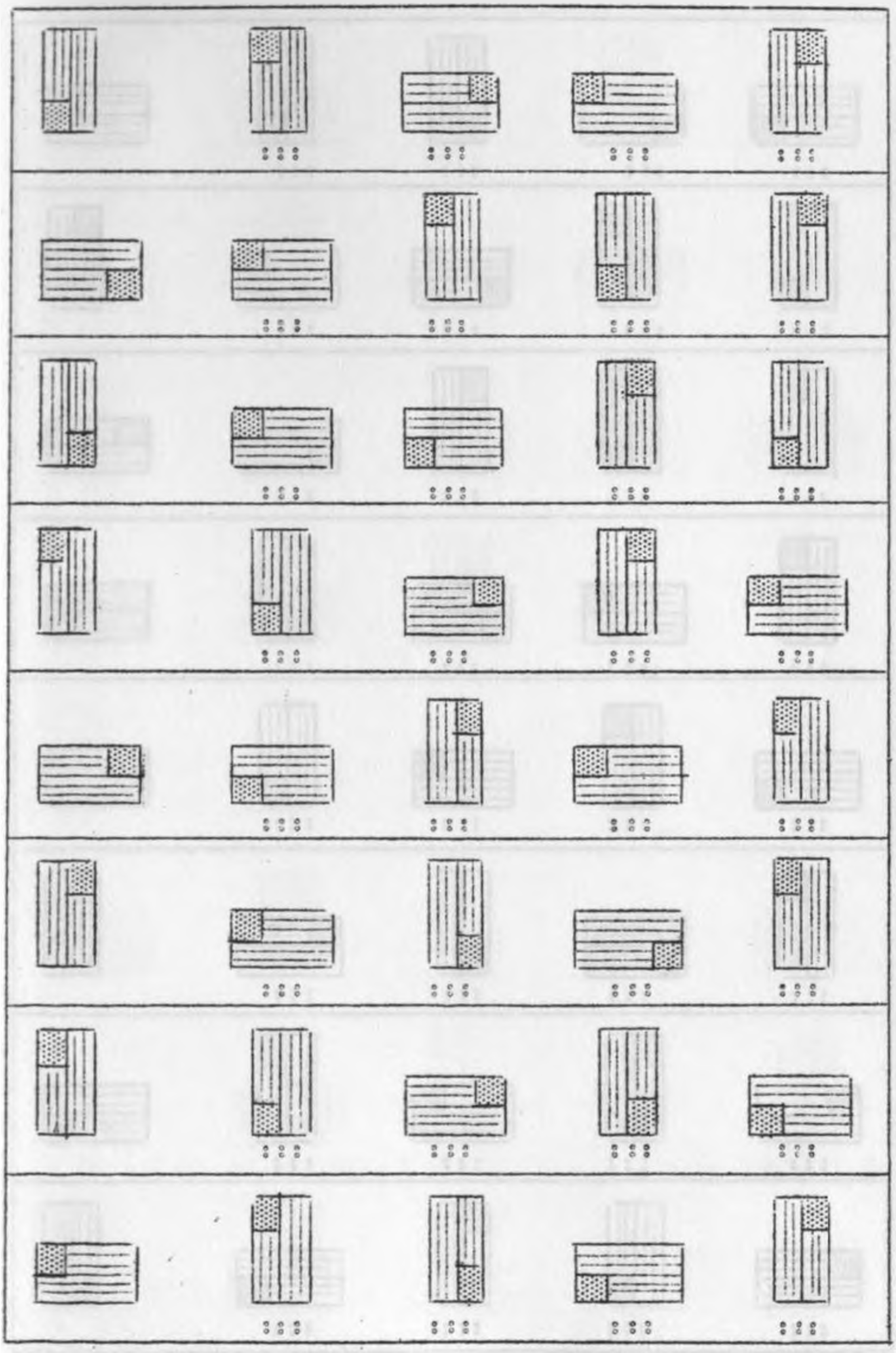
STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

In each row mark every flag that is like the first flag in the row

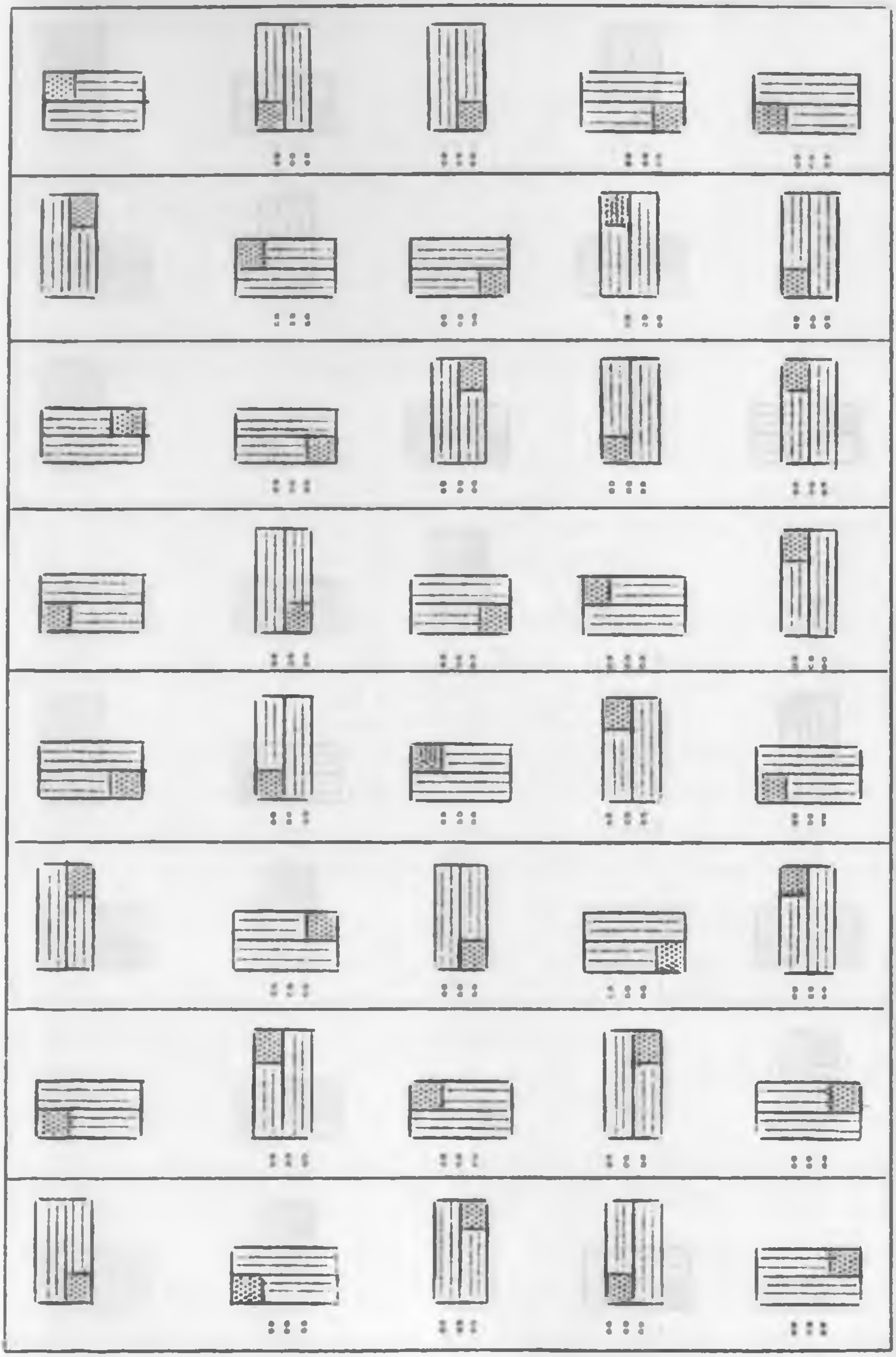
N.B. There are FOUR pages of flags.



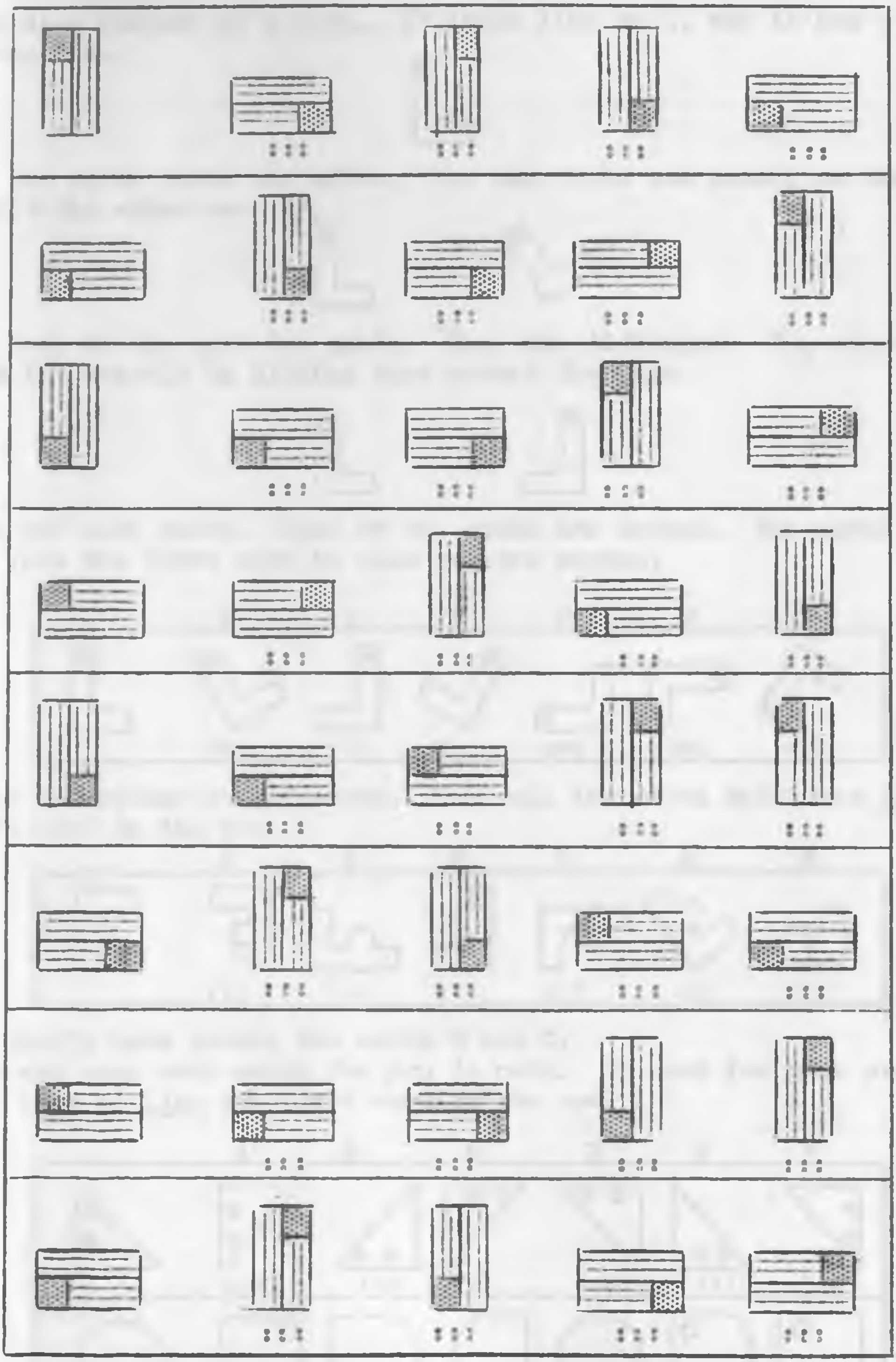
GO STRAIGHT ON TO NEXT PAGE.



GO STRAIGHT ON TO NEXT PAGE.



GO STRAIGHT ON TO NEXT PAGE.



STOP HERE

Name . . . .

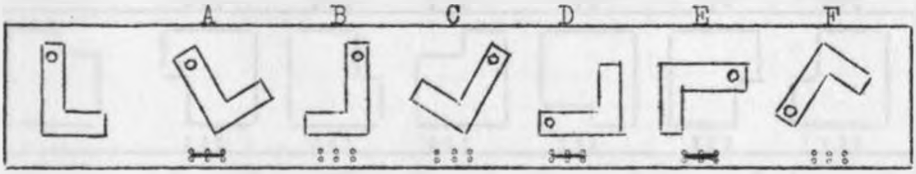
C A R D S

Here is a picture of a card. It looks like an L, and it has a hole in one end.

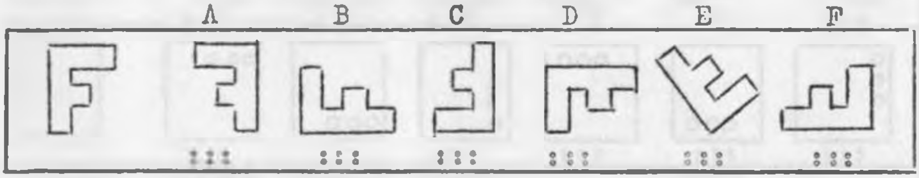
The two cards below are alike. You can slide one around on the page to fit the other exactly.

Now look at the next two cards. They are different. You cannot make them fit exactly by sliding them around the page.

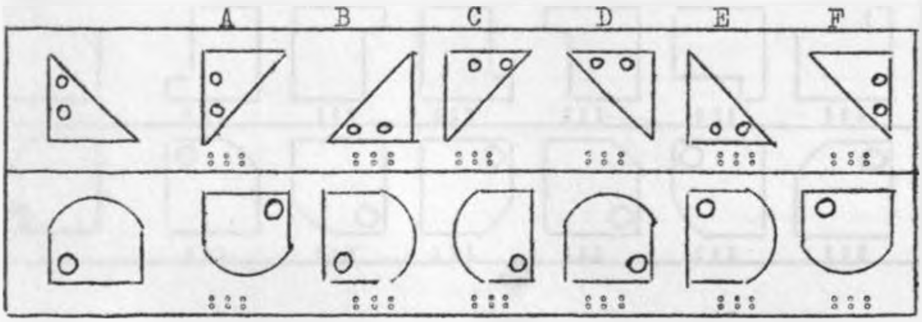
Here are more cards. Some of the cards are marked. The cards which are like the first card in this row are marked.



Below is another row of cards. Mark all the cards which are <u>like</u> the first card in the row.



