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ABSTRACT
The chemical content knowledge of secondary science teachers is seldom measured directly in developed countries as there are practical, ethical and political problems involved that would be likely to be insuperable.

In Papua New Guinea (PNG), the author assisted in some of the work involved in the second IEA Science Study (SISS), where the PNG education system took part in the scheme which involved twenty-six different countries. The author suggested that the science teachers taking the classes being tested completed the tests themselves. These scripts were returned to be marked in the same way of the student scripts.

The results of the research were significant and can be considered as a start to the fuller and more detailed research which would be necessary to be more confident of the conclusions. However, evidence was produced to indicate that that the knowledge of some experienced science teachers was less than would be considered desirable. The scientific knowledge Goroka diploma holders, whether experienced or more recent, was less as a group than other Grade 10 teachers. There was also evidence that chemistry is an area of difficulty, particularly for Goroka diploma holders. Item analysis of SISS data yielded some inkling of specific problems which national teachers had in their own understanding; it might eventually lead to appropriate solutions being found for these problems.

THE CHEMICAL KNOWLEDGE OF SECONDARY SCIENCE TEACHERS IN PAPUA NEW GUINEA

W. P. Palmer

Introduction

'My revolutionary suggestion is that students [student-teachers] should be sent out not only full of friendly feelings towards their charges, but actually knowing something' (Bantock, 1969). The challenge which faces teacher trainers worldwide is to ensure that the new teachers sent out possess the minimum subject knowledge to enable them to pass on this knowledge to their students. They must have many other skills, but without this minimum subject knowledge they are doomed to failure as teachers.

This same point has been expressed by a number of educationalists in different words: '…it is abundantly clear that no amount of general intellectual skill or mastery over cognitive strategies will overcome lacks in content knowledge' (Schulman, 1974. 'In teaching, knowledge enters into the professional work in a more unique fashion: knowledge is what teaching is about' (Buckman, 1982)

Walsh (1984) complains about the lack of content knowledge of Australian secondary science teachers. He considers that the reason for this lack of knowledge is that science teachers who are expert in one field of science have to teach other science areas in which they are not expert. In Papua New Guinea (PNG), because national teachers are trained to some extent in all areas of science, this particular problem does not arise, though it is a problem for some expatriate teachers. However P.N.G. secondary science curricula do not emphasise content knowledge (Palmer, 1984) in keeping with the deliberate policy of 'containment' (Wilson and Deutrom, 1984), and this causes problems in tertiary education.

In general, at Grade 10 level, students are considered to be about three years behind Grade 10 students in industria1ised countries. Goroka Teachers College, which is the main source of secondary teachers in PNG, recruits at Grade 10 level, with graduates normally qualifying after three years, and also at Grade 12 level, with graduates qualifying after a two year course. It is thus obvious that the academic standards of teachers graduating at GTC will be below those accepted in developed countries.

However the question this paper will attempt to answer is this: Is the knowledge of PNG teachers sufficient to enable them to teach science competently in the top classes (Grade 10) of provincial high schools?

Relevant Research

At a recent meeting of teacher educators in Australia, Phillips (1986), in a keynote address, stated that when he was looking for educational research relating to excellence in teaching he found that research findings proved that good teachers mumble and give more badly structured explanations than do unsuccessful teachers, and that teachers who have the most repulsive personalities are more successful than those who are pleasant, and so on. This was greeted with stunned silence. A few moments later he pointed out that the truth was the exact opposite of the research findings quoted. The point made by Phillips, which is being emphasised here too, is that educational research findings are usually unsurprising and often platitudinous. The area of teacher knowledge appears to be under-researched worldwide. For example, the well-known surveys such as Bennett (1976) and Rutter (1979) which look at the effect of teachers/schools on pupils do not include teacher knowledge as a variable. Similarly, the sociological studies looking for causes of inequality between children (Jencks, 1972) do not appear to consider teacher knowledge as a possible factor. One reason for this may be that teachers and teachers' unions do not like researchers investigating the knowledge of teachers (Bruning, 1986), because teachers' apparent lack of knowledge has sometimes been a cause of embarrassment to the profession. Researchers have thus sought less contoversia1 avenues such as looking at the academic quality of students about to enter teaching, as compared with those considering other careers. The pattern that emerges, with the notable exception of Norway (Rust, 1985), is that those entering teaching as a profession in countries such as USA (Weaver, 1978) and Japan (Inoue, 1975) occupy very

lowly positions in the ranks of all new graduates. This is likely to be true of PNG also, as the entry requirements of those entering teaching through GTC are lower than those required for other faculties of UPNG or the University of Technology, Lae. This is in spite of recent advertisements in the local press which state that 'Papua New Guinea needs many more high school teachers - teachers who are scholarly, skilled and professional. GTC is committed to producing only the best' (GTC, 1986). Entrance requirements for teaching have however been rising over the last five years, so it is earnestly hoped that more scholarly, skilled and professional teachers are now being produced, but on the whole, those starting teaching in PNG are less academically able than those entering other professions.

An early study by Nisbet (1954) clearly shows that teachers with higher intelligence prior to graduation were more successful in their careers over a twenty year period. There is also a considerable body of research literature on teacher knowledge of certain specialised subject areas such as metrication (Rowsey et al, 1978) and nutrition (Penner and Kolasa, 1983). However, straightforward studies linking teacher knowledge to pupil achievement are rare, partly because they are liable to be misunderstood through over-simplification, and partly because the shadow of 'payment by results' still hovers over the profession.

Within PNG, there is evidence of student achievement in Eastern Highlands community schools being related to teacher quality, measured on a number of criteria (Weeks, 1985). Tuppen (1981) showed that for provincial high schools there was a greater success rate on the MYRE (Mid Year Rating Examination, now void) from schools where a high proportion of staff had undergone advanced training. Roberts (1985) carefully researched the difficulties in mathematics education in community schools in PNG. The general thrust of his study will be given by quoting from his abstract:

> The findings showed that teachers and children were generally weak at mathematics with pupil mastery levels decreasing rapidly in the upper grades. Some teachers themselves know very little more mathematics than their pupils.