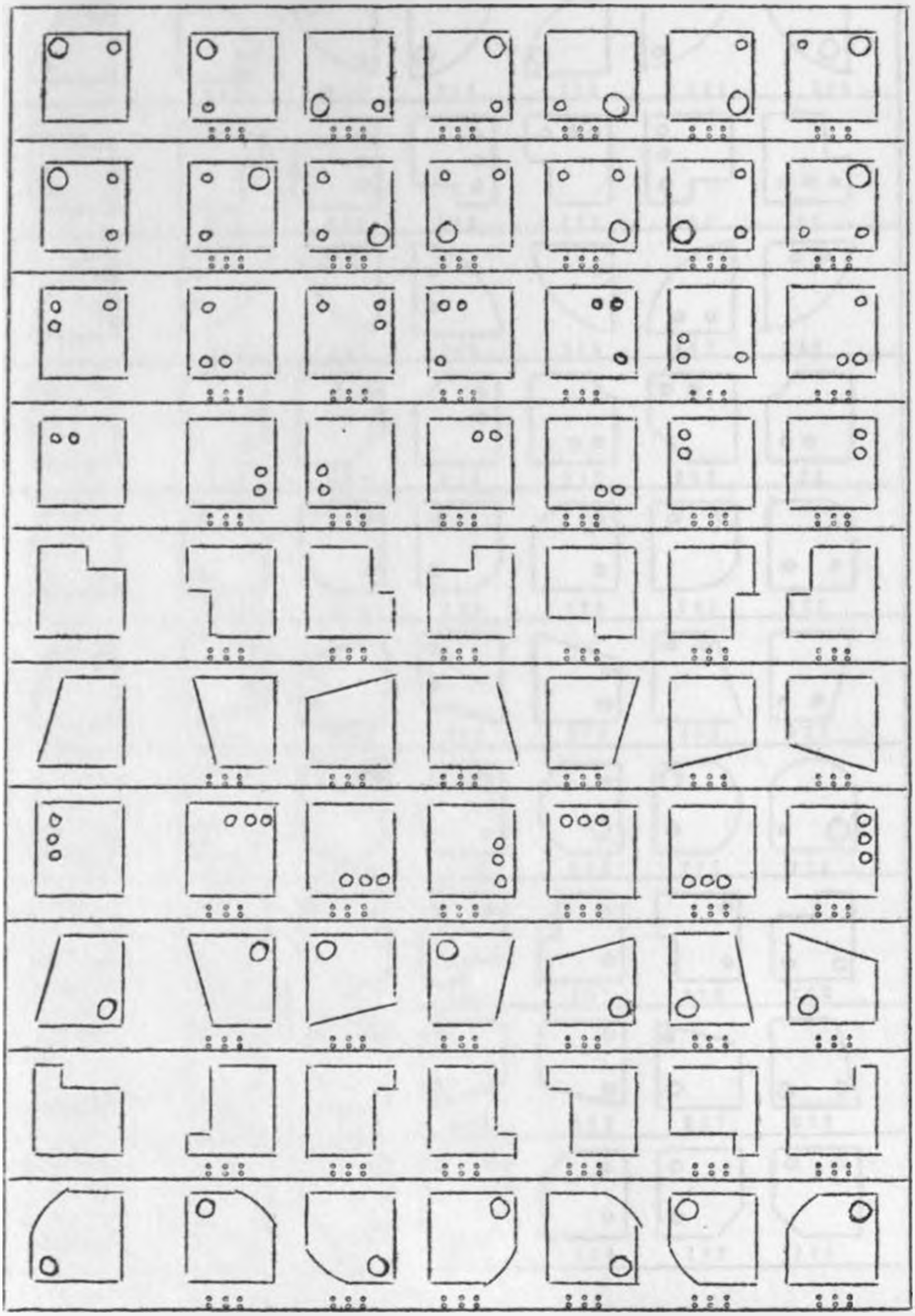
You should have marked the cards B and C.
Here are some more cards for you to mark. In each row mark every card that is <u>like</u> the first card in the row.



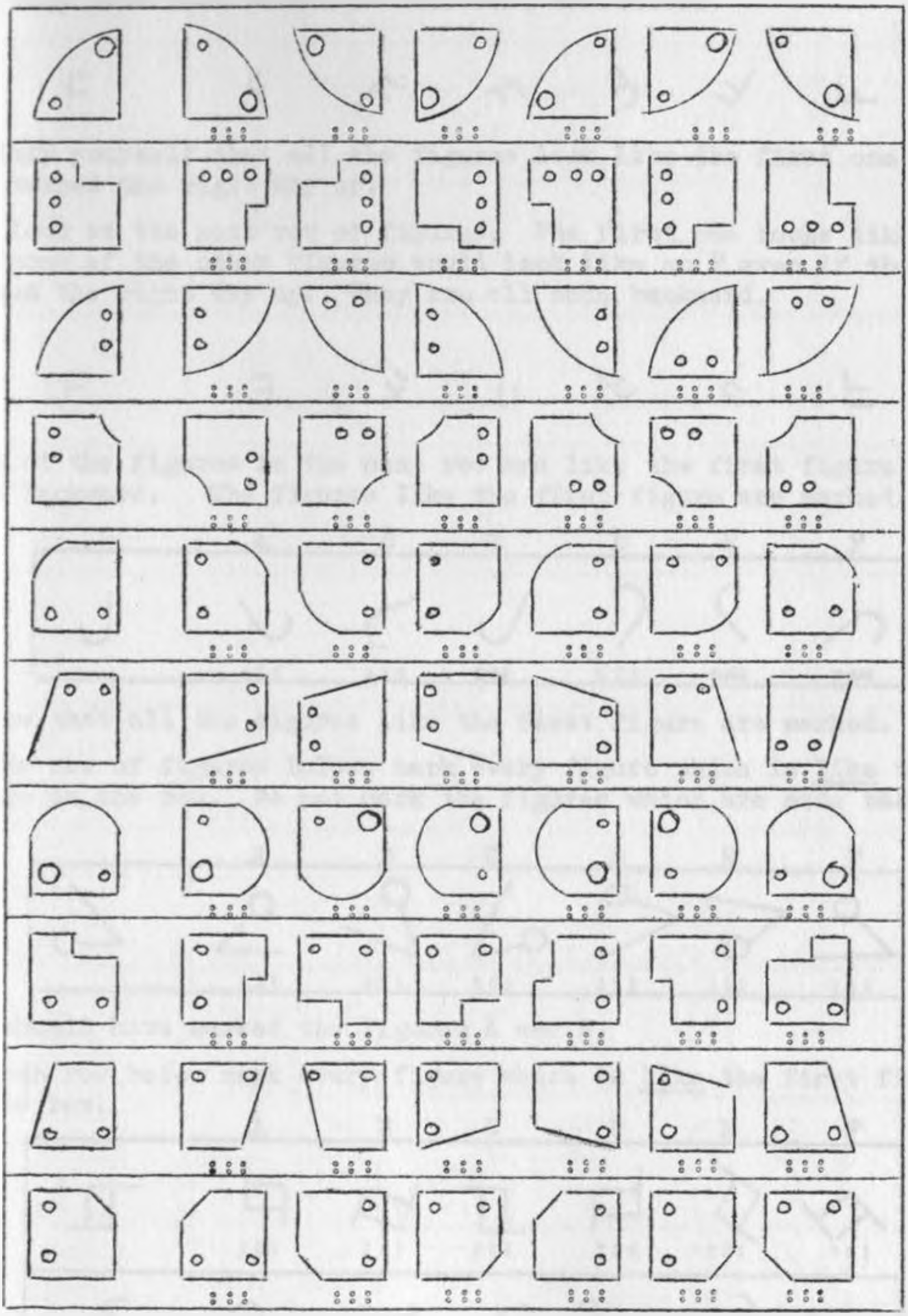
<u>STOP HERE</u>. WAIT FOR FURTHER INSTRUCTIONS.

In each row mark every card that is <u>like</u> the first card in the row.

N.B. There are TWO pages of cards.



GO STRAIGHT ON TO NEXT PAGE.



STOP HERE

Name . . . .

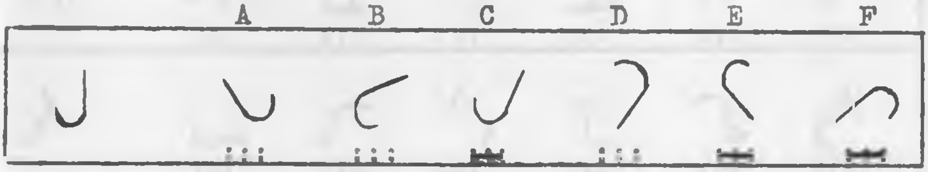
FIGURES

Look at the row of figures below. The first figure is like the letter F which is the right side up. All the other figures are like the first but they have been turned in different directions.

Satisfy yourself that all the figures look like the first one if they are turned the right way up.

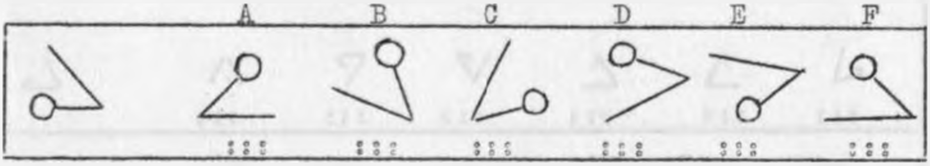
Now look at the next row of figures. The first one looks like an F. But none of the other figures would look like an F even if they were turned the right way up. They are all made backward.

Some of the figures in the next row are like the first figure. Some are made backward. The figures like the first figure are marked.



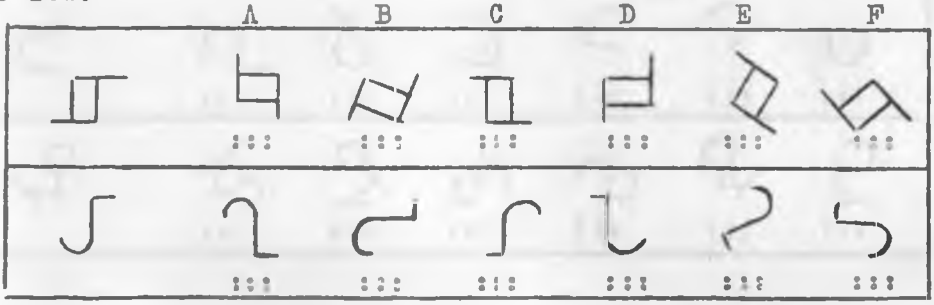
Notice that all the figures like the first figure are marked.

In the row of figures below, mark every figure which is <u>like</u> the first figure in the row. Do not mark the figures which are made backward.



You should have marked the figures A and E.

In each row below mark every figure which is <u>like</u> the first figure in the row.

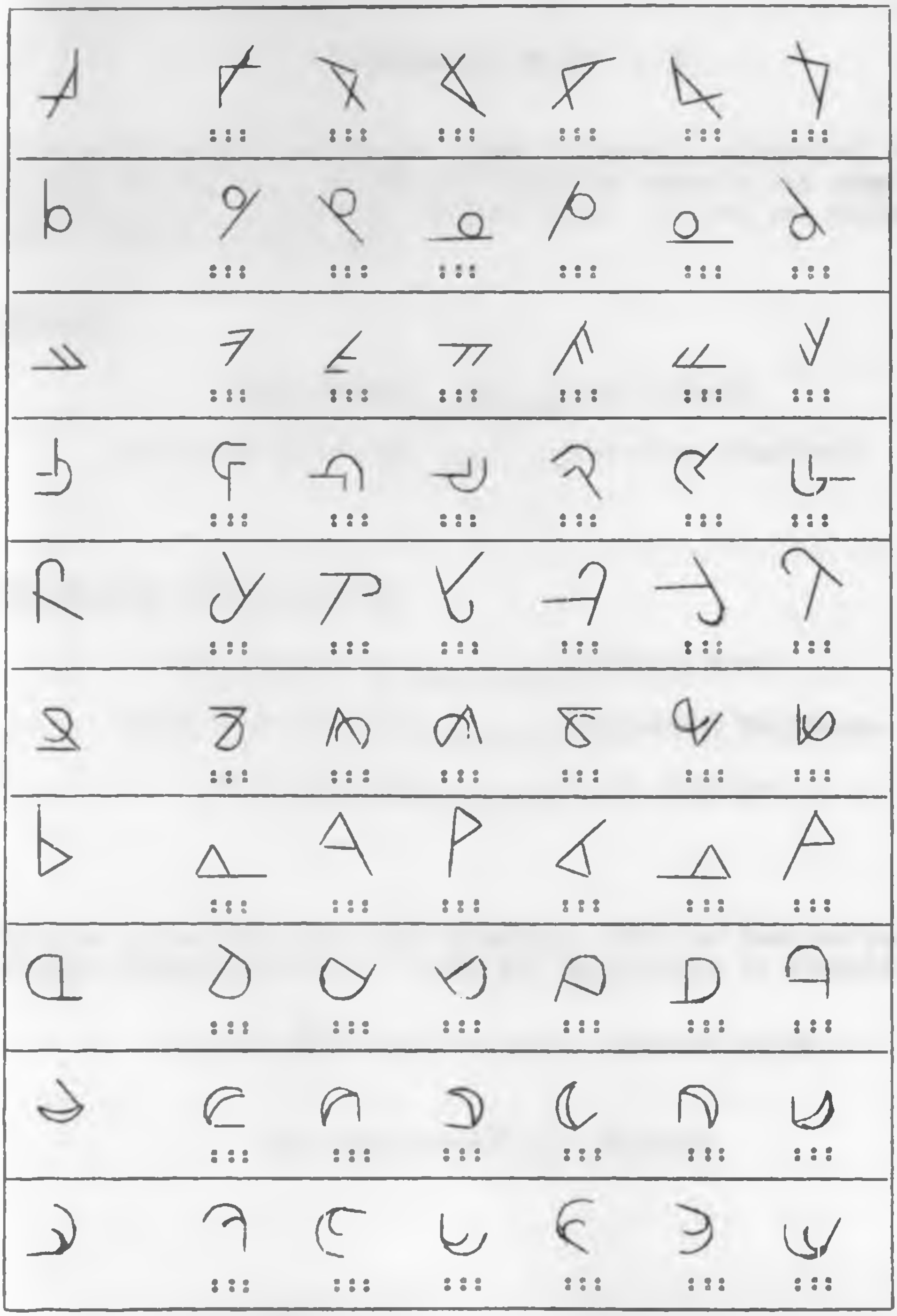


STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

In each row put a mark under every figure which is like the first figure in the row.

N.B. There are TWO pages of figures.

GO STRAIGHT ON TO NEXT PAGE.



STOP HERE

TEST 11PERW

Name: ____

PERCEPTUAL TE ST - P

This test consists of names; names of people, companies, buildings, streets and so on. If the two names are exactly the same make a tick mark (✓) on the line between them; if they are different, make a cross on that line.

Example.

John C.Kamau____×____John C.Kamua

Investors Syndicate____✓____Investors Syndicate

Now try the examples below

Salisbury Hotel __________Salsbury Hotel

Parliament Building__________Parliament Buildings

F. N. Njoroge__________F. N. Njoroge

This is a test for Speed and Accuracy. Work as fast as you can without making mistakes: there are three pages to attempt.

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

The time allowed is minutes

1.	Ruhr-Stickstoff	________	Ruhr Stickstoff
2.	Macos (E.A.) Ltd.	________	Macos (E.A.) Ltd.
3.	Ruaraka General Store	________	Ruaraka General Store
4.	Tutu Coffee Ltd.	________	Tutu Coffee Co.
5.	Twentsche Overseas	________	Twentsche Overseas
6.	Wigglesworth & Co.	________	Wigglesworth & Co.
7.	C.C.K. Nakuru	________	C.C.K. Nakuru
8.	Samuel Muchiru	________	Samual Muchiru
9.	Pictorial Review	________	Pictorial Review
10.	Dagoretti Centre	________	Dagorreti Centre
11.	J. T. Mathai	________	J. T. Mathai
12.	John Skinner & Sons	________	John Skinner & Sons
13.	Vishram Pirbhai	________	Vishram Pirbhaj
14.	Harambee Avenue	________	Harambee Street
15.	Red Hill Road	________	Red Hill Road
16.	Sheikh H.El-Kindy	________	Shiekh H.El-Kindy
17.	Kariithi K. G.	________	Kariithi K. G.
18.	Total Ltd.	________	Total Ltd.
19.	J. Omondi	________	J. Omonde
20.	Keeley Institute	________	Keeley's Institute
21.	Jan Mohammed	________	Jan Mohamed
22.	Upland's Bacon	________	Uplands' Bacon
23.	MacMillan Library	________	McMillan Library
24.	J. F. M. Koite	________	J. F. W. Koite
25.	Lake Victoria	________	Lake Victoria

GO STRAIGHT ON TO THE NEXT PAGE.

26.	Rev. L. MacPherson	Rev. L. Macpherson
27.	S. O. Onamu	S. O. Onamu
28.	Adams Arcade	Adam Arcade
29.	Kariokor	Kariokor
30.	Mamugee Brothers	Mamugee Bros.
31.	Glad Rags'	Glad Rags'
32.	Zimmermann Ltd.	Zimmermann Ltd.
33.	Malik Street	Malek Street
34.	Fred Berger	Fred Berger
35.	Nyanjuki Mills	Nyanjuki Mills
36.	E. T. Monks Ltd.	E. T. Monks Ltd.
37.	Elisabeth Njeru	Elizabeth Njeru
38.	Giraffe Ltd.	Giraffe Ltd.
39.	Kajiado Plains	Kajiado Plains
40.	M. E. Ogond'o	M. E. Ogondo
41.	Thompson's Falls	Thomson's Falls
42.	Sceix Co.	Sciex Co.
43.	Goodyear Tyre Co.	Goodyear Tyre Co.
44.	New Stanley Hse.	New Stanley Hse.
45.	Shimba Hills	Simba Hills
46.	Thakrar J. K.	Thakrar K. J.
47.	"Henry" Hairdresser	'Henry' Hairdresser
48.	Twentieth Century	Twentieth Century
49.	Meru Co-operative Ltd.	Meru Cooperative Ltd.
50.	H. Merryweather	H. Merryweather

GO STRAIGHT ON TO THE NEXT PAGE.

51.	Chege Tile Co.__________	Cege Tile Co.
52.	Dr. J. R. Singh__________	Mr. J. R. Singh
53.	Shah Keshavlal__________	Shah Keshavlal
54.	Kilindini Road__________	Klinidini Road
55.	Taws Ltd.__________	Taws Ltd.
56.	Polytechnic College__________	Polytechnic College
57.	Sales & Service__________	Sales & Service
58.	Kamagambo__________	Kamagambo
59.	Selous Co.__________	Selos Co.
60.	Clinton F. N.__________	Clinten F. N.
61.	Otieno Oyoo St.__________	Otieno Oyoo St.
62.	Mbaya House__________	Mbaya House
63.	Kamau Stores__________	Kamau Stores
64.	Kenol Oil__________	Kenol Oil
65.	Bernard Gdns.__________	Bernard Gdrs.
66.	Raja Co.__________	Raja Co.
67.	University College__________	University College
68.	Keekerok Lodge__________	Keekerok Lodge
69.	Panafric Hotel__________	Panafrica Hotel
70.	Dr. Ngata__________	Dr. Ngatia
71.	The Orphanage__________	The Orphanage
72.	Mwangi & Oloo (E.A.)__________	Mwangi & Oloo (A.E.)
73.	Esso Ltd.__________	Esso Ltd.
74.	Blanche Acadamy__________	Blanche Academy
75.	Herbert Chitepo__________	Herbert Chitepo

STOP HERE.

TEST 12PERN

Page 5

Perceptual Test - P

PART II

This tset consists of numbers. If the two numbers are exactly the same mako a tick mark (✓) on the line between them: if they are different make a cross on that line.

Example.

3,562,315	×	3,526,315
2047·321	✓	2047·321

Now try the examples below

0·2584321	________	0·2584321
83465·21	________	834652·1
5231987	________	523987

This is a test for Speed and Accuracy with numbers. Work as fast as you can without making mistakes.
Thero is only one page; do both columns.

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

The time allowed is minutes

Column 1

25634	_____	25634
100,231	_____	100,231
745,261	_____	754,261
1·0294	_____	1.0294
32056892	_____	32056892
2678902	_____	2768902
0·982471	_____	0·982417
72·985	_____	72·985
69·9697	_____	96·9697
724,856,001	_____	724,856,001
7243·856	_____	724·3856
92,573,218	_____	92,573,218
65,432,432	_____	65,423,432
0·01010101	_____	0·01010101
0·234567	_____	0·23467
47502·56	_____	47502·56
853210·78	_____	853210·87
5431	_____	5431
7432	_____	7342
932,405,318	_____	93,245,318
0·2000002	_____	0·2000002
1·31679	_____	1·36179
4,004,212	_____	4,004,212
3,040,050,006	_____	3,040,059,006
2·197421	_____	2·179421

Column 2

5,001,010,001	_____	5,001,001,010
101	_____	1001
3450165	_____	345165
30,473	_____	30,473
59,642	_____	59,246
34567890	_____	34567890
876421	_____	876431
942187532	_____	942187532
4321·297	_____	4321·297
9375·3562	_____	937·53562
10·012	_____	10·12
274,362	_____	274,462
2043074	_____	2043074
40132009	_____	4013009
0·9753	_____	0·09753
0·0001437	_____	0·001437
65,421,777	_____	65,412,777
4·2143658	_____	4·2143678
2,222,000,002	_____	2,202,000,002
0·9321	_____	0·9331
47,362·9	_____	47,362·9
35,421·7	_____	35,420·7
101001001000	_____	10101001000
3457	_____	3745
4987·654	_____	4987·654

STOP.

TEST 130BMR

Name: ______________________________

OBJECT - NUMBER TEST — Ma-2

This is a test of your ability to learn combinations of words and numbers. In each part of the test you will study a page showing 15 object names with numbers. After studying the page showing both objects and numbers you will turn to a page showing the names of the objects in a different order. You will be asked to write down the numbers that go with them.

Here is a practice list. Study it until you are asked to turn to the practice test page (1 minute).

Object	Number
window	73
desk	41
carpet	19
door	84
glass	90

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

PRACTICE TEST PAGE

For the first object below, the correct number has been written. Write all of the other numbers that you can remember.

Object	Number
desk	41
glass	____
window	____
door	____
carpet	____

Your score will be the number marked correctly. Even if you are not sure of the correct answer to a question, it will be to your advantage to guess.

There are two parts in this test. Each part has two pages:

The first of these is a memory page which you are to study for 3 minutes.

The second is a test page on which you are to write the numbers that go with the objects. You will have 2 minutes to write.

When you have finished Part 1, STOP. Please do not go on to Part 2 until you are asked to do so.

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

MEMORY PAGE FOR PART 1

Study this list. You will have 3 minutes.

Object	Number
tree	58
floor	29
chair	33
wall	56
shoe	17
table	78
coat	49
roof	22
dish	36
pillow	43
post	65
tile	35
plate	26
shade	40
rock	62

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

STOP.

TEST PAGE FOR PART 1

Write the number that belongs with each of the objects. You will have 2 minutes.

Object	Number
coat	____
post	____
pillow	____
floor	____
shoe	____
shade	____
tile	____
roof	____
wall	____
rock	____
tree	____
chair	____
plate	____
dish	____
table	____

DO NOT TURN TO PART 2 UNTIL ASKED TO DO SO.

STOP.

MEMORY PAGE FOR PART 2

Study this list. You will have 3 minutes

Object	Number
mop	23
jacket	18
brick	54
mat	31
board	14
cup	77
bush	37
clip	42
spoon	63
piano	28
bed	59
ceiling	82
vase	44
panga	13
razor	91

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

STOP.

TEST PAGE FOR PART 2

Write the number that belongs with each of the objects. You will have 2 minutes.

Object	Number
mat	___
clip	___
panga	___
board	___
ceiling	___
spoon	___
vase	___
mop	___
cup	___
bed	___
bush	___
jacket	___
razor	___
piano	___
brick	___

DO NOT GO BACK TO PART 1

STOP.

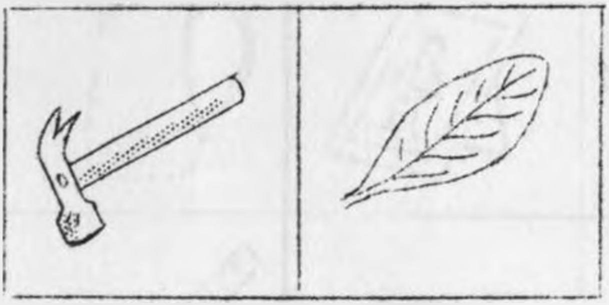
TEST 14PCMR

Name : ____

PICTURE MEMORY TEST

This is a test of your ability to remember names of objects. You will study a page of twenty objects. After studying the page showing the objects you will turn to the next page and will write down the names of objects in any order you like.

Here is an example. Below are drawings of two objects.



They are, of course, a hammer and a leaf.

On the following page you would have written:

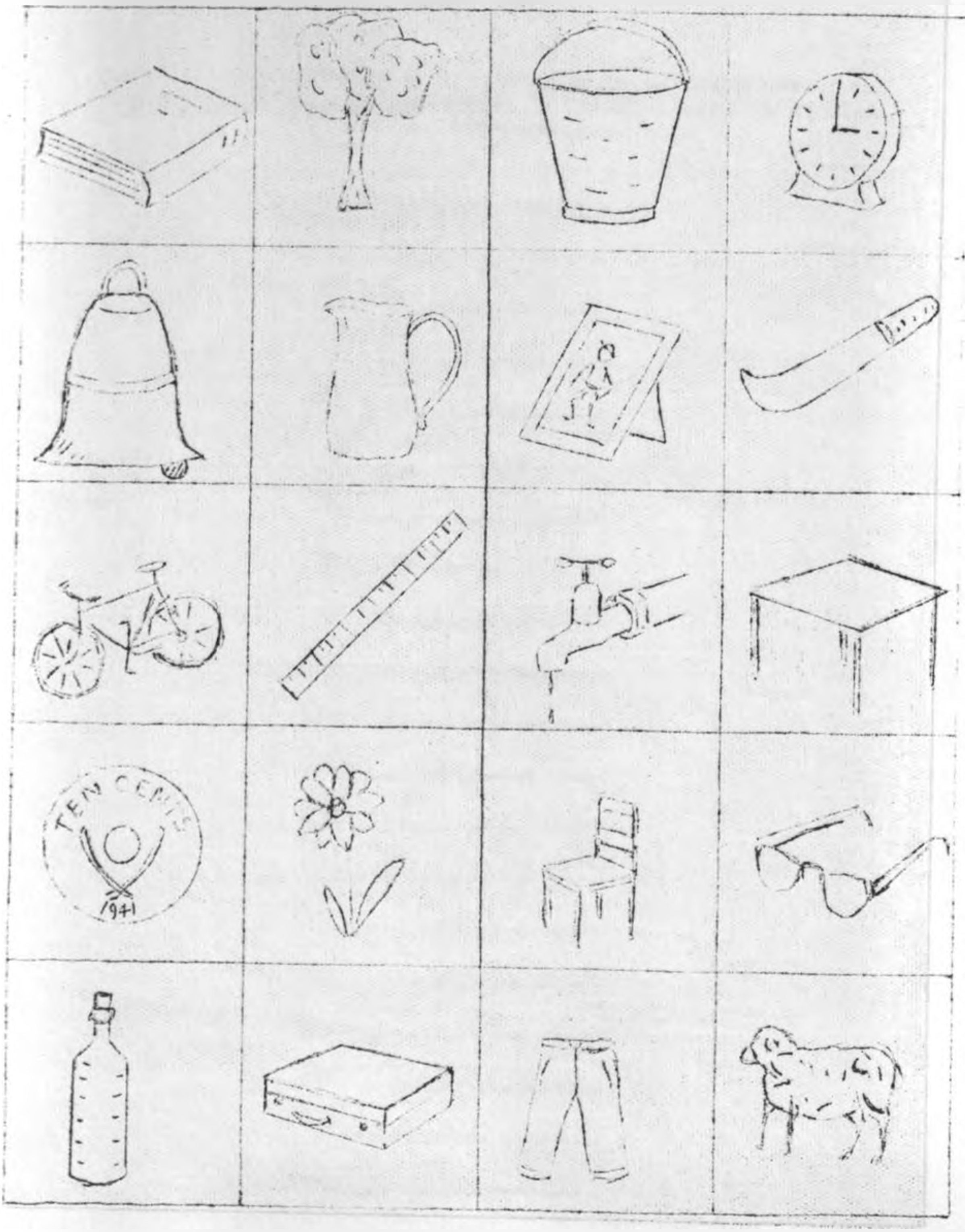
1. LEAF
2. HAMMER

You will have 2 minutes to study the pictures and $1\frac{1}{2}$ minutes to write down their names.

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

MEMORY PAGE

Study these objects. You will have 2 minutes to learn their names



DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

TEST PAGE

Write the name of each of the objects in the pictures. You can write them in any order. You will have $1\frac{1}{2}$ minutes.

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________
6. ____________________
7. ____________________
8. ____________________
9. ____________________
10. ____________________
11. ____________________
12. ____________________
13. ____________________
14. ____________________
15. ____________________
16. ____________________
17. ____________________
18. ____________________
19. ____________________
20. ____________________

Name: ....TEST 15OTIS

This is a test to see how well you can think. It contains questions of different kinds. Here is a sample question already answered correctly. Notice how the question is answered.

Which one of the five words below tells what an apple is?
1 flower, 2 tree, 3 vegetable, 4 <u>fruit</u>, 5 animal .... (4)

The right answer, of course, is "fruit"; so the word "fruit" is underlined. And the word "fruit" is No.4; so the figure 4 is placed in the brackets at the end of the dotted line. This is the way you are to answer the questions.

Try this sample question yourself. Do not write the answer; just draw a line under it and then put its number in the brackets:

Which one of the five things below is round?
1 a book, 2 a brick, 3 a ball, 4 a house, 5 a box .... (   )

The answer is, of course, is "a ball"; so you should have drawn a line under the words "a ball" and put a figure 3 in the brackets. Try this one:

A foot is to a man and a paw is to a cat the same as a hoof is to a -what?
1 dog, 2 horse, 3 shoe, 4 blacksmith, 5 saddle .... (   )

The answer, of course, is "horse"; so you should have drawn a line under the word "horse" and put a figure 2 in the brackets. Try this one:

At forty cents each, how many cents will 6 pencils cost? .... (   )

The answer of course is 240, and there is nothing to underline; so just put the 240 in the brackets.

If the answer to any question is a number or a letter, put the number or letter in the brackets without underlining anything. Make all letters like printed capitals.

The test contains 75 questions. You are not expected to be able to answer all of them, but do the best you can. You will be allowed half an hour after the examiner tells you to begin. Try to get as many right as possible. Be careful not to go so fast that you make mistakes. Do not spend too much time on any one question. No questions about the test will be answered by the examiner after the test begins.

DO NOT TURN THE PAGE UNTIL YOU ARE ASKED TO DO SO.