Further study of his results shows geometry to be an area of particular difficulty in mathematics. Teachers' scores showed an average of 78.1%, standard deviation 9.7, with a range of teacher scores from 92.8% to 52.8%. For comparison, the pupils' overall mean was 47.9%. Roberts points out that the gap between pupils and teachers is 35.7% in Grade 2, but only 17.2% in Grade 6. He considers that the size of the gap in knowledge between pupils and teachers in Grade 6 is too narrow for confidence that the quality of teaching is adequate at this level.

The SISS Study

The first IEA Science Study (SISS) took place between 1970 and 1973. PNG did not take part in it. The survey aimed to look at science education as a whole in the nineteen participating countries, and to measure levels of achievement by pupils at four different ages in these countries (Comber and Keeves, 1973), (Rosier, 1973). Planning the second IEA Science Study (SISS) started in 1980 (Keeves and Rosier, 1981) and has involved more than twenty six countries, including PNG. A PNG National Study Committee was formed (Research Co-ordinator, Michael Wilson) to ensure the smooth administration of the international tests, and also to see that other tests were designed to obtain any additional information required for purposes specific to PNG (Wilson, 1982). Population 3, who were 16 year olds in the international study and Grade 12 students in PNG, were tested in 1983 (Wilson, 1986a). Population 2, who were 14 year olds in the study as a whole and Grade 10 students in PNG, were tested in September 1984. (Some information on the results of these tests is being now produced in mimeographed form.) Wilson (1986b) gives a full description of PNG SISS developments to date.

The PNG National Study Committee did however encourage some additional national research over and above the international plan for Grade 10 students (Wilson, 1984). Firstly it was agreed that the teachers who actually teach Grade 10 would be asked to answer the same questions as their students. Secondly, because the international tests contained comparatively few chemistry questions, an additional eight chemistry questions at Grade 10 level were added to the seventy international questions. It is these two local additions to the main international effort which will be discussed in this paper.

The SISS Instruments at Population 2 Level

The SISS Science Understanding tests were made up of five tests - 2M, 2A, 2B, 2C and 2D. The 2M test consisted of 30 questions, all of which were provided by the International Study. Test 2A, 2B, 2C and 2D contained 10 questions from the International Study and questions 11 and 12 in each paper were objective chemistry questions based on the Grade 10 chemistry unit called *Chemical Technology, Unit 10.1.* These eight additional questions had been chosen from 27 possible questions pretested by GTC preliminary year students. The questions were of middle level difficulty and covered different aspects of Unit 10.1. The tests are included as Appendix 1. Grade 10 students were asked to do Test 2M and two of the other tests. The teachers were asked to answer all the questions in all five multiple choice tests. They were also asked to state how much stress they had placed on the content of each of the 78 questions on a three point scale called the Opportunity to Learn Index (OTL). It should be emphasised that there was no means of checking whether the teachers answered the questions with or without help, or did so hurriedly, painstakingly or not at all. Teachers were simply advised to fill in all their forms, 78 questions plus a lengthy teacher questionnaire, whilst their class was doing the tests and the student questionnaire. If there was more than one Grade 10 science teacher in the school, each teacher was expected to answer the questions and questionnaire.

Although 90 result sheets were received out of a possible 126 from 78 schools only 70 teachers completed all five tests (Two of these did not complete the ATL tests but these have been included). Of the sample, about 25% were female, 64% were national and about half had graduated from GTC. It should be noted, however, that all of the sample were Grade 10 teachers and wou1d therefore be expected to be the most experienced and capable teachers in provincial high schools. It should also be noted that the test is designed to be suitable in the main for 14 year old students in developed countries and was considered to be suitable for Grade 10 students in PNG, so experienced teachers at this level should not have much difficulty in scoring high marks.

Appendix 2 contains the raw results of five tests for the 70 Grade 10 teachers. Basic statistics far the tests are in Table 1 below. Table 2 is a correlation matrix showing the correlations between each of the five tests and the total.

Table 1. Means, Standard Deviations and Percentage Means for Each Test

Test	1 Test 2M	2 Test 2A	3 Test 2B	4 Test 2C	5 Test 2D	6 Total
Mean	26.51	10.26	10.39	10.79	10.86	68.71
Standard Deviation	3.16	1.59	1.48	1.27	1.28	6.48
Maximum Score	30	12	12	12	12	78
Mean as a Percentage	88.37%	85.50%	86.08%	89.92%	90.50%	88.09%

Table 2 Correlations between Test 2M, 2A, 2B, 2C, 2D and Total

	Test 2M	Test 2A	Test 2B	Test 2C	Test 2D	Total
Test 2M	1.000	0.437	0.345	0.345	0.497	0.847
Test 2A	0.437	1.000	0.291	0.444	0.620	0.734
Test 2B	0.345	0.291	1.000	0.122	0.508	0.598
Test 2C	0.345	0.444	0.122	1.000	0.311	0.561
Test 2D	0.497	0.620	0.508	0.311	1.000	0.774
Total	0.847	0.734	0.598	0.561	0.774	1.000

Table 1 indicates the high average scores obtained by the 70 teachers, all between 85% and 91%. Table 2 shows reasonably high correlations between the tests, indicating they are generally similar in nature.

Appendix 1 was treated in an arbitrary manner to split the teachers into five groups based on overall attainment. The teachers who made no errors were given the grade M (Master teachers). It was considered that up to one casual error per test might be made by a teacher who had a good grasp of science. Such teachers were called Grade A teachers. If up to two errors per test were made the teachers were categorised as Grade B teachers. Teachers with up to three errors per test were called Grade C teachers. Those with more than three errors per test were called Grade D teachers. There were 4 Grade M teachers, 20 Grade A teachers, 18 Grade B teachers, 15 Grade C teachers and 13 Grade D teachers. Since this is an arbitrary categorisation, it is a matter of judgment whether any particular group has an adequate subject knowledge. Such judgments can only be made by looking at the level of difficulty of the questions, in relation to what an experienced teacher needs to know in order to teach the syllabus satisfactorily. The judgment here will be made that there is little cause for concern about teachers in categories M, A or B, some cause for concern about teachers in category C and considerable worry about the ability of teachers in category D to cope with the syllabus.

Which Areas of Science caused most difficulty to teachers?

The seventy eight questions previously marked for each of the seventy teachers were re-marked so as to give results in the four separate sciences. The raw results can be seen in Appendices 3 and 4. Basic statistics for these tests can be found in Table 3. Correlations between the marks the teachers obtained for the four separate sciences and the total are shown in Table 4 below.

Table 3. Table of Basic Statistics for Tests in Separate Subjects for 70 Teachers

	Chemistry	Physics	Biology	Earth Science	Total
Mean	18.89	21.04	20.89	8.03	68.74
Standard Deviation	2.55	2.28	2.10	1.20	6.43
Maximum Score	22	24	23	9	78

Table 4. Tests in the Separate Sciences Correlation Matrix

	Chem Test	Phys Test	Biol Test	E. Sci Test	Total
Chem Test	1.000	0.695	0.473	0.233	0.847
Phys Test	0.695	1.000	0.538	0.248	0.857
Biol Test	0.473	0.538	1.000	0.386	0.778
E.Sci Test	0.233	0.248	0.386	1.000	0.503
Total	0.847	0.857	0.778	0.503	1.000

The eight additional chemistry questions set on Unit 10.1 have been included throughout. Numbers of questions in each subject were as follows: physics, 24; biology, 23; chemistry, 22; earth science,9. A brief glance at the correlations between the tests in the separate sciences indicates a generally high level of correlation, but with the earth science test not correlating well with the other areas. Because each test had different numbers of questions, means for each were calculated as percentages which may be found in Table 5. From the percentage means which are similar between tests chemistry can be seen as marginally the most difficult subject for teachers. It was thought that teachers who were less knowledgeable overall would find greatest difficulty with chemistry, so the percentage means of C and D grade teachers were calculated and may also be found in Table 5.

Table 5 Percentage Means of Tests in the Separate science for Various Groups of Teachers.

	Number	Chem Test	Physics Test	E. Science Test	Biology Test
All Teachers	70	85.85%	87.68%	89.20%	90.81%
Grade C and D Teachers	28	75.90%	79.60%	81.40%	82.90%
Grade D Teachers Only	13	69.58%	76.60%	77.78%	79.93%

It should be noticed that the order of difficulty is consistently chemistry, physics, earth science and biology, with biology causing least difficulty. Chemistry is the most difficult subject area for teachers in this test. Table 5 appears to support the suggestion made above that teachers with the least knowledge as a group will do worst in chemistry. Statistically the following result is obtained: in looking at the fraction chemistry marks/physics, biology, earth science marks for the 42 M, A and B teachers and comparing them with the fraction chemistry marks/physics, biology, earth science marks for the C and D teachers, it was found that the difference in the means was only significant at the 10% level. Thus the hypothesis that teachers with least knowledge as a group will do worst in chemistry cannot be sustained.

The separate science tests may be looked at in a different way to see how many Master teachers were produced in each area. A Master teacher is defined as one who scored full marks in a particular area. Ten teachers achieved mastery status in chemistry, eleven teachers in physics, seventeen in biology and twenty nine in earth science. Here again chemistry and physics seem to be the most difficult areas for teachers to master.

Which teachers had the most difficulty with the Tests?

In addition to the cognitive tests for teachers, there was also a questionnaire which asked for such information as sex, academic qualifications, nationality and length of experience, etc. from the teachers. Considerable future work will be required to correlate each of these and other results with the cognitive data.

However, the test results for the two largest groups in the sample, GTC diplomates and expatriate degree holders, will be looked at briefly. The results indicated that the overseas graduates averaged just below an A grade (about 6 errors), whilst the GTC diplomates averaged just above C grade (about 16 errors). The small sample of B.Ed. graduates from UPNG averaged just below a B grade (about 11 errors).

These results appear to be very much in agreement with the views of the Regional Secondary Inspectors quoted in Guthrie (1983), to the effect that GTC graduates lack subject knowledge. These results may well be in accord with earlier research on GTC students in mathematics (Allen, Thomas and Patu, 1975) where they state:

> The most crucial part of the teacher training problem is that with such a poor standard of understanding the student is not equipped to improve his lot by self-study or in-service training.

However, as stated earlier, it remains a matter of judgment whether an overall average score of 75% for Grade D teachers on this test is success or failure. In terms of Master Teachers in any of the separate sciences for the GTC diplomate group, there were ten teachers who made no error in earth science, two who made no error in biology, one who made no errors in chemistry and none who made no errors in physics. The surprise is the number of teachers who have mastered questions in earth science, because Wilson (1985) found that teachers consider this an area of difficulty 'Very few teachers are secure in their understanding of Unit 10.4 (Geology)'.

Finally, no obvious relation between test scores and years of experience of GTC diplomates was found when simply considering the scores of those with more than five years experience compared with those with less than five years experience.

One major source of error has been the forms that were only partially completed. These have been excluded. But viewing a few of these papers, I have the impression that they would probably be among the lower scores. No conclusion can be drawn from this but the fear is that many of those who did not answer the tests at all, or answered incompletely, would have been amongst the low scores. If this were the case overall, science teaching in schools would be worse than the impression given in this paper.

Analysis of Chemistry Test Errors

Error analysis in tests can be a major source of understanding of the way in which the science teachers thought about the questions, so not only can the analysis be used to show which areas teachers are having difficulty with, but such analysis can also be used to find improved ways of teaching them in in-service. The full analysis included subject areas for each question stated. In all tests except one, a chemistry question is the most difficult question within that test. Conversely more biology questions were answered correctly by all teachers than any other subject, indicating that biology questions were found to be easier.

Teachers' views on Grade 9 and Grade 10 units indicate that they consider chemistry hard for their pupils, but strangely enough consider they have reasonable confidence in their own understanding of chemistry (Wilson, 1985).

As an example, some analysis will be carried out on a single question containing a basic generalisation in chemistry, in the context of similar questions from previous research which also tested this generalisation.

The most difficult question in Test 2M was Q18 which asks:

> Two given elements combine to form a poisonous compound. Which of the following conclusions about the properties of these two elements can be drawn from this information?
>
> A. Both elements are certainly poisonous.
> B. At least one element is certainly poisonous.
> C. One element is poisonous, the other is not.
> D. Neither element is poisonous.
> E. No conclusions can be made.