1. Which one of the five things below does not belong with the others?
   1 potato, 2 turnip, 3 carrot, 4 stone, 5 onion .... ( )
2. Which one of the five words below tells best what a saw is?
   1 something, 2 tool, 3 furniture, 4 wood, 5 machine .... ( )
3. Which one of the five words below means the opposite of west?
   1 north, 2 south, 3 east, equator, 5 sunset .... ( )
4. A hat is to a head and a glove is to a hand the same as a shoe is to what?
   1 leather, 2 a foot, 3 a shoe-lace, 4 walk, 5 a toe .... ( )
5. A child who knows he is guilty of doing wrong should feel (?)
   1 bad, 2 sick, 3 better, 4 afraid, 5 ashamed .... ( )
6. Which one of the five things below is the smallest?
   1 twig, 2 limb, 3 bud, 4 tree, 5 branch .... ( )
7. Which one of the five things below is most like these three: cup, plate, saucer?
   1 fork, 2 table, 3 eat, 4 bowl, 5 spoon .... ( )
8. Which one of the five words below means the opposite of strong?
   1 man, 2 weak, 3 small, 4 short, 5 thin .... ( )
9. A finger is to a hand the same as a toe is to what?
   1 foot, 2 toe-nail, 3 heel, 4 shoe, 5 knee .... ( )
10. Which word means the opposite of sorrow?
    1 sickness, 2 health, 3 good, 4 joy, 5 pride .... ( )
11. Which one of the ten numbers below is the smallest? (Tell by letter)
    A 6084, B 5160, C 4342, D 6521, E 9703, F 4296, G 7475, H 2657, J 8839, K 3918 .... ( )
12. Which word means the opposite of pretty?
    1 good, 2 ugly, 3 bad, 4 crooked, 5 nice .... ( )
13. Do what this mixed-up sentence tells you to do.
    number Write the the in 5 parentheses .... ( )
14. A book is to an author as a statue is to (?)
    1 sculptor, 2 marble, 3 model, 4 magazine, 5 man .... ( )
15. If we believe some one has committed a crime, but we are not sure, we have a (?)
    1 fear, 2 suspicion, 3 wonder, 4 confidence, 5 doubtful .... ( )
16. Which is the most important reason that words in the dictionary are arranged alphabetically?
    1 That is the easiest way to arrange them. 2 It puts the shortest words first. 3 It enables us to find any word quickly. 4 It is merely a custom. 5 It makes the printing easier .... ( )

17. Which one of the five things below is most like these three: plum, apricot, apple?
1 tree, 2 seed, 3 mango, 4 juice, 5 ripe .... ( )

18. At 40 cents each, how many pencils can be bought for Shs.3/60 ? .... ( )

19. If a person walking in a quiet place suddenly hears a loud sound, he is likely to be (?)
1 stopped, 2 struck, 3 startled, made deaf, 5 angered .... ( )

20. A boy is to a man as a (?) is to a sheep.
1 wool, 2 lamb, 3 goat, 4 shepherd, 5 dog .... ( )

21. One number is wrong in the following series. What should that number be? (Just write the correct number in the brackets.)
1 6 2 6 3 6 4 6 5 6 7 6 .... ( )

22. Which one of the five things below is most like these three: horse, pigeon, grasshopper?
1 stall, 2 saddle, 3 oat, 4 goat, 5 chirp .... ( )

23. If the words below were rearranged to make a good sentence, with what letter would the last word of the sentence begin? (Make the letter like a printed capital.)
nuts from squirrels trees the gather .... ( )

24. A man who betrays his country is called a (?)
1 thief, 2 traitor, 3 enemy, 4 coward, 5 slacker .... ( )

25. Food is to the body as (?) is to an engine.
1 wheels, 2 fuel, 3 smoke, 4 motion, 5 fire .... ( )

26. Which tells best just what a pitcher is?
1 a vessel from which to pour liquid, 2 something to hold milk, 3 It has a handle,
4 It goes on the table, 5 It is easily broken .... ( )

27. If Samuel is older than Joseph, and Joseph is older than Eliud, then Samuel is (?) Eliud.
1 older than, 2 younger than, 3 just as old as, 4 cannot say which .... ( )

28. Count each 7 below that has a 5 next after it. Tell how many 7's you count.
7 5 3 0 9 7 3 7 8 5 7 4 2 1 7 5 7 3 2 4 7 0 9 3 7 5 5 7 2 3 5 5 7 7 5 4 7 .... ( )

29. If the words below were rearranged to make a good sentence, with what letter would the last word of the sentence begin? (Make the letter like a printed capital)
leather shoes usually made are of .... ( )

30. An electric light is to a candle as a motor-cycle is to (?)
1 bicycle 2 motor-car, 3 wheels, 4 speed, 5 police .... ( )

31. Which one of the words below would come first in the dictionary?
1 march, 2 ocean, 3 horse, 4 paint, 5 elbow, 6 night, 7 flown .... ( )

32. The daughter of my mother's brother is my (?)
1 sister, 2 niece, 3 cousin, 4 aunt, 5 grand-daughter .... ( )

33. One number is wrong in the following series. What should the number be?
3 4 5 4 3 4 5 4 3 5 .... ( )

34. Which one of the five things below is most like these three: boat, horse, train?
1 sail, 2 row, 3 motor-cycle, 4 move, 5 track .... ( )

35. If Omolo is taller than Otieno and Omolo is shorter than Oyodo, then Oyodo is (?) Otieno.
1 taller than, 2 shorter than, 3 just as tall as, 4 cannot say which .... ( )

36. What is the most important reason that we use clocks?
1 to wake us up in the morning, 2 to regulate our daily lives, 3 to help us catch trains, 4 so that children will get to School on time, 5 They are ornamental .... ( )

37. A coin made by an individual and meant to look like one made by the government is called (?)
1 duplicate, 2 counterfeit, 3 imitation, 4 forgery, 5 libel .... ( )

38. A wire is to electricity as (?) is to gas.
1 a flame, 2 a spark, 3 hot, 4 a pipe, 5 a stove .... ( )

39. If the following words were arranged in order, with what letter would the middle word begin?
Yard Inch Mile Foot Rod .... ( )

40. One number is wrong in the following series. What should that number be?
5 10 15 20 25 29 35 40 45 50 .... ( )

41. Which word means the opposite of truth?
1 cheat, 2 rob, 3 liar, 4 ignorance, 5 falsehood .... ( )

42. Order is to confusion as (?) is to war.
1 guns, 2 peace, 3 powder, 4 thunder, 5 army .... ( )

43. In a foreign language, good food = Bano Naab
good water = Heto Naab
The word that means good begins with what letter? .... ( )

44. The feeling of a man for his children is usually (?)
1 affection, 2 contempt, 3 joy, 4 pity, 5 reverence .... ( )

45. Which one of the five things below is most like these three: stocking, flag, sail?
1 shoe, 2 ship, 3 staff, 4 towel, 5 wash .... ( )

46. A book is to information as (?) is to money.
1 paper, 2 shillings, 3 bank, 4 work, 5 gold .... ( )

47. If Harry is taller thanWilliam, and William is just as tall as Charles, then Charles is (?) Harry.
1 taller than, 2 shorter than, 3 just as tall as, 4 cannot say which .... ( )

48. If the following words were arranged in order, with what letter would the middle word begin?
Six Ten Two Eight Four .... ( )

49. If the words below were rearranged to make a good sentence, with what letter would the third word of the sentence begin? (Make the letter like a printed capital.)
men high the wall a built stone .... ( )

50. If the suffering of another makes us suffer also, we feel (?)
1 worse, 2 harmony, 3 sympathy, 4 love, 5 repelled .... ( )

51. In a foreign language, grass = Moki
green grass = Moki Laap
The word that means <u>green</u> begins with what letter? .... ( )

52. If a man has walked west from his home 9 miles and then walked east 4 miles, how many miles is he from his home .... ( )

53. A pitcher is to milk as (?) is to flowers.
1 stem, 2 leaves, 3 water, vase, 5 roots .... ( )

54. Do what this mixed-up sentence tells you to do.
sum three Write two the four and of .... ( )

55. There is a saying, "Don't count your chickens before they are hatched." This means (?) 266
1 Don't hurry. 2 Don't be too sure of the future. 3 Haste makes waste. 4 Don't gamble .... ( )

56. Which statement tells best just what a fork is?
1 a thing to carry food to the mouth, 2 It goes with a knife, 3 an instrument with prongs at the end, 4 It goes on the table, 5 It is made of metal .... ( )

57. Wood is to a table as (?) is to a knife.
1 cutting, 2 chair, 3 fork, 4 steel, 5 handle .... ( )

58. Do what this mixed-up sentence tells you to do.
sentence the letter Write last this in .... ( )

59. Which one of the words below would come last in the dictionary?
1 alike, 2 admit, 3 amount, 4 across, 5 after, 6 amuse, 7 adult, 8 affect .... ( )

60. There is a saying, "He that scatters thorns, let him go barefoot." This means (?)
1 Let him who causes others discomforts bear them himself also. 2 Going barefoot toughens the feet. 3 People should pick up what they scatter. 4 Don't scatter things around .... ( )

61. If the following words were arranged in order, with what letter would the middle word begin?
Plaster Frame Wallpaper Lath Foundation .... ( )

62. In a foreign language, many boys = Boka Hepo
many girls = Marti Hopo
many boys and girls = Boka Ello Marti Hopo
The word that means <u>and</u> begins with what letter? .... (   )

63. A statement which expresses just the opposite of that which another statement expresses is sais to be a (?)
1 lie, 2 contradiction, 3 falsehood, 4 correction, 5 explanation .... (   )

64. There is a saying, "Don't look a gift horse in the mouth." This means (?)
1 It is not safe to look into the mouth of a horse. 2 Although you question the value of a gift, accept it graciously. 3 Don't accept a horse as a gift. 4 You cannot judge the age of a gift horse by his teeth .... (   )

65. Which one of the words below would come last in the dictionary?
1 hedge, 2 glory, 3 label, 4 green, 5 linen, 6 knife, 7 honour .... (   )

66. Which statement tells best just what a watch is?
1 It ticks, 2 something to tell time, 3 a small, round object with a strap, 4 a pocket-sized time-keeping instrument, 5 something with a face and hands .... (   )

67. Ice is to water as water is to what?
1 land, 2 steam, 3 cold, 4 river, 5 thirst .... (   )

68. Which statement tells best just what a window is?
1 something to see through, 2 a glass door, 3 a frame with a glass in it, 4 a glass opening in the wall of a house, 5 a piece of glass surrounded by wood .... (   )

69. Which one of the five words below is most like these three: large, red, good?
1 heavy, 2 size, 3 colour, 4 apple, 5 very .... (   )

70. Write the letter that follows the letter that comes next after M in the alphabet .... (   )

71. One number is wrong in the following series. What should that number be?
1 2 4 8 16 24 64 .... (   )

72. An uncle is to an aunt as a son is to a (?)
1 brother, 2 daughter, 3 sister, 4 father, 5 girl .... (   )

73. If I have a large box with 3 small boxes in it and 4 very small boxes in each of the small boxes, how many boxes are there in all? .... (   )

74. One number is wrong in the following series. What should that number be ?
1 2 4 5 7 8 10 11 12 14 .... (   )

75. There is a saying, "Don't ride a free horse to death." This means (?)
1 Don't be cruel, 2 Don't abuse a privilege, 3 Don't accept gifts, 4 Don't be reckless.(   )

<u>STOP HERE</u>.

FORM 2 EXPRESSION AND COMPREHENSION Third Term 1966

TEST 16EXPR Time: ½ hour

The Kikuyu Warriors

The whole warrior class was divided into several regimental groups, according to the system of age grades. Every age grade had its leader who was responsible for the activities of his group. His main duty was to keep harmony and discipline in the group, and to settle minor disputes and quarrels among the members of his regiment. He also acted as spokesman of the group in general matters. He was the chief composer and organizer of songs and dances in his group, and sometimes arranged competitions between his and other groups. The warrior dances and songs served two purposes, namely, enjoyment and drill for physical development. In jumping and running, warriors developed the powers of endurance and the art of battle. In the time of war these regiments were united under the leadership of a council of war composed of several leaders of the age grades. At the head of this council was a war magican whose duty was to advise it as to the best time of waging war He blessed the warriors and gave them medicine to protect them against the enemy.

Every regiment had its regimental songs and war-cry. There were distinctive designs on the shields and headgear to distinguish each regiment. There was no particular uniform, for warriors went to war practically naked except for a small apron which was worn at the back, and the headgear. On the outbreak of war, a war-horn sounded as a sign of readiness. The warriors immediately took to arms and started shouting their particular war-cry. This brought together all the regimental units in the district until they formed a procession towards the enemy. Each regiment followed different directions, all leading to the battlefield. The senior warriors formed the front lines and the junior ones the rear lines. The council of war went between the two giving advice to both sections. The motive of the fighting was merely to capture livestock of the enemy and to kill those who offered resistance. In other words, it was a form of stealing by force of arms.

If the warriors were successful in the war and captured the enemy's livestock, they returned home as quickly as possible to avoid the recapture of their loot by the enemy. Before reaching home, after crossing the enemy's boundary, they halted and counted the cattle that had been captured. The council of war then divided the loot among the regiments. In the first place, 'brave warriors' were rewarded according to the task performed in fighting the enemy. Then a small number of cattle were set aside for the chief, the medicine man was given his share, and the other members of the council of war. If there were any left, and not enough to go round equally, it was settled by drawing lots.

(from "Facing Mount Kenya" by Jomo Kenyatta)

1. Write one sentence which contains all the duties of the leader of the age groups.
2. What happens from the time the war-horn is sounded to the time they cross from the enemy's territory? (Give your answer in less than 60 words.)
3. Use two sentences to describe how the loot is divided between the tribe.

TEST 17COMP

FORM 2 — COMPREHENSION — Third Term 1966

Time: $\frac{1}{2}$ hour

Read the following passage very carefully and then in each of the questions 1 to 8 which follow select the best of the four choices given. Do not write any words.

Many young elephants develop the naughty habit of plugging up the wooden bell they wear hung around their necks (kalouk) with good stodgy mud or clay, so that the clappers cannot ring, in order to steal silently into a grove of cultivated bananas at night. There they will have a whale of a time, quietly stuffing, eating not only the bunches of bananas, but the leaves and, indeed the whole tree as well, and they will do this just beside the hut occupied by the owner of the grove, without waking him or any of his family ......

Oozies are not always as innocent as they pretend on such occasions. I once had to pay a fine to the Forest Department for damage by my elephants to some experimental plantations of teak saplings. Naturally, I gave the oozies a reprimand for their slackness in allowing their animals to stray into these plantations. A month afterwards I happened to meet the Forest Officer who had fined me, near a large village, where we both camped for the night. He had four elephants with him, and I had eight. Next morning his annoyance can be imagined when the village headman arrived to ask for compensation for no less than a hundred banana-trees, destroyed by his four elephants. Strangely enough, not one of my eight elephants had been involved in the mischief, a fact which made it even more annoying for him. It was not until a week after we had parted company that I found out that though my elephants were innocent, my oozies were quite the reverse. They had taken the bells off the Forest Officer's four elephants and during the night had led them quietly into the banana groves - and had paid him out for fining me for the damages to the teak plantation.

(from "Elephant Bill" by Col. W. Williams)

1. The most important characteristic of the young elephants we learn of from the first paragraph is their
   (a) intelligence,
   (b) greed,
   (c) naughtiness,
   (d) shyness

2. 'They will have a whale of a time'. This means they will
   (a) have an enormous amount of time at their disposal,
   (b) enjoy themselves greatly,
   (c) have enough time to eat a very large quantity of bananas,
   (d) have a very busy time.

3. Neither the owner of the grove or his family are disturbed by the elephants because
(a) they sleep very soundly,
(b) the elephants operate at the dead of night,
(c) of the great delicacy of the touch of the elephants,
(d) the elephants are careful not to go too near to the hut.

4. 'Oozies' is probably a new word for you. But after reading through the second paragraph it is possible to infer that it means
(a) baby elephants,
(b) forest rangers,
(c) elephant attendants.
(d) plantation labourers.

5. Which one of the following is the best substitute for the word 'reprimand' in the third sentence of the second paragraph?
(a) beating,
(b) lecture,
(c) scolding,
(d) fine.

6. The first sentence of the second paragraph means that the oozies
(a) are generally innocent although they pretend they are not,
(b) are never innocent but they pretend they are,
(c) are sometimes guilty when they pretend they are innocent,
(d) are always as innocent as they pretend to be.

7. The thing that increased the annoyance of the Forest Officer was
(a) the fact that the headman demanded compensation from him,
(b) that his four elephants had destroyed no less than a hundred banana-trees,
(c) that none of the writer's elephants had been responsible for the mischief,
(d) that the writer's oozies were responsible for the damage while he had to pay the compensation.