The generalisation which teachers or pupils need to know to answer the question is that 'The properties of a compound are different from those of its constituent elements'. A similar question was put to Grade 12 students in the SISS 3M test (Q4):

Two given elements combine to form a poisonous compound. Which of the following conclusions about the properties of these two elements can be drawn from this information?

A. Both elements are certainly poisonous.
B. At least one element is certainly poisonous.
C. One element is poisonous, the other is not.
D. Neither element is poisonous.
E. Neither element need be poisonous.

Strangely enough, sixteen years earlier, a question (Item 58) involving a similar principle was set by McKay (1968) to Grade 10 students in PNG and also to a group of Australian students. It was:

A scientist discovered a compound that had the following properties at normal room temperature and pressure: (i) it was a gas, (ii) it was heavier than air, (iii) it had a pungent odour, (iv) it was colourless. Which of the following assumptions was the scientist justified in making about the component elements that made up the compound he had discovered?

A. Each of the component elements must have had properties (i), (ii), (iii), (iv).
B. The component elements must have had properties (i), (ii), (iii), (iv) between them, but each of them need not have had all of these properties.
C. The newly discovered compound must be made up of four elements, each having one of the four properties listed.
D. None of the component elements need have any of the properties listed.

Boeha (1980) reset McKay's test to a group of remedial Unitech students as part of a study to find the problems of this group and then to help them overcome their problems. Fewer students got the correct answer to the McKay question in the 1968 test than would be expected by chance, and on this question the Australian pupils did better than the PNG pupils. In 1980, the Unitech scores on this same question were below half those expected by chance. Wilson (1986) records that scores were no better than chance on the question on this topic in the 1983 Grade 12 SISS tests. For the 1984 SISS Grade 10 test the question on this topic was one of the most difficult ones for teachers and pupils. Wilson (1986) suggests the language of the question may be the key to poor results, and indeed both McKay's 1968 question and the two SISS questions are unnecessarily convoluted. Wilson may well be correct but perhaps the alternative hypothesis that over nearly twenty years teachers have not made clear to their students the principle that the properties of compounds differ from those of their constituent elements at least bears consideration. If this is the case, it shows that a basic understanding of the meaning of chemical combination is absent from both pupils and teachers alike. This would be a sad state of affairs.

Conclusion or What To Do Now?

The results described in this paper should be considered as a start to the fuller and more detailed research necessary to be more confident of the conclusions. However, evidence has been produced here that the knowledge of some experienced science teachers is less than would be considered desirable, and that in terms of scientific knowledge Goroka diploma holders, whether experienced or more recent, have less knowledge as a group than other Grade 10 teachers. There is also evidence that chemistry is an area of difficulty, particularly for Goroka diploma holders. Finally, item analysis of SISS data may yield some inkling of specific problems which national teachers have in their own understanding and may eventually lead to appropriate remedies being found for these problems. Practically, several solutions have been tried for improving the quality of science teaching in PNG. Amongst these are the Subject Masters' Course (Palmer, 1984), the Major Science/ Minor Mathematics Course (Bunker and Palmer, 1984) (Bunker, 1984) and the Advanced Diploma Course for science teachers (Steward, 1985). It is perhaps too early to claim success for any of these solutions.

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APPENDIX 1

1 The Sun is the only body in our solar system that gives off a lot of light and heat. Why can we see the Moon?

A It is reflecting light from the Sun.
B It is without an atmosphere.
C It is a star.
D It is the biggest object in the solar system.
E It is nearer the Earth than the Sun.

2 About how long would it take a rocket ship to reach the Moon?

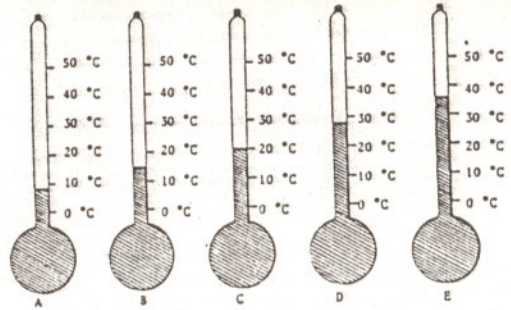
A two hours
B several hours
C a few days
D a light-year
E several years

3 A boy sitting under a tree watched a bird getting insects from between the cracks of the bark. Which drawing shows the kind of beak this bird had?

The next two questions refer to the following table which shows some temperature readings made at different times on three days.

	6 a.m.	9 a.m.	12 noon	3 p.m.	6 p.m.
Monday	15 °C	17 °C	20 °C	21 °C	19 °C
Tuesday	15 °C	15 °C	15 °C	10 °C	9 °C
Wednesday	8 °C	10 °C	14 °C	14 °C	13 °C

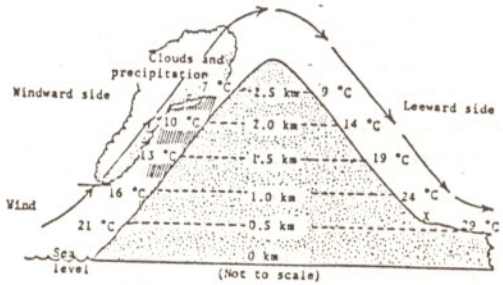
4 Which of the following shows the temperature at 6 a.m. on Wednesday?



5 On one day a cool wind began to blow. When did this happen?

A Monday morning
B Monday afternoon
C Tuesday morning
D Tuesday afternoon
E Wednesday afternoon

6 The diagram below shows a mountain. The wind direction and average air temperatures at different heights on both sides of the mountain are indicated.



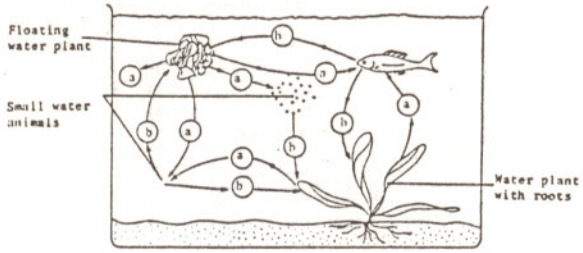
Which feature is probably located at the base of the mountain on the leeward side (location X)?

A a dry region
B a jungle
C a glacier
D a large lake
E a rain forest

7 Fossils very similar in shape to marine shellfish which live in oceans today have been found in the rocks of high mountains. What is the most likely explanation of this?

A The particular marine shellfish can live in the sea or on land.
B Marine forms once had organs that enabled them to breathe atmospheric air.
C The rocks in which the fossils were found were formed under the sea.
D Marine forms, in certain cases, migrate on to the land.
E Marine forms have evolved from land forms.

8 The diagram below shows an example of interdependence among aquatic organisms. During the day the organisms either use up or give off (a) or (b) as shown by the arrows.



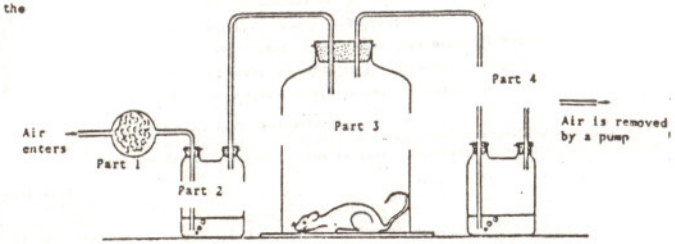
Choose the right answer for (a) and (b) from the alternatives given.

A (a) is oxygen and (b) is carbon dioxide.
B (a) is oxygen and (b) is carbohydrate.
C (a) is nitrogen and (b) is carbon dioxide.
D (a) is carbon dioxide and (b) is oxygen.
E (a) is carbon dioxide and (b) is carbohydrate.

9 A girl found the skull of an animal. She did not know what the animal was but she was sure that it killed and ate other animals for its food. What clue led to this conclusion?

A The eye sockets faced sideways.
B The skull was much longer than it was wide.
C There was a projecting ridge along the top of the skull.
D Four of the teeth were long and pointed.
E The jaws could move sideways as well as up and down.

10 This question refers to the following diagram of apparatus used to show that an animal gives out carbon dioxide in respiration.



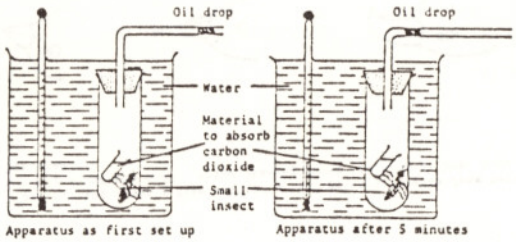
Part 1 contains a substance which removes carbon dioxide from the air passing through it. Parts 2 and 4 both contain a liquid which changes in appearance when carbon dioxide passes through it.

Of the following kinds of containers for the animal which one would give the quickest result?

A a small container
B a large container
C a container in bright light
D a container covered with a dark cloth
E a container in which the air is kept moist by means of wet cotton wool

11 Which of the cells shown below would commonly be found in the human nervous system?

12 Animals take in oxygen and give out carbon dioxide. Ordinary air contains very little carbon dioxide.



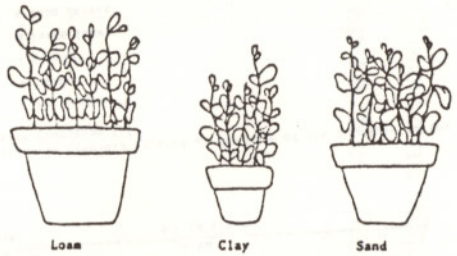
Which of the following can be measured with the above apparatus?

A The rate of movement of the animal.
B The amount of heat produced by the animal.
C The rate of respiration of the animal.
D The effect of carbon dioxide on the animal.
E The amount of carbon dioxide absorbed by the animal.

13 Which of the following statements is true about seeds?

A Every plant produces seeds.
B All fruits contain a large number of seeds.
C All seeds are good to eat.
D Every seed contains a young plant, stored food and a seed coat.
E The food stored in seeds is always in the cotyledon.

14 A girl wanted to learn which of three types of soil (clay, sand and loam) would be best for growing beans. She found three flower pots and filled each with a different type of soil. She then planted the same number of beans in each, as shown in the drawing. She placed them side by side near a window and gave each pot the same amount of water.



Why was the experiment not a good one to find out about the soil?

A The plants in one pot got more sunlight than the plants in the other pots.
B The amount of soil in each pot was not the same.
C One pot should have been placed in the dark.
D Different amounts of water should have been used.
E The plants would get too hot near the window.

15 Milk kept in a refrigerator does not go sour for a long time. Why?

A The cold changes the water of the milk into ice.
B The cold separates the cream.
C The cold slows down the action of bacteria.
D The cold keeps flies away.
E The cold causes a skin to form on the surface of the milk.

16 The male insects in a population are treated to prevent sperm production. Would this reduce this insect population?

A No, because the females would still lay eggs.
B No, because the insects would still mate.
C No, because it would not change the offspring mutation rate.
D Yes, because it would sharply decrease the reproduction rate.
E Yes, because the males would die.

17 When 2 g (grams) of zinc and 1 g of sulphur are heated together almost no zinc or sulphur remains after the compound zinc sulphide is formed. What happens if 2 g zinc are heated with 2 g of sulphur?

A Zinc sulphide containing approximately twice as much sulphur is formed.
B Approximately 1 g of sulphur will be left over.
C Approximately 1 g of zinc will be left over.
D Approximately 1 g of each will be left over.
E No reaction will occur.

18 Two given elements combine to form a poisonous compound. Which of the following conclusions about the properties of these two elements can be drawn from this information?

A Both elements are certainly poisonous.
B At least one element is certainly poisonous.
C One element is poisonous, the other is not.
D Neither element is poisonous.
E No conclusions can be made.

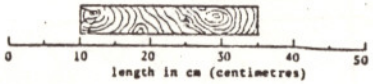
19 Paint applied to an iron surface prevents the iron from rusting. Which one of the following provides the best reason?

A It prevents nitrogen from coming in contact with the iron.
B It reacts chemically with the iron.
C It prevents carbon dioxide from coming in contact with the iron.
D It makes the surface of the iron smoother.
E It prevents oxygen and moisture from coming in contact with the iron.