8. The actions of the oozies described in the second paragraph shows that their attitude towards their master was
(a) disrespectful
(b) loyal and affectionate,
(c) revengeful,
(d) highly respectful

TEST 18ESSY

FORM 2 | ENGLISH ESSAY | Third Term. 1966

Time: 1 hour

Write on ONE of the following subjects:-

1. An hour at the Railway Station.
2. When we lost our way.
3. A journey I have made.
4. Write a story about a man, a boy, a donkey that would not do what it was told, rain, a telephone, the full moon.
5. Write about a street in your town. If you like you can pretend to be walking down it, and write about the things and people you see.
6. A young policeman doing his first night duty in a big town heard loud cries and footsteps running away. Finish the story.
7. By the river.
8. The rainy season.
9. Compare aeroplanes, lorries, bicycles and camels or horses as means of travelling. Write a paragraph about each.

Now re-read your essay and check mistakes. Careless errors which have not been corrected will lose marks.

TEST 19SENT

FORM 2 — SENTENCE STRUCTURE — Third Term 1966

Time: ½ hour

1. Rewrite the following sentences as directed.

(a) The coffee wasn't of a good grade so it could not be exported.
(Rewrite using ..... enough ... and omitting ... so)

(b) He is not clever and he is not handsome either.
(Rewrite using ..... neither .....)

(c) I was stupid in believing him.
(Begin: It was .....)

(d) I'm sure it must be somewhere.
(Make it negative.)

(e) The story is too well known to need any repetition here.
(Begin: The story is so well known .....)

(f) I believed that an occasional train still ran there.
(Begin: It was .....)

(g) My first need was to go to Isfahan.
(Begin: I first .....)

(h) Having sent off my telegram, I spent two agreeable days in Isfahan.
(Begin: I spent .....)

2. Join the following pairs of sentences by using one of the following sentence connectors:
nevertheless, consequently, moreover, therefore, however.
Do not use the same connector twice.

Example: The people are illiterate. The establishment of democracy will be difficult.
Answer: The people are illiterate; therefore the establishment of democracy will be difficult

(a) She is rich. She is unhappy.

(b) She is poor. She is unhappy.

(c) He did not study. He failed in his examination.

(d) He lost his luggage. He did not lose his wallet.

(e) He was an ignorant man. He was stubborn as well.

TEST 20VOCB

Name: ______________________________

VOCABULARY - V

The first word in the following line is "big".

big	ill	large	down	sour

One of the other words means the same as "big". The word " large " has been marked because it means the same as"big".

The first word in the following line is "ancient". Mark one of the other words that means the same as "ancient".

ancient	dry	long	happy	old

You should have marked "old" because it means the same as "ancient".

In each of the following lines mark the word that means the same as the first word.

quiet	blue	still	tense	watery
safe	secure	loyal	passive	young
brave	hot	cooked	red	courageous

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

VOCABULARY - In each row of five words below, mark the word which means the same as the first word in that row.

moist	curt	humane	damp	moderate
quick	major	hasty	narrow	vigorous
annual	variable	yearly	listless	untenable
splendid	expansive	gay	rigid	excellent
customary	nocturnal	radial	prime	usual
fluid	livid	dead	liquid	talkative
idle	lazy	cross	wild	useful
deserted	drab	absurd	disturbed	abandoned
rare	holy	crass	infrequent	weak
contented	nasty	continuous	defamatory	satisfied
enraged	pleasing	poor	angry	domestic
beneficial	artificial	tamable	helpful	piquant
mouldy	tonic	musty	shapeless	mute
rasping	harsh	minute	kinaesthetic	marshy
dietary	diagrammatic	amorphous	dietetic	grammatical
sober	dirty	cloudy	serious	fitting
droll	delightful	odd	forceful	foreign
stately	dignified	thin	digestible	valid
disreputable	shameful	forensic	horticultural	susceptible
genteel	wealthy	urban	polite	ignorant
original	oral	derelict	first	reliable
novel	expensive	new	gloomy	radical
famous	celebrated	faithful	renewed	nimble
systematic	laudatory	orderly	jubilant	ambitious
fatigued	pliable	grave	weary	fanatic

GO STRAIGHT ON TO PAGE 3.

resplendent	phonetic	tart	brilliant	fearless
generous	oblivious	ardent	liberal	defiant
kingly	bland	facial	recent	regal
flexible	pitiable	formal	pliant	peaceful
sagacious	exotic	apparent	wise	mild
heedless	patient	eligible	parallel	rash
deficient	constant	dreary	lacking	peculiar
vigilant	watchful	indulgent	valorous	nascent
minimum	humid	restricted	tranquil	least
gallant	chivalrous	authentic	treacherous	probable
giddy	feminine	casual	dizzy	comical
discreet	caustic	redolent	honourable	prudent
destined	simplified	fated	directional	lucky
eternal	momentous	benign	priceless	perpetual
lavish	combined	ribald	worthy	extravagant
defective	concealed	mythical	faulty	external
vague	numb	obscure	indecent	vermiculate
essential	classical	indispensable	deplorable	candid
impulsive	impetuous	petrified	immature	compulsory
diffident	fabulous	shy	valuable	alphabetical
erroneous	solemn	false	ironic	tragic
benevolent	kind	native	suitable	modest
grimy	stern	filthy	grim	colourful
lacerated	disgruntled	mangled	fringed	stricken
insolent	studious	envious	arrogant	accidental

STOP HERE.

F I R S T   L E T T E R S

TEST 21LETT

Name: ______________________________

Look at the words in the following list. Each word <u>begins</u> with <u>D</u>.

dull

dinner

different

disappear

On the blanks below write several words which <u>begin</u> with <u>P</u> . One word you might write is <u>pretty</u>. Write more words which begin with <u>P</u> below.

____

____

____

____

____

____

When the signal is given, turn the page. You will be given a <u>new letter</u>. Write as many words as you can which begin with the new letter. Write the words as fast as you can.

STOP HERE. WAIT FOR THE SIGNAL.

FIRST LETTERS

The new letter is S.

Write as many words as you can which begin with S.

1. ______	21. ______	41. ______	61. ______
2. ______	22. ______	42. ______	62. ______
3. ______	23. ______	43. ______	63. ______
4. ______	24. ______	44. ______	64. ______
5. ______	25. ______	45. ______	65. ______
6. ______	26. ______	46. ______	66. ______
7. ______	27. ______	47. ______	67. ______
8. ______	28. ______	48. ______	68. ______
9. ______	29. ______	49. ______	69. ______
10. ______	30. ______	50. ______	70. ______
11. ______	31. ______	51. ______	71. ______
12. ______	32. ______	52. ______	72. ______
13. ______	33. ______	53. ______	73. ______
14. ______	34. ______	54. ______	74. ______
15. ______	35. ______	55. ______	75. ______
16. ______	36. ______	56. ______	76. ______
17. ______	37. ______	57. ______	77. ______
18. ______	38. ______	58. ______	78. ______
19. ______	39. ______	59. ______	79. ______
20. ______	40. ______	60. ______	80. ______

STOP HERE.

P R E F I X E S

TEST 22PRFX

Name: ____________________

Look at the words in the following list. Each word begins with PER.

perfect

perhaps

permanent

persecute

On the blanks below write several words which begin with SUB. One word you might write is subject. Write more words which begin with SUB.

When the signal is given, turn the page. You will be given a new prefix. Write as many words as you can which begin with new prefix. Write the words as fast as you can.

STOP HERE. WAIT FOR THE SIGNAL.

PREFIXES

The new prefix is CON.

Write as many words as you can which begin with CON.

1. ______	21. ______	41. ______
2. ______	22. ______	42. ______
3. ______	23. ______	43. ______
4. ______	24. ______	44. ______
5. ______	25. ______	45. ______
6. ______	26. ______	46. ______
7. ______	27. ______	47. ______
8. ______	28. ______	48. ______
9. ______	29. ______	49. ______
10. ______	30. ______	50. ______
11. ______	31. ______	51. ______
12. ______	32. ______	52. ______
13. ______	33. ______	53. ______
14. ______	34. ______	54. ______
15. ______	35. ______	55. ______
16. ______	36. ______	56. ______
17. ______	37. ______	57. ______
18. ______	38. ______	58. ______
19. ______	39. ______	59. ______
20. ______	40. ______	60. ______

STOP HERE.

S U F F I X E S

TEST 23SUFX

Name: ______________________________

Look at the words in the following list. Each word ends with EST

finest

coldest

nearest

softest

On the blanks below write several words which end with NESS. One word you might write is kindness. Write more words which end with NESS.

____

____

____

____

____

____

____

When the signal is given, turn the page. You will be given a new suffix. Write as many words as you can which end with the new suffix. Write the words as fast as you can.

STOP HERE. WAIT FOR THE SIGNAL.

S U F F I X E S

The new suffix is TION.

Write as many words as you can which end with TION.

1. ________________
2. ________________
3. ________________
4. ________________
5. ________________
6. ________________
7. ________________
8. ________________
9. ________________
10. ________________
11. ________________
12. ________________
13. ________________
14. ________________
15. ________________
16. ________________
17. ________________
18. ________________
19. ________________
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21. ________________
22. ________________
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25. ________________
26. ________________
27. ________________
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29. ________________
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31. ________________
32. ________________
33. ________________
34. ________________
35. ________________
36. ________________
37. ________________
38. ________________
39. ________________
40. ________________
41. ________________
42. ________________
43. ________________
44. ________________
45. ________________
46. ________________
47. ________________
48. ________________
49. ________________
50. ________________
51. ________________
52. ________________
53. ________________
54. ________________
55. ________________
56. ________________
57. ________________
58. ________________
59. ________________
60. ________________

STOP HERE.

TEST 24THME

Name ______________________________

THEME TEST - Fi-2

In this test you are to write a few paragraphs about two given topics. You are to write all you can about each topic. Use any idea whether or not it seems very closely related to the topic. Expand on any idea as much as you like, and be sure you write as much as you can.

Your score on this test will be the amount of appropriate material that you write.

You will have 4 minutes for each of the topics in this test. When you have finished the first topic, STOP. Please do not go on to the second topic until you are asked to do so.

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

Part 1 (4 minutes)

The topic is "a parcel".

Write all you can about a parcel.

(If you run out of space, write on the back of the preceding page.)

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

STOP.

Part 2 (4 minutes)

The second topic is "a locked door".

Write all you can about a locked door.

(If you run out of space, write on the back of the preceding page.)

DO NOT GO BACK TO PART 1.

STOP.

TEST 25CATG

Name ______________________________

THING CATEGORIES TEST - Fi-3

This is a test to see how many things you can think of that are alike in some way.

Below are two examples of things that are always red or that are red more often than any other colour. Look at these examples. Then go ahead and write in the blanks more things that are always red or that are red more often than any other colour. You may use one word or several words to describe each thing.

blood ______________

bricks ______________

____

____

____

____

____

____

____

____

Your score will be the number of correct things you write

You will have three minutes for each of the two parts of this test. When you have finished Part 1, STOP. Please do not go on to Part 2 until you are asked to do so.

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

Part 1 (3 minutes)

The category is "round".

Go ahead and write all the things that are round or that are round more often than any other shape.

1. ______	19. ______
2. ______	20. ______
3. ______	21. ______
4. ______	22. ______
5. ______	23. ______
6. ______	24. ______
7. ______	25. ______
8. ______	26. ______
9. ______	27. ______
10. ______	28. ______
11. ______	29. ______
12. ______	30. ______
13. ______	31. ______
14. ______	32. ______
15. ______	33. ______
16. ______	34. ______
17. ______	35. ______
18. ______	36. ______

DO NOT GO ON TO THE NEXT PAGE UNTIL ASKED TO DO SO.

STOP.

Part 2 (3 minutes)

The new category is "blue".

Go ahead and write all things that are always blue or that are blue more often than any other colour.

1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________
6. ______________________
7. ______________________
8. ______________________
9. ______________________
10. ______________________
11. ______________________
12. ______________________
13. ______________________
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25. ______________________
26. ______________________
27. ______________________
28. ______________________
29. ______________________
30. ______________________
31. ______________________
32. ______________________
33. ______________________
34. ______________________
35. ______________________
36. ______________________

DO NOT GO BACK TO PART 1.

STOP.

FORM 2 TEST 26CHCN **C H E M I S T R Y** Term 3, 1966

From Section A answer Question 1 and either Question 2(a) or 2(b).

From Section B answer TWO questions.

N.B. Credit will be given for word or formulae equations wherever possible.

Section A

1. Write balanced formulae equations for the reactions between:

   i) steam and red hot charcoal
   ii) zinc carbonate and dilute nitric acid
   iii) aluminium hydroxide and dilute sulphuric acid
   iv) sodium and water
   v) calcium chloride and sodium hydroxide solutions.

2(a) EITHER

   i) Describe an experiment to determine accurately the percentage, by volume, of oxygen in the air. Draw a diagram of the apparatus.

   ii) Name the products formed when sulphur and sodium are burnt in gas jars containing oxygen. What colour changes are seen when water containing litmus is added to the jars after the sulphur and sodium have been burnt? What does this show? 282

2(b) OR

   i) Describe, with a diagram, how you would prepare a few gas jars of dry hydrogen in the laboratory.

   ii) Describe ONE experiment which shows that water contains hydrogen and oxygen chemically combined. (No diagram required.)

Section B (Answer TWO questions.)

3. i) Starting from calcium metal, describe briefly how you could prepare a sample of limewater in the laboratory.

   ii) Place the following metals in order of decreasing reactivity with dilute hydrochloric acid: iron, aluminium, copper and magnesium. Write down the names of the products, if any, for each reaction.

   iii) State ONE industrial use for each of the following:
   a) hydrogen c) coal
   b) carbon dioxide d) diamonds

4. i) Describe the preparation of a few gas jars of dry chlorine in the laboratory. (No diagram required.)

   ii) Describe what you would see, naming the products, when chlorine reacts with a) phosphorus b) hydrogen sulphide c) sodium.

   iii) State TWO industrial uses for chlorine.

5. i) Starting from zinc, describe how you would prepare crystals of zinc sulphate in the laboratory. Give practical details, but no diagrams required.

   ii) State whether the following are physical or chemical changes, giving ONE good reason in each case for your answer.
   a) sugar dissolves in water to form a solution
   b) carbon dioxide dissolves in water to form a solution
   c) food is digested in the stomach.

   iii) Describe and explain what happens when burning magnesium is plunged into a gas jar containing carbon dioxide.

—oooooOOOOOOOOOOOOOOoooooo—

FORM 2 TEST 27PHCN **PHYSICS** Third Term 1966

Time: $1\frac{1}{2}$ hours

Answer FOUR questions, ONE from SECTION A and THREE from SECTION B

SECTION A

1. Draw ray diagrams for the passage of light through (a) a periscope; (b) a rectangular glass block; (c) a 60° glass prism (white light); (d) a converging lens of 10 cm. focal length when the object is 15 cm. from the lens; (e) a pond so that the eye views an object on the bottom; (f) the formation of an umbra and a penumbra on a screen.

2. (a) Label a sketch of a concave lens showing (i) the optical axis, (ii) the principal focus, (iii) the focal length, (iv) the aperture.

   (b) An object 1 cm. high is placed perpendicular to and on the axis of a convex lens of focal length 3 cm. Find, by construction, the position, nature and size of the image when the object is placed at the following distances from the lens:
   (i) 7 cm. (ii) 2 cm.

SECTION B

3. Distinguish between the mass and weight of a body.
   State the laws of friction.

   A block of wood weighing 10 lbs. is pulled along the bench top by a string held horizontally and attached to a spring balance which reads 3 lbs. What is the coefficient of friction? What would the balance read if a 6 lbs. weight were resting on the block?

4. Explain the terms force, resolved part of a force.

   State the conditions under which a body will remain in equilibrium under the action of three coplanar forces which are not parallel.

   A mass of 50 lb. is supported by two threads inclined respectively at angles of 60° and 30° to the vertical. Find the tensions in the threads.