20 Which of the following particles are gained, lost or shared during chemical changes?

A electrons furthest from the nucleus of the atom
B electrons closest to the nucleus of the atom
C electrons from the nucleus of the atom
D protons from the nucleus of the atom
E neutrons from the nucleus of the atom

21 How long is the block of wood shown in the diagram?

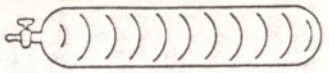


A 10 cm
B 20 cm
C 25 cm
D 30 cm
E 35 cm

22 Mary and Jane each bought the same kind of rubber ball. Mary said, "My ball bounces better than yours." Jane replied, "I'd like to see you prove that." What should Mary do?

A Drop both balls from the same height and notice which bounces higher.
B Throw both balls against a wall and see how far each ball bounces off the wall.
C Drop the two balls from different heights and notice which bounces higher.
D Throw the balls down against the floor and see how high they bounce.
E Feel the balls by hand to find which is the harder.

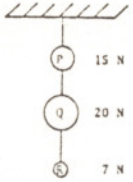
23 An iron container is weighed after the air in it has been pumped out (evacuated). Then it is filled with hydrogen gas and weighed again.



What is the weight of the container full of hydrogen compared to the weight of the evacuated container?

A less
B greater
C the same
D greater or less depending on the volume of the gas in the container
E greater or less depending on the temperature of the gas in the container.

24 The objects P, Q and R of weight 15 N (newtons), 20 N and 7 N, are hung with a light thread as shown in the figure.

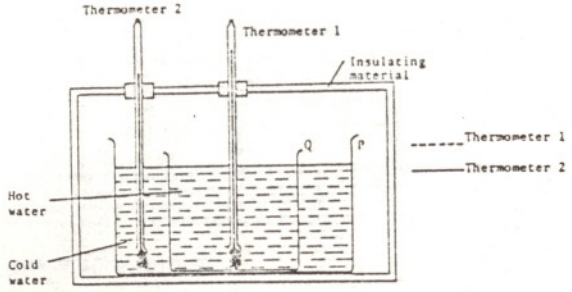


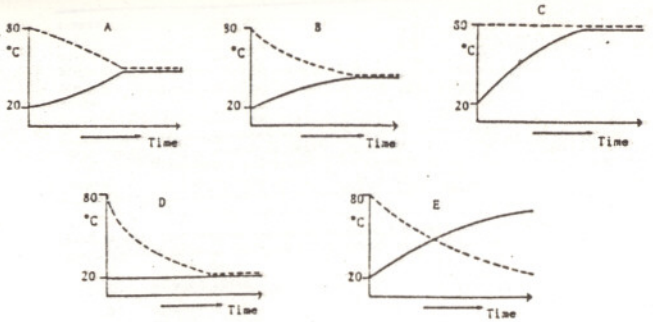
What is the force in the thread between P and Q?

A 42 N
B 35 N
C 27 N
D 15 N
E 7 N

25 Using the apparatus shown in the figure below, 100 g (grams) of water at 20 °C (degrees Celsius) was poured into the outer container P and its temperature read at intervals from thermometer 2. At the same time 100 g of water at 80 °C was poured into the inner container Q and its temperature read at intervals from thermometer 1.

Which of the following graphs best represents the changes in the temperatures of the water in the two containers?





26 A set of bells was made by cutting four pieces of pipe of different lengths from a long metal pipe and hanging them as shown in the picture below. Which of the pipes gave the lowest note when struck with a hammer?

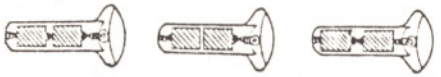
A Pipe X
B Pipe Y
C All gave the same note.
D You cannot tell without trying.
E It depends on where you hit it.

27 A cupful of water and a similar cupful of petrol were placed on a table near a window on a hot sunny day. A few hours later it was observed that both the cups had less liquid in them but that there was less petrol left than water. What does this experiment show?

A All liquids evaporate.
B Petrol gets hotter than water.
C Some liquids evaporate faster than others.
D Liquids will only evaporate in sunshine.
E Water gets hotter than petrol.

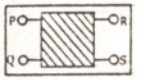
28 A flashlight holds two batteries. In order to make it work, in which of the following ways must we place the batteries?

A as in diagram K
B as in diagram L
C as in diagram M
D either as in diagram L or in diagram M
E none of these would do

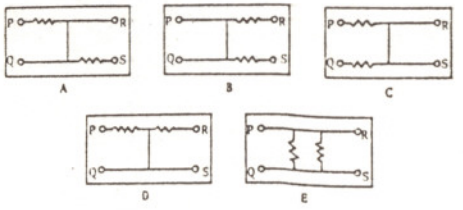


29 The figure shows a box with four terminals: P, Q, R and S. The following observations were made.

1 There is a certain amount of resistance between P and Q.
2 Resistance between P and R is twice that between P and Q.
3 There is no resistance between Q and S.

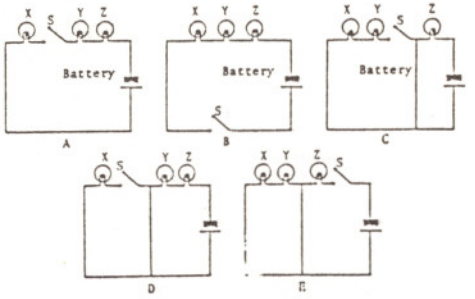


Which of the following circuits is most likely to be within the box Assume that the resistances shown are equal.



30 X, Y and Z represent three lamps in a circuit, which also includes a battery and a switch S. When the switch is open X does not light while Y and Z do light.

Which of the following circuits is it?



1 Some seeds germinate (start to grow) best in the dark, others in the light, while others germinate equally well in the dark or the light. A girl wanted to find out by means of an experiment to which group a certain kind of seed belonged. She should put some of the seeds on damp newspaper and

A keep them in a warm place in the dark.
B keep some in the light and some others in the dark.
C keep them in a warm place in the light.
D put some on dry newspaper and keep them in the light.
E put some on dry newspaper and keep them in the dark.

2 Flowers cannot usually produce seeds unless

A they are visited by insects.
B they appear in the dry season.
C they are on plants growing in good soil.
D they produce nectar.
E suitable pollen is placed on their stigmas.

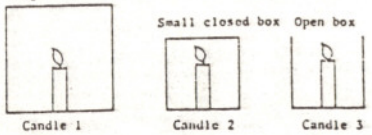
3 The selling of reheated food in shops is often discouraged and sometimes prohibited by law. Which of the following is the main reason for this?