5. Define the moment of force about a point.
   State the principle of moments.

   A uniform rod 5 ft. long and of mass 10 lb. is supported from a horizontal beam by two equal vertical strings, one attached to one end X, and the other to a point P 1 ft. from the other end Y. Find the tension in each string.

6. Explain the terms stable equilibrium, centre of gravity.
   How would you find experimentally the position of the centre of gravity of a flat plate of wood of irregular outline?

   One half AB of a straight uniform rod AC 2 ft. long is bored out uniformly so that it weighs half as much as the half BC. Find by calculation the position of the centre of gravity of the rod.

FORM 2 TEST 28CHOB Term 3, 1966

CHEMISTRY

1½ hours

This paper contains 60 questions. Attempt all the questions. The questions are not arranged in order of difficulty, so do not spend too much time on any one question; if you cannot do it quickly, pass on to the next and return to it at the end if you have time.

There are four alternatives to most questions, but there are a few with only three alternative answers. Only one of the alternatives is correct. Decide which you think is correct and put a cross over the appropriate number on your Answer Sheet.

Sample Question:

101. Of what is water composed?

1. hydrogen and nitrogen
2. sulphur and hydrogen
3. carbon monoxide and hydrogen
4. hydrogen and oxygen.

Sample Answer Sheet:

101. 1 2 3 ~~4~~

(The correct answer is the fourth alternative, so)
a cross is put over 4

If you wish to change your answer, make sure that you write in the number again above the cross.

A fraction of the marks will be deducted for wrong answers, so it will not be to your advantage to guess unless you are able to eliminate one or more of the alternatives.

Please do not write on this question paper: use paper provided for rough work.

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

290

1. Phosphorus is used in some match heads because it
    1. has a low ignition point
    2. is not poisonous
    3. will burn without oxygen
    4. can be heated by friction.

2. A molecule of water may be separated into its elements by
    1. vigorous boiling
    2. evaporation
    3. a magnetic field
    4. a direct current of electricity.

3. Which one of the following substances has the highest boiling point?
    1. petrol
    2. mercury
    3. water
    4. alcohol.

4. Which would be the best way to show that a given liquid was pure water?
    1. Taste it
    2. Add a piece of sodium and note its reaction
    3. Determine its melting point and boiling point
    4. Add a drop onto anhydrous copper sulphate.

5. Which one of the following metals will not react with steam?
    1. zinc
    2. lead
    3. iron
    4. calcium.

6. Sodium is kept in the laboratory under oil because
    1. the metal catches fire in air
    2. the metal reacts with the oxygen of the air
    3. the oil prevents the pieces of metal sticking together
    4. All reactive metals are kept under oil.

7. Which one of the following is an acidic oxide?
    1. hydrogen oxide
    2. sodium oxide
    3. phosphorus pentoxide
    4. carbon monoxide.

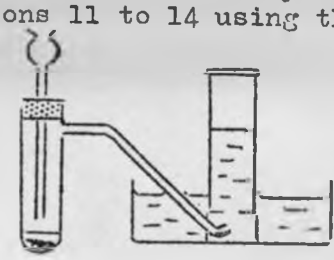
8. Which one of the following is <u>not</u> a mixture?
    1. muddy water
    2. brass
    3. gunpowder
    4. marble.

When a fixed weight of copper is heated in a measured volume of air until no further change takes place, the copper becomes coated with a black substance and the air decreases to about four-fifths of its original volume. The same result is obtained each time the experiment is repeated, PROVIDED that sufficient copper is used to leave some unchanged at the end of the experiment. Answer Questions 9 and 10 based on these experiments.

9. The evidence of this experiment indicates that
    1. air consists of one substance only
    2. air consists of two substances only
    3. air consists of at least two substances
    4. air consists of more than two substances.

10. If more copper were used in the experiment you would expect
    1. the volume of the air would decrease by more than one-fifth
    2. all the air would be used up
    3. The volume of air would decrease by one-fifth
    4. the volume of air would decrease by less than

A student attempted to prepare and collect hydrogen using the apparatus shown below. Answer Questions 11 to 14 using this apparatus.



11. Which one of the following reactions could be used to prepare the hydrogen?
    1. copper and dilute hydrochloric acid
    2. zinc and dilute sulphuric acid
    3. aluminium and dilute nitric acid
    4. zinc oxide and dilute hydrochloric acid.

12. From the above diagram, which one of the following statements can be deduced?
    1. hydrogen is not very soluble in water
    2. hydrogen is colourless
    3. hydrogen is less dense than air
    4. hydrogen in inflammable.

13. The student found that although he had chosen suitable reagents no hydrogen was being collected. He eventually discovered that it was because
    1. the level of the water in the trough was higher than the level of the acid in the test-tube
    2. the end of the thistle funnel was above the level of the acid
    3. the test-tube should have been heated
    4. The top of the gas jar was below the top of the thistle funnel.

14. If the gas were required dry, which one of the following methods would be the best method for drying and collecting the gas?
    1. pass through anhydrous calcium chloride and collect by upward displacement of air.
    2. pass through concentrated sulphuric acid and collect by downward displacement of air
    3. pass through a heated tube and collect over mercury
    4. pass through anhydrous copper sulphate and collect over oil.

In Queations 15 to 17 you are asked to choose the best method for separating mixtures so as to obtain the constituents in a pure state. The processe must be carried out in the order stated.

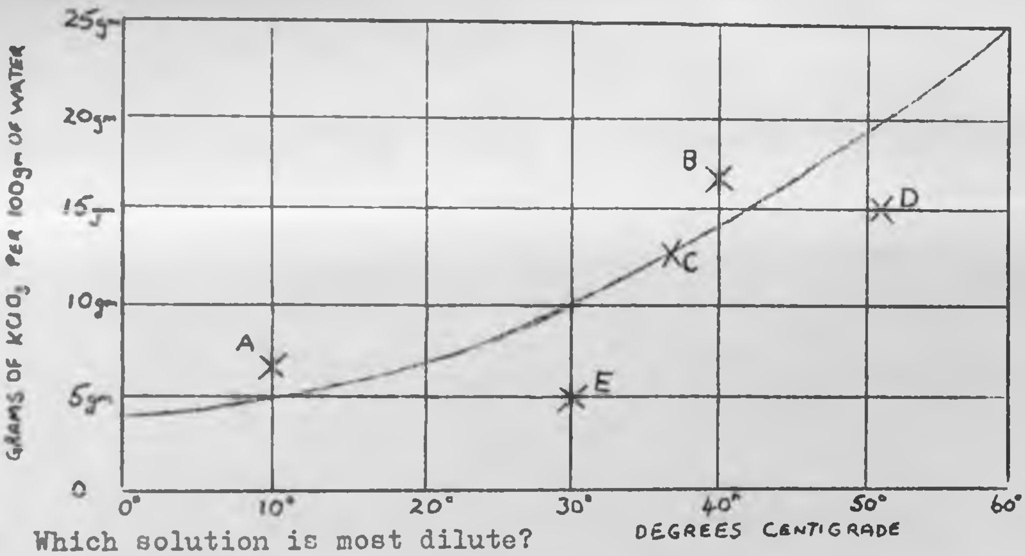
15. Which would be the best way to obtain sand and wax separately from a mixture of the two?
    1. filtration
    2. evaporation and filtration
    3. dissolving in a solvent and distillation
    4. dissolving in a solvent, filtration and evaporation.

16. Which way would be the best way for obtaining common salt and ammonium chloride from a mixture of their solutions?
    1. evaporation and sublimation
    2. distillation and filtration
    3. evaporation, dissolving in water, filtration and evaporation.
    4. sublimation

17. Which would be the best method for obtaining reasonably pure samples of water, sand and copper sulphate crystals from a mixture of sand in a copper sulphate solution?
    1. Filtration and evaporation
    2. filtration and distillation
    3. distillation, dissolving in water and filtration
    4. filtration and sublimation.

292

The following chart is a solubility curve for potassium chlorate dissolved in water. Points A, B, C, D and E represent five solutions of different compositions at different temperatures. Use the graph to answer Questions 18 to 21.



18. Which solution is most dilute?
    1. A
    2. B
    3. D
    4. E

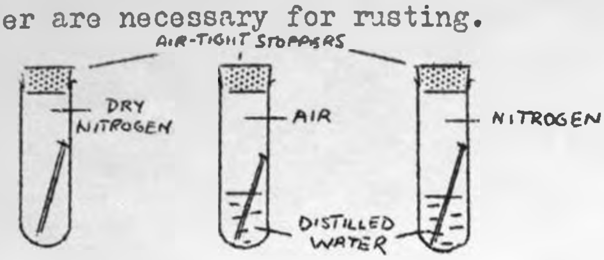
19. A small crystal of potassium chlorate is added to each of the five solutions. Crystallisation takes place in
    1. in both A and B
    2. in both A and E
    3. in C only
    4. in both D and E

20. Solution E could be made saturated by
    1. lowering the solubility curve
    2. adding about 2 gm. of the solute
    3. raising the temperature to 40°C. and adding 5 gm. of the solute
    4. by lowering the temperature to 10°C.

21. About how many grams of water would be needed to dissolve 20 gm. of potassium chlorate at 30°C.?
    1. 5 gm.
    2. 10 gm.
    3. 20 gm.
    4. 200 gm.

---

22. A student assembled the following apparatus in an attempt to show that oxygen and water are necessary for rusting.



After the tubes had been left for a few days he found that the nail in the tube B had rusted and that the other two nails had not. He then realised that in order to show that water and oxygen together are necessary for rusting, he should have set up a fourth tube. What should he have put into this fourth tube?
    1. a nail, distilled water and oxygen
    2. a nail and dry air
    3. a nail and tap water
    4. a nail and wet air.

293

In the following questions 23 - 34 you are given a hypothesis, which may, or may not, be true. After each hypothesis are four experimental observations. Think carefully about each experimental observation and decide which of the following alternatives apply:

1. the experimental observation suggests that the hypothesis is true
2. the experimental observation suggests that the hypothesis is false
3. the experimental observation does not give any information about the truth or falsehood of the hypothesis.

Hypothesis I 'Hydrogen is a reducing agent'

23. Water is formed when hydrogen is burned in oxygen.

24. The reaction between red hot iron and steam is reversible.

25. Hydrogen is a non-metal.

26. Hydrogen is oxidised to hydrogen chloride by chlorine.

Hypothesis II 'All acids contain hydrogen, which is directly replaceable by all metals'

27. Copper does not react with dilute hydrochloric acid.

28. Copper sulphate can be prepared from dilute sulphuric acid and copper oxide.

29. Hydrogen is evolved when iron reacts with dilute sulphuric acid.

30. Aluminium will not react with nitric acid.

Hypothesis III 'The hardness of water is caused by calcium salts'

31. Hard water forms a scum with soap.

32. A precipitate of calcium carbonate is formed when washing soda is added to hard water.

33. Calcium carbonate does not dissolve in hard water.

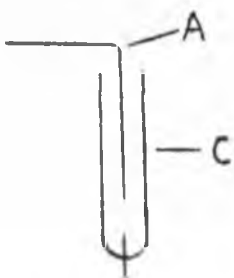
34. Hard water becomes softer when a small amount of limewater is added to it.

---

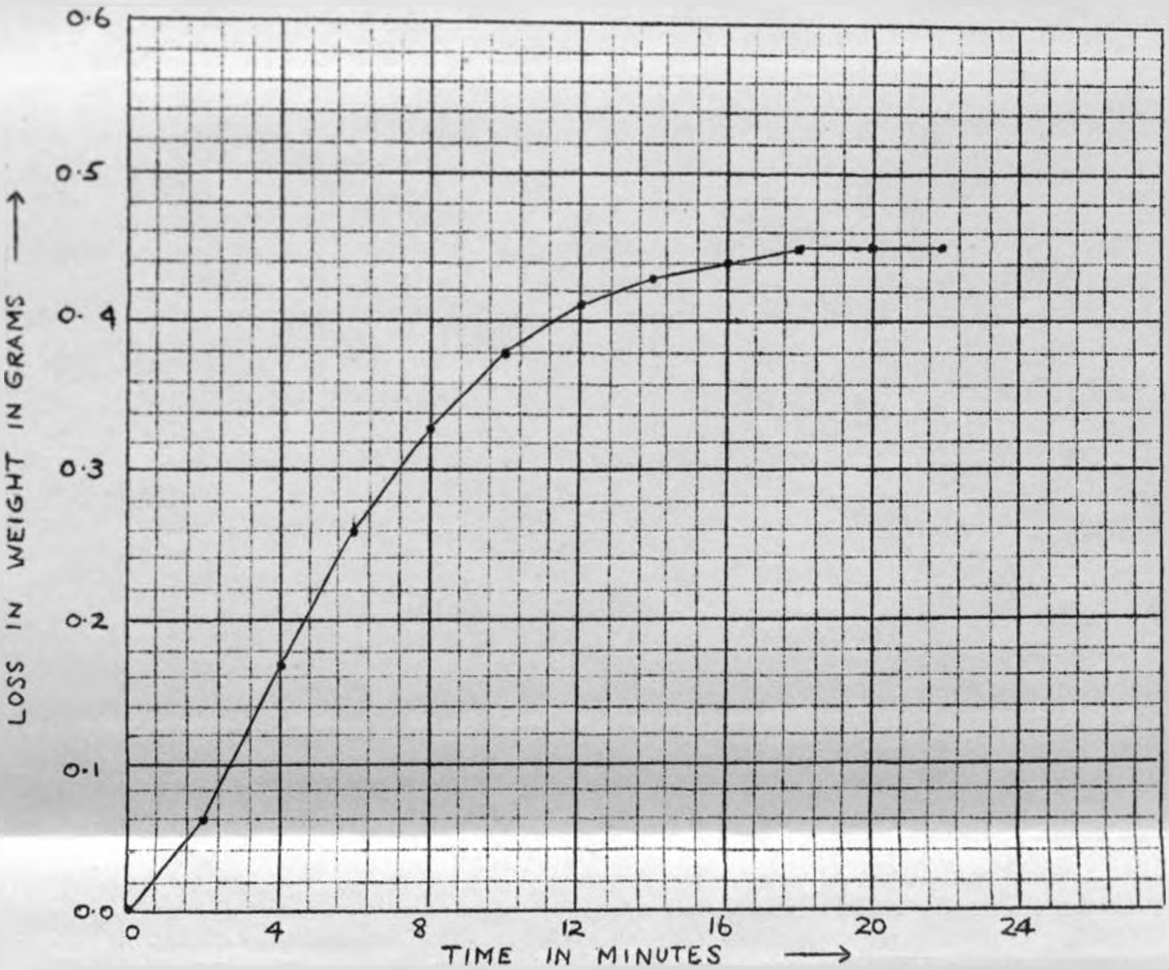
35. Which one of the following will not produce any aluminium oxide?
    1. heating aluminium in air
    2. heating aluminium with iron oxide
    3. heating aluminium in nitrogen
    4. heating aluminium in steam

36. A certain gas extinguished a candle flame immediately. It had no action on limewater, and copper did not change when heated in the gas. Which one of the following could it be?
    1. Air
    2. Nitrogen
    3. Carbon dioxide
    4. Chlorine

37. Suppose you wanted to make an electrical connection between the wire A and electrode B, which is to be used in the electrolysis of an aqueous solution. Which one of the following would you put into the glass tube C?
    1. mercury
    2. molten sulphur
    3. pure water
    4. powdered sulphur.



The following information concerns an experiment to investigate the rate of reaction between calcite (a form of calcium carbonate) and excess hydrochloric acid. 1·05 gm. of calcite were put into 10 ml. of bench hydrochloric acid in a small flask. The flask and its contents were weighed at 2-minute intervals to determine the loss of weight caused by the evolution of carbon dioxide. The results were recorded in the form of a graph as shown below. In this graph the loss in weight is plotted against the time from the moment the two substances were mixed.



Use this graph to answer Questions 38 to 41.

38. What weight of carbon dioxide has been produced after 9 minutes?
    1. 0·695 gm.
    2. 0·325 gm.
    3. 0·30 gm.
    4. 0·355 gm.

39. During which one of the following 2-minute intervals was the rate of reaction the quickest?
    1. 0 to 2 minutes
    2. 2 to 4 minutes
    3. 8 to 10 minutes
    4 16 to 18 minutes.

40. After how many minutes had just half the calcite reacted?
    1. 9 minutes
    2. 5 minutes
    3. 11 minutes
    4. 22 minutes.

41. What was the total weight of carbon dioxide formed?
    1. 1.05 gm.
    2. 0·9 gm.
    3. 0.6 gm.
    4. 0·45 gm.

295

42. P is a white solid, insoluble in water, but dissolves in dilute hydrochloric acid giving off a colourless gas, which when bubbled through limewater produces a white precipitate. P is most likely to be
    1. calcium
    2. calcium carbonate
    3. sodium bicarbonate
    4. carbon dioxide.

43. Q is a substance which reacts with cold water to produce a gas which burns in air. The remaining solution turns red litmus blue. On adding a solution of sodium carbonate to this solution, a white precipitate is formed. Q is most likely to be
    1. calcium hydroxide
    2. sodium
    3. calcium oxide
    4. calcium.

44. R is a red solid which dissolved in dilute nitric acid forming a 296
colourless solution. If hydrogen is passed over hot R, a grey metallic solid is left. There is no change if R is heated. R is likely to be
    1. mercury oxide
    2. ferric oxide
    3. lead oxide
    4. copper

45. S is a brown solid which produces chlorine when warmed with concentrated hydrochloric acid. When the solution is cooled, a white precipitate is formed. S is most likely to be
    1. manganese dioxide
    2. ferric chloride
    3. lead monoxide
    4. lead dioxide

In the following questions, 46 - 51, you are given a statement followed by a condition. Decide which one of the three alternatives apply in each question.
1. The statement is true only under the condition stated.
2. The statement is true and does not depend on the condition.
3. The statement is false regardless of the condition.

	Statement		Condition
46.	Iron rusts in water	if	the water contains dissolved oxygen
47.	Manganese dioxide acts as a catalyst in the preparation of oxygen from potassium chlorate	if	the manganese dioxide is added in small quantities
48.	Iron reacts chemically with pure water	if	steam is passed over red hot iron
49.	Copper reacts with dilute sulphuric acid	if	they are heated together
50.	Temporary hardness in water can be removed by boiling	if	there is no permanent hardness present in the water
51.	A base reacts with an acid to produce a salt and water only	if	the base is insoluble in water

Using the information below, answer the questions 52 - 57.

Substance	Electrical Conduction	Melting Point	Boiling Point	Effect of heating in air
1.	Good when solid or liquid	97°C.	889°C	Burns to form a single oxide, which forms an alkaline solution in water
2.	Non-conductor	113°C.	444°C.	Burns to form a single oxide, which forms an acid solution in water.
3.	Non-conductor	5°C.	80°C.	Burns to form carbon dioxide and water only.
4.	Non-conductor when solid: good conductor when molten	800°C.	1413°C.	Melts; no new substance formed.

52 Which substance would be a liquid at room temperature? 297

53. Which substance could be a metallic element?

54. Which substance could have been sodium chloride?

55. Which substance which when heated would not change in weight?

56. **Which** substance nearly resembles petrol?

57. Which substance could be sulphur?

---

58. X, Y and Z are three metals. The metals X and Y will displace hydrogen from dilute hydrochloric acid, but Z will not react. Metal Y displaces X from a solution of a salt of X. On this evidence, which one of the following is the order of reactivity, putting the most reactive first?
    1. X, Y, Z
    2. X, Z, Y
    3. Y, X, Z
    4. Z, X, Y

59. A certain solid H was heated in a stream of gas called ammonia (a compound of nitrogen and hydrogen). H changed to another solid which was a good conductor of electricity and at the same time water and nitrogen gas were formed. Which one of the following is the most likely conclusion?
    1. H is an oxide of a metallic element
    2. H is an oxide of a non-metallic element
    3. H is a metallic element
    4. H is a non-metallic element.

60. When potassium chlorate is heated it decomposes to form oxygen. Suppose you wanted to investigate whether a certain black powder acted as a catalyst to the decomposition. Which one of the following would you do?
    1. Measure the volume of oxygen produced from different weights of black powder on heating with a fixed weight of potassium chlorate.
    2. Measure the rate at which oxygen is formed from different weights of potassium chlorate heated alone.
    3. Measure the volume of oxygen produced when different weights of potassium chlorate are heated with a fixed weight of black powder.
    4. Measure the rate at which oxygen is formed from a fixed weight of potassium chlorate with and without the black powder.

Name . . . .   Number . . . . .

ANSWER SHEET

Form 2   Chemistry   Term 3, 1966

1.	1	2	3	4	21.	1	2	3	4	41.	1	2	3	4
2.	1	2	3	4	22.	1	2	3	4	42.	1	2	3	4
3.	1	2	3	4	23.	1	2	3		43.	1	2	3	4
4.	1	2	3	4	24.	1	2	3		44.	1	2	3	4
5.	1	2	3	4	25.	1	2	3		45.	1	2	3	4
6.	1	2	3	4	26.	1	2	3		46.	1	2	3	
7.	1	2	3	4	27.	1	2	3		47.	1	2	3	
8.	1	2	3	4	28.	1	2	3		48.	1	2	3	
9.	1	2	3	4	29.	1	2	3		49.	1	2	3	
10.	1	2	3	4	30.	1	2	3		50.	1	2	3	
11.	1	2	3	4	31.	1	2	3		51.	1	2	3	
12.	1	2	3	4	32.	1	2	3		52.	1	2	3	4
13.	1	2	3	4	33.	1	2	3		53.	1	2	3	4
14.	1	2	3	4	34.	1	2	3		54.	1	2	3	4
15.	1	2	3	4	35.	1	2	3	4	55.	1	2	3	4
16.	1	2	3	4	36.	1	2	3	4	56.	1	2	3	4
17.	1	2	3	4	37.	1	2	3	4	57.	1	2	3	4
18.	1	2	3	4	38.	1	2	3	4	58.	1	2	3	4
19.	1	2	3	4	39.	1	2	3	4	59.	1	2	3	4
20.	1	2	3	4	40.	1	2	3	4	60.	1	2	3	4

FORM 2 TEST 29PHOB Term 3, 1966

P H Y S I C S

1½ hours

This paper contains 55 questions. Attempt all the questions. The questions are not arranged in order of difficulty, so do not spend too much time on any one question; if you cannot do it quickly, pass on to the next and return to it at the end if you have time.

There are four alternatives to each question. Only one of the alternatives is correct. Decide which alternative is correct and put a cross over the appropriate number on your Answer Sheet.

Sample Question:

75. Which one of the following is a liquid at room temperature?
    1. iron
    2. mercury
    3. iodine
    4. silver

Sample Answer Sheet:

75. 1 $\cancel{2}$ 3 4

(The correst answer is the second alternative, so) a cross is put over 2

If you wish to change your answer , make sure that you write in the number again above the cross.

A fraction of the marks will be deducted for wrong answers, so it will not be to your advantage to guess unless you are able to eliminate one or more of the alternatives.

Please do not write on this question paper; use paper provided for rough work.

DO NOT TURN THIS PA

1. It is not possible to hear a bell ringing in a vacuum because
   1. there is no material in the vacuum in which the sound waves can exist
   2. the clapper of the bell gives up kinetic energy to the vacuum
   3. the vacuum acts as a sound conductor
   4. the vacuum decreases the pitch of the bell.

2. A certain machine is said to have an efficiency of 50%. Does this mean that
   1. the machine operates at a maximum efficiency only 50% of the time
   2. only half of the work put into the machine is used up.
   3. half of the energy put into the machine is destroyed
   4. only half of the work put into the machine is returned as useful work done.

3. The approximate pressure of air at sea-level, expressed as inches of mercury is
   1. 10
   2. 30
   3. 50
   4. 76

4. The chief difference between the highest note and the lowest note on a piano is that the high note
   1. is always a louder sound
   2. is always a softer sound
   3. has more vibrations per second
   4. has fewer vibrations per second

5. Many of the small motors used in refrigerators are rated at one-fourth horsepower. How many foot-pounds of work can such a motor do in 1 minute?
   1. 550
   2. 8,250
   3. 33,000
   4. 137½

6. At certain times the moon comes in between the sun and the earth and cuts off the sunlight. This phenomenum is called
   1. a shadow
   2. a penumbra
   3. an eclipse
   4. a sunspot

7. When the E string on a violin is tightened the
   1. pitch is raised
   2. pitch is lowered
   3. intensity is increased
   4. overtones are improved

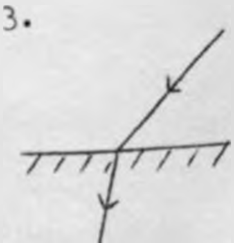
8. In order to operate successfully, an electric motor does <u>not</u> need
   1. an armature
   2. an electromagnet
   3. a coil
   4. a transformer

9. The following diagrams represent rays of light reflected from a plane mirror. Which one of the reflections is incorrect?

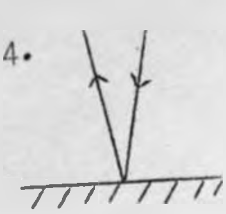
1.

2.

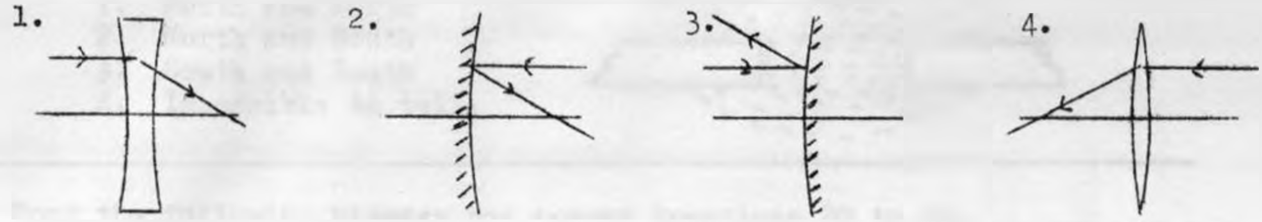
3.



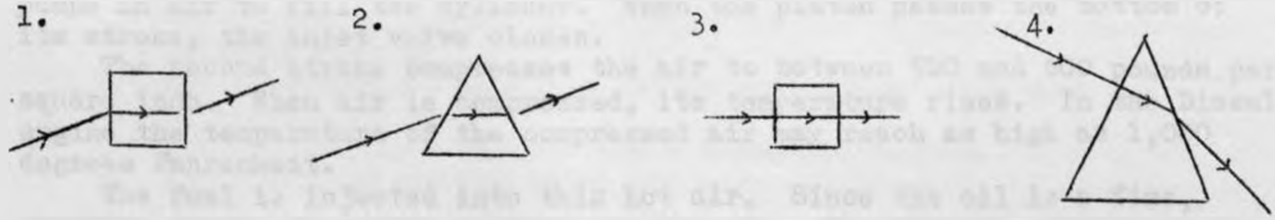
4.



10. The following diagrams represent rays of light falling on to lenses or mirrors. Which one of the diagrams is incorrect?

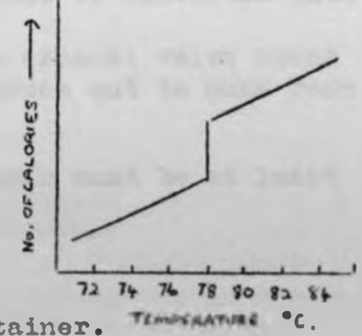


11. The following diagrams show rays of light passing through glass blocks. Which one of the diagrams is incorrect?



12. The number of calories required to heat 100 gm. of a metal, specific heat 0·2 cal/gm./deg.C., from 20°C. to 80°C. is
    1. 1,600
    2. 0.33
    3. 120
    4. 1,200

13. The graph shown is a plot of temperature against number of calories required to heat a certain mass of alcohol. The reason for the vertical part of the graph at 78°C. is that
    1. no heat is being supplied to the alcohol
    2. the heat being supplied is wasted
    3. the alcohol is boiling
    4. the heat supplied is absorbed by the container.



14. A boat is to be pulled out of the water on to the beach on a set of rollers. Before the amount of work required for the operation can be calculated, it is necessary to know
    1. only the distance the boat is to be moved along the beach
    2. the volume of the boat and the distance it is to be moved
    3. the force required to move the boat and the distance it is to be moved
    4. the weight of the boat and the diameter of the rollers.

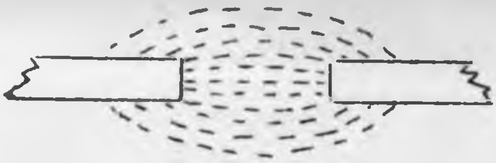
15. A magnet will lose some of its magnetism if it is
    1. dipped in hot water
    2. hammered
    3. brought near a compass
    4. surrounded by soft iron.

16. The function of the valves in wind musical instruments is to
    1. control the loudness of the sounds produced
    2. make the air columns vibrate
    3. keep the length of the air column from changing
    4. change the length of the air columns.

17. The material used in fuses must
    1. have a high melting point
    2. have a low melting point
    3. have a high electrical resistance
    4. contain copper

19. The diagram shows the magnetic field between the poles of two magnets. The poles are

1. North and North
2. North and South
3. South and South
4. Impossible to tell.



Read the following passage and answer Questions 20 to 23.

The first stroke of the four-stroke cycle Diesel engine is the intake of fresh air. With the inlet valve open, the piston, moving downward, pumps in air to fill the cylinder. When the piston passes the bottom of its stroke, the inlet valve closes.

The second stroke compresses the air to between 500 and 600 pounds per square inch. When air is compressed, its temperature rises. In the Diesel engine the temperature of the compressed air may reach as high as 1,000 degrees Fahrenheit.

The fuel is injected into this hot air. Since the oil is a fine, fog-like spray, it starts to burn immediately. The injector continues to spray fuel oil into the cylinder until all of the charge is injected. The pressure in the cylinder rises to bewteen 800 and 850 pounds per square inch.

The third stroke is the power stroke. The hot gases expand and force the piston downward. The chemical energy of the fuel is converted into mechanical energy to move the piston.

The fourth stroke is the exhaust stroke. The exhaust valve opens and the piston, moving upward, forces the burned gases out to make room for a new charge of air.

20. The pressure which injects oil into a Diesel cylinder must be at least

1. 15 pounds per square inch
2. 100 pounds per square inch
3. 400 pounds per square inch
4. 800 pounds per square inch.

21. Which of the following processes is most important during the third stroke of the piston?

1. Air is compressed
2. Energy is stored
3. Energy is destroyed
4. Chemical changes occur.

22. What causes the fuel to ignite in a Diesel cylinder?

1. hot fuel
2. a spark
3. hot air
4. heat of friction

23. In what position are the valves during the compression stroke?

1. both are open
2. both are closed
3. the inlet valve is open and the exhaust valve is closed
4. the inlet valve is closed and the exhaust valve is open.

---

24. Water in a paper bag can be boiled using a flame without the paper burning because

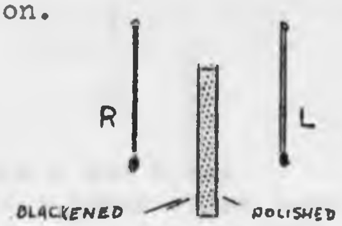
1. paper will not burn when wet
2. The water keeps the temperature of the paper below its ignition point
3. the water cools the flame
4. It is impossible to burn anything which is in contact with water.