A Most people do not like it.
B Valuable mineral salts are lost on reheating.
C It is uneconomic to heat food twice.
D Bacteria will multiply quickly on the warmed-up food.
E Reheating causes a reduction in protein content.

4 A boy used a hand pump to put more air into a bicycle tyre. After a while it becomes harder to use the pump. Why?

A Air in the tyre pushes against the pump.
B Air starts to leak out of the pump.
C The pump gets too hot to hold.
D The pump gets too sticky to push.
E The tyre is bigger than the pump.

5 Three candles, which are exactly the same, are placed in different boxes as shown in the diagram. Each candle is lit at the same time.



In what order do the candle flames go out?

A 1, 2, 3
B 2, 1, 3
C 2, 3, 1
D 1, 3, 2
E 3, 2, 1

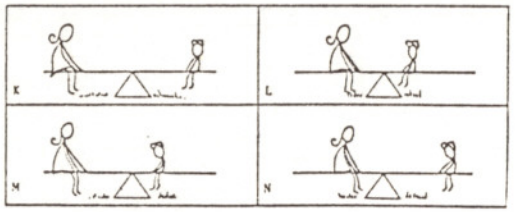
6 The freezing point of a liquid is the temperature at which it freezes. The boiling point is the temperature at which it boils.

Which one of the entries in the following table shows how the freezing point and boiling point of salt water compare with those of pure water?

	Freezing point of salt water	Boiling point of salt water
A	lower than pure water	lower than pure water
B	lower than pure water	higher than pure water
C	higher than pure water	lower than pure water
D	higher than pure water	higher than pure water
E	same as pure water	same as pure water

7 A girl wanted to seesaw with her little brother.

Which picture shows the best way for the girl, who weighed 50 kg (kilograms), to balance her brother, who weighed 25 kg?



A picture K
B picture L
C picture M
D picture N
E none of these

8 The following results are from experiments which were made to find how long it took for newborn babies of different mammals to double in weigh

Mammal	Time in days to double the weight of the newborn baby	Percentage protein in the milk of the mother
human	180	1.6
horse	60	2.0
cow	47	3.5
pig	18	5.9
sheep	10	6.5
dog	8	7.1
rabbit	6	10.4

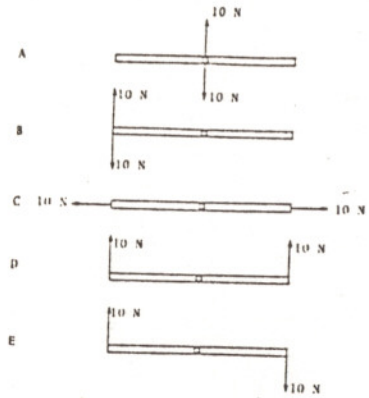
What do the results of these experiments suggest?

A The larger the mammal, the greater the protein concentration in the milk.
B The smaller the mammal, the greater the protein concentration in the milk.
C The greater the protein concentration in the mammal's milk the slower the newborn baby will double its weight.
D The greater the protein concentration in the mammal's milk the faster the newborn baby will double its weight.
E There appears to be no relationship between protein concentration in mammal's milk and time taken for a newborn baby to double its birth weight.

The crews of two boats at sea can communicate with each other by shouting. Why is it impossible for the crews of spaceships a similar distance apart in space to do this?

A The temperature is too low.
B The sound is reflected.
C The pressure is too high inside the spaceship.
D The sound barrier has been broken.
E There is no air.

10 A rod is pivoted at its centre. It is acted on by two forces. Each force has the same size, equal to 10 N (newtons). In which case will the rod turn?



11 Floatation is a process whereby

A A copper compound is split up into its component elements.
B Two elements are combined to form a compound of copper.
C Copper is separated from iron due to their different densities.
D Copper ore is separated from iron due to their different melting points.
E Copper ore is separated from crushed rock due to their different densities.

12 Dilute hydrochloric acid is put on a piece of limestone and bubbles of gas are evolved.

Which of the following gases is produced?

A Chlorine
B Oxygen
C Hydrogen
D Carbon dioxide
E Sulphur dioxide

1 Where is the energy for photosynthesis generally obtained?

A chlorophyll
B chloroplasts
C sunlight
D carbohydrates
E carbon dioxide

2 Which of the following organs is not situated in the abdomen?

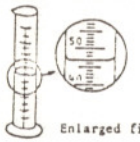
A liver
B kidney
C stomach
D bladder
E heart

3 The formula for the compound acetic acid (present in vinegar) is CH_3 COOH.

What is the total number of atoms in one molecule of acetic acid?

A 1
B 2
C 3
D 6
E 8

4 The measuring cylinder contains a certain volume of water. The enlarged figure shows a view of the surface of the water as seen from the side. What is the volume of the water?



Enlarged figure

A 50 cm^3
B 49 cm^3
C 48 cm^3
D 47 cm^3
E 46 cm^3

5 Dressed in the same way, a man can jump higher on the Moon than on the Earth. Which of the following is the best explanation of this?

A His mass is less when he is on the Moon.
B The force of gravity is less on the Moon than on the Earth.
C His distance from the Earth is greater when he is on the Moon.
D There is no air on the Moon to offer resistance.
E Newton's Laws of Motion do not apply on the Moon.

6 A mixture of powdered iron and sulphur is heated. What will be formed?

A a single element
B two other elements
C a solution
D an alloy
E a compound

7 Under which of the following conditions does water evaporate fastest?

A on a hot and dry day
B on a hot and moist day
C on a cold and dry day
D on a cold and moist day
E on a calm and moist day

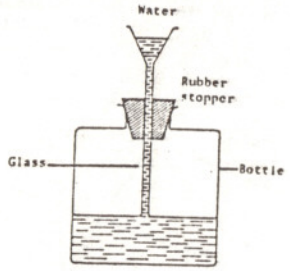
8 What is the advantage of using a lever such as that shown in the diagram to raise a weight W instead of lifting it directly?

A less energy is required
B it is quicker
C less force is needed
D less movement is required
E less work has to be done

9 A metal tray feels colder to touch than its plastic handle. Why?

A Metal always has a lower temperature than plastic.
B Metal radiates much more heat than plastic and so cools more quickly.
C Metal conducts the heat away from your hand better than plastic.
D Plastic is a better heat conductor than metal.
E A smooth surface allows a closer contact than a rough one.