25. A woollen jumper is used to keep oneself warm in cold weather because

1. it keeps out the cold air
2. wool is a poor conductor of heat
3. the air between the fibres act as a good insulator
4. woollen garments are always warm.

26. A glass bottle sometimes breaks if boiling water is poured into it because
    1. glass cannot stand the temperature of boiling water
    2. the glass expands unevenly
    3. glass bottles are badly manufactured
    4. glass has a very low coefficient of expansion.

27. The metal sheet (shown in the diagram) is heated to a temperature greater than 100°C. Thermometers R and L are placed at equal distances away from the blackened and polished surfaces respectively. Thermometer R is found to rise in temperature faster than thermometer L because



    1. the blackened surface is a worse absorber of radiation than the polished surface
    2. the blackened surface is a better radiator of heat than the polished surface
    3. air conducts heat better from a blackened surface
    4. the blackened surface gives off more electrons

Questions 28 to 32 concern a mercury in glass thermometer.

28. The bulb of the thermometer is made of thin glass because
    1. mercury is expensive
    2. the mercury can be seen more clearly
    3. glass is a poor conductor of heat
    4. if it were thick, the glass would break owing to expansion

29. The stem of the thermometer is a narrow tube because
    1. mercury is expensive
    2. it is too difficult to make a uniform wide tube
    3. there will be uniform expansion
    4. the thermometer will be more sensitive.

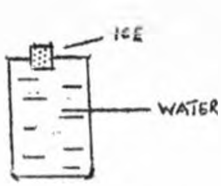
30. The stem of the thermometer has a thick wall because
    1. it will not break so easily
    2. it will magnify the mercury thread
    3. it is easier to mark the graduations
    4. it will prevent heat being conducted from the mercury

31. There is a space at the top of the bore
    1. to hold the mercury vapour
    2. so that the air can be compressed into this space when the mercury expands
    3. due to the method of sealing the bore during manufacture
    4. to give more safety in case of overheating.

32. The thermometer is made of glass because
    1. other solids react chemically with mercury
    2. glass is transparent
    3. glass does not expand when heated
    4. glass is a good conductor of heat.

---

33. A beaker is filled to the top with water containing 1 c.c. of ice (specific gravity = $\frac{1}{2}$) floating on the surface, as shown in the diagram. What will happen when the ice melts?



    1. $\frac{1}{2}$ c.c. of water will overflow
    2. the level of the water will go down
    3. the level of the water will stay the same
    4. 1 c.c. of the water will overflow

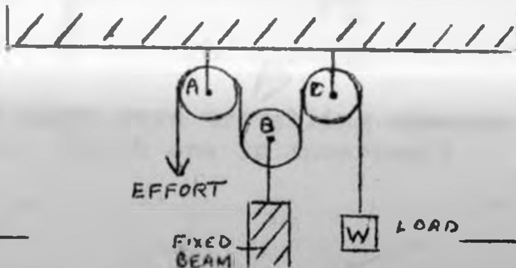
34. A cylinder of cork has a diameter of 4 cm. and a mass of 22 gm. The density of cork is 0·25 gm. per c.c. What is the length of the cylinder?
    1. $^{7}/_{16}$ cm.
    2. $1\frac{3}{4}$ cm.
    3. 22 cm.

35. A block of material 2 cm. x 9 cm. x 5 cm. weighed 100 gm. It sinks when placed in water. What volume of cork (specific gravity = 0·5) would be needed to be attached to this piece of material so that it just floated in water?

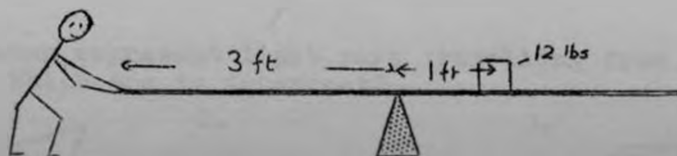
1. 10 c.c.
2. 20 c.c.
3. 45 c.c.
4. 50 c.c.

36. The diagram shows a pulley and tackle system. Pulleys A and C are attached to an upper beam and Pulley B is attached to a lower fixed beam. Assuming that the system is frictionless, what effort would be required to lift a load W lb.wt.?

1. W lb.wt.
2. W/2 lb.wt.
3. W/3 lb.wt.
4. W/4 lb.wt.



The diagram represents a lever. By pushing down with a force applied 3 ft. from the pivot, a man raises a load of 12 lb.wt, which is placed 1 ft. from the pivot. No friction is assumed.



Answer questions 37 to 39 using this information.

37. What force does the man have to apply to lift the load?

1. 12 lb.wt.
2. 4 lb.wt.
3. 36 lb.wt.
4. $1\frac{1}{3}$ lb.wt.

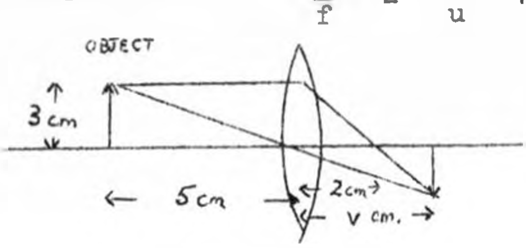
38. If the force moves 2 ft. downwards, how far will the load be raised?

1. $\frac{2}{3}$ ft.
2. 2 ft.
3. 6 ft.
4. 1 ft.

39. The energy transfered from the man to the load is

1. $\frac{1}{3}$ rd. the energy supplied by the man's push
2. equal to the energy supplied by the man's push
3. 3 times the energy supplied by the man's push
4. $\frac{2}{3}$ rd the energy supplied by the man's push.

The diagram represents the image of the object from a convex lens. f is the focal length; u is the distance of the object from the lens; v is the distance of the image from the lens. They are related according to the expression $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$



(NOT TO SCALE)

Answer Questions 40 and 41 using the above information.

40. The distance of the image from the lens is

1. 3 cm.
2. $1\frac{1}{4}$ cm.
3. $3\frac{1}{3}$ cm.
4. 5 cm.

41. The size of tho image will be
 1. 2 cm.
 2. 3 cm.
 3. $\frac{3}{4}$ cm.
 4. $9/5$ cm.

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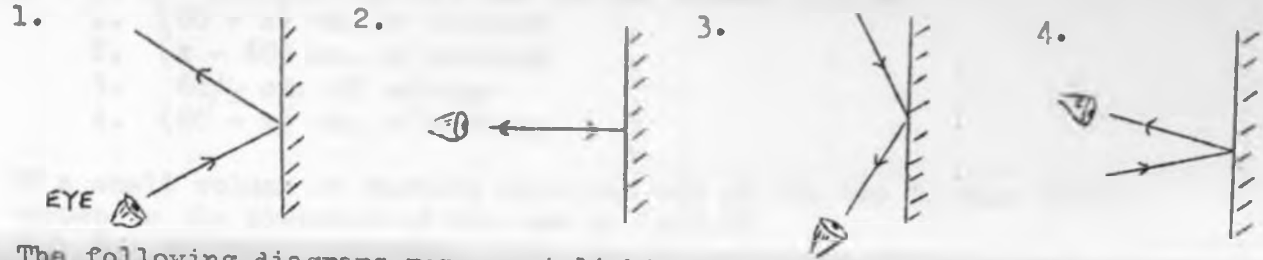
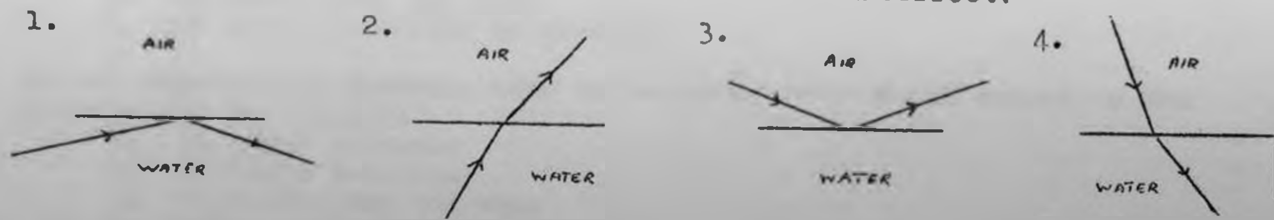
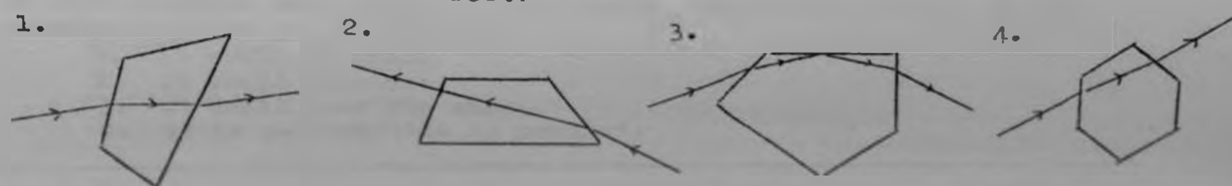
42. The following diagrams represent light falling on plane mirrors. Which one of the diagrams is incorrect?



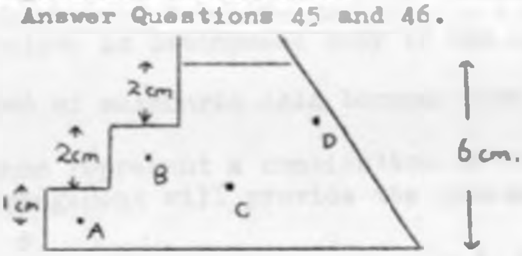
43. The following diagrams represent light rays travelling towards an air-water or water-air interface. Which one is incorrect?



44. The diagrams represent light rays travelling from air through glass blocks. Which one is incorrect?



The diagram below represents a container with dimensions as shown, containing water. Answer Questions 45 and 46.

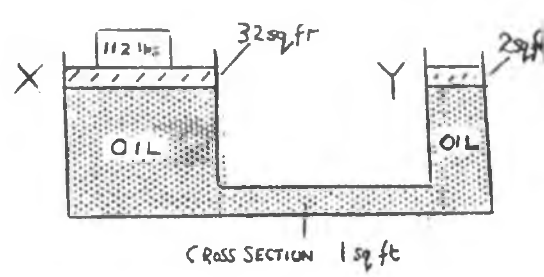


45. At which one of tho four points would there be the greatest water pressure?
 1. A
 2. B
 3. C
 4. D

46. What would be the water pressure at Point A?
 1. 1 gm.wt./sq.cm.
 2. 3 gm.wt./sq.cm.
 3. 4 gm.wt./sq.cm.
 4. 5 gm.wt./sq.cm.

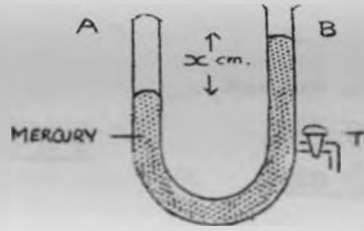
---

47. The diagram shows a system containing oil with a piston in each limb. Area of the piston X is 32 sq.ft. Area of piston Y is 2 sq.ft.
What weight must be placed on piston Y in order to raise the 112 lb.wt. on piston X?
 1. 112 lbs.
 2. 28 lbs.
 3. 7 lbs.
 4. 1,792 lbs.



Questions 48 to 51.
The diagram represents a manometer filled with mercury.

Atmospheric Pressure
= 60 cm. of mercury.



48. What is the pressure of the gas in the closed limb A?
   1. (60 + x) cm. of mercury
   2. (x − 60) cm. of mercury
   3. $60/x$ cm. of mercury
   4. (60 − x) cm. of mercury

49. If a small volume of mercury were run out of the tap T, what would happen to the pressure of the gas in limb A?
   1. it would decrease
   2. it would increase
   3. it would stay the same
   4. it is not possible to predict.

50. If the atmospheric pressure were to increase, what would happen to the pressure in the limb A?
   1. it would decrease
   2. it would increase
   3. it would stay the same
   4. it is not possible to predict.

51. If more mercury were added to the limb B, what would happen to the pressure of the gas in limb A?
   1. it would decrease
   2. it would increase
   3. it would stay the same
   4. it is not possible to predict.

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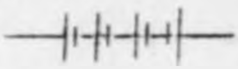
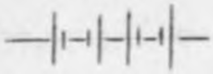
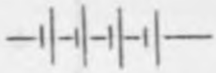
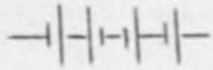
52. Which one of the following statements about the electrolysis of dilute sulphuric acid using platinum electrodes is true?
   1. Equal volumes of hydrogen and oxygen are produced at the electrodes.
   2. Water is decomposed into its elements by a physical change.
   3. The electrolyte is decomposed only if the electrodes are close together.
   4. The solution of sulphuric acid becomes more concentrated.

53. The following diagrams represent a combination of four cells,(each of 2 volts). Which arrangement will provide the greatest electrical pressure?

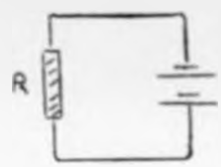
1.


2.


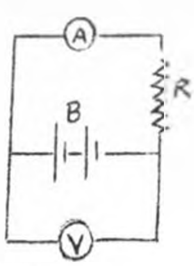
3.


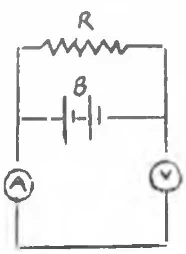
4.


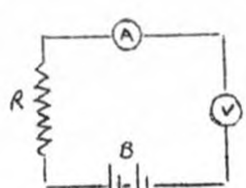
54. In the circuit shown, the following are placed in position R. Which one will allow a current to flow?
   1. a glass rod
   2. an asbestos rod
   3. a pencil
   4. a plastic rod.

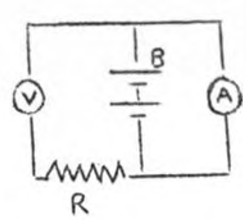


55. You are provided with a battery B, an ammeter A, a voltmeter V, a resistance R and connecting wire. Which one of the following circuits would you set up to measure the current flowing through the circuit and the elctrical pressure across the battery?

1.


2.


3.


4.


STOP HERE

Name . . . .   Number . . . . .

ANSWER SHEET

Form 2

Physics

Term 3, 1966

1.	1	2	3	4	21.	1	2	3	4	41.	1	2	3	4
2.	1	2	3	4	22.	1	2	3	4	42.	1	2	3	4
3.	1	2	3	4	23.	1	2	3	4	43.	1	2	3	4
4.	1	2	3	4	24.	1	2	3	4	44.	1	2	3	4
5.	1	2	3	4	25.	1	2	3	4	45.	1	2	3	4
6.	1	2	3	4	26.	1	2	3	4	46.	1	2	3	4
7.	1	2	3	4	27.	1	2	3	4	47.	1	2	3	4
8.	1	2	3	4	28.	1	2	3	4	48.	1	2	3	4
9.	1	2	3	4	29.	1	2	3	4	49.	1	2	3	4
10.	1	2	3	4	30.	1	2	3	4	50.	1	2	3	4
11.	1	2	3	4	31.	1	2	3	4	51.	1	2	3	4
12.	1	2	3	4	32.	1	2	3	4	52.	1	2	3	4
13.	1	2	3	4	33.	1	2	3	4	53.	1	2	3	4
14.	1	2	3	4	34.	1	2	3	4	54.	1	2	3	4
15.	1	2	3	4	35.	1	2	3	4	55.	1	2	3	4
16.	1	2	3	4	36.	1	2	3	4					
17.	1	2	3	4	37.	1	2	3	4					
18.	1	2	3	4	38.	1	2	3	4					
19.	1	2	3	4	39.	1	2	3	4					
20.	1	2	3	4	40.	1	2	3	4					