10 This question refers to the diagram below.



No more water will go into the bottle. Why?

A Air pushes harder than the water.
B Air is heavier than the water.
C Air takes up space and must get out to let the water in.
D The glass tube is too thin.
E The mass of the water is greater than the mass of the air.

11 Which of the following is not a major use for copper?

A Coins
B Radios
C Car bodies
D Computors
E Metal alloys

12 An iron nail is dipped into a copper II nitrate solution. It is now coated with a shiny deposit.

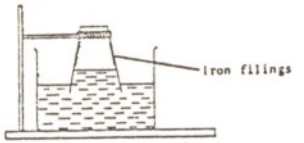
This deposit is:-

A nitrate
B brass
C copper
D iron
E copper ore

1 Here are some possible reasons why kettles and cooking pots are often made of copper. Which one of the reasons is wrong?

A Copper is a bad conductor of heat.
B Copper is a tough metal.
C Copper can be polished to make the pots shine.
D Copper is easy to shape.
E Copper does not dissolve in hot water.

2 A glass coated with iron filings on the inside was clamped vertically in a container of water. As shown in the diagram, water gradually rose a short distance in the glass.



What is the best explanation of this?

A Water condenses inside the glass.
B The iron gives off a gas which dissolves in the water.
C The rust which replaces the iron takes up less space than the iron.
D The iron reacts with oxygen from the air inside the glass.
E Oxygen from inside the glass dissolves in the water.

3 A quantity of a substance Z was heated in a special container. It combined with oxygen from the air to produce a new substance. The following results were obtained.

mass of container	16.1 g (grams)
mass of container + substance Z before heating	16.4 g (grams)
mass of container + new substance after heating	16.6 g (grams)

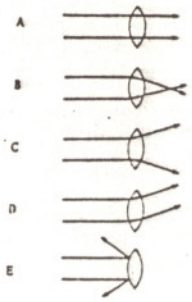
What was the mass of the oxygen taken from the air which combined with the original substance?

A 0 g
B 0.2 g
C 0.3 g
D 0.5 g
E 1.0 g

4 Which one of the following could you not pick up with a magnet?

A a magnetic compass needle
B a steel screw
C an iron nail
D a sewing needle
E a brass screw

5 Which diagram best shows what happens when light passes through a magnifying glass?



6

Day		Mon	Tues	Wed	Thurs	Fri	Sat	Sun
Time		noon	noon	noon	noon	noon	noon	noon
Cloudiness								
Temperature °C	30° 20° 10°							
Atmospheric pressure milli bars	1040 1020 1000							

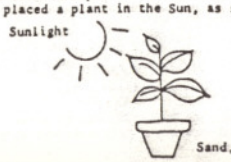
From the information in the above diagram which one of the following conditions might have predicted the rain on Sunday?

A The pressure was dropping, and the temperature was rising.
B The pressure was rising, and the temperature was dropping.
C The pressure was dropping, and the temperature was dropping.
D The pressure was rising, and the temperature was rising.
E The pressure was stable and the temperature was stable.

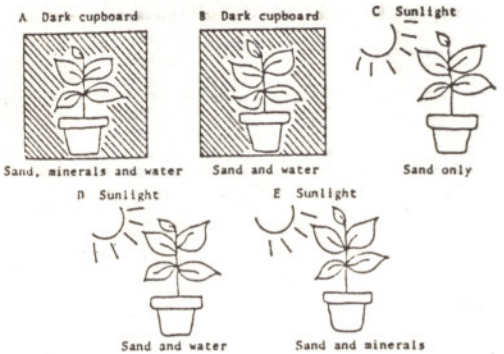
7 Years ago farmers found that corn plants grew better if decaying fish were buried nearby. What did the decaying fish probably supply to the plants to stimulate their growth?

A energy
B minerals
C protein
D oxygen
E water

8 A girl had an idea that plants needed minerals from the soil for healthy growth. She placed a plant in the Sun, as shown in the diagram below.



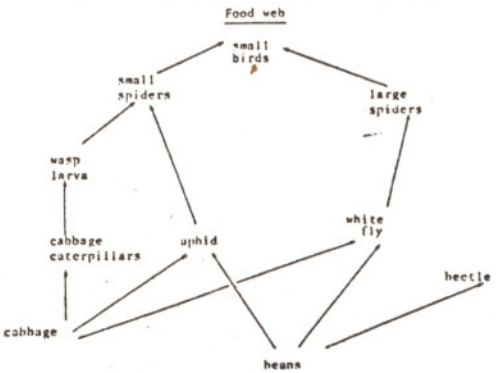
In order to check her idea she also needed to use another plant. Which of the following should she use?



9 What is the main function of the kidneys?

A to produce antibodies to help fight diseases
B to digest food
C to circulate the blood
D to produce red blood cells
E to remove waste materials from the blood

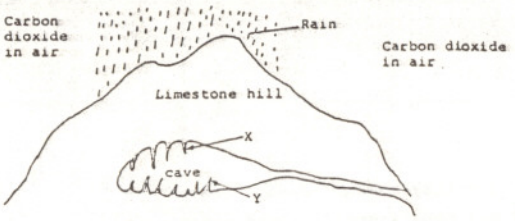
10 Below is a diagram showing a food web. A food web shows what the animals eat. Some animals eat the plants. These are then eaten by other animals who may be eaten by others. The arrows go from the food to the eater. For example: cabbage → aphid (means aphids eat cabbages).



If all the beans were dug up and destroyed, which animal would disappear?

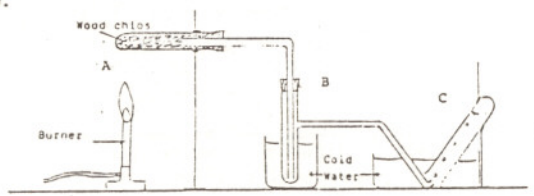
A large spiders
B beetles
C aphids
D whiteflies
E small birds

11 In limestone caves stalactites and stalagmites are formed. In the diagram below which are the stalactites and which are the statagmites and what is the chemical name of the substance from which they are formed?



A X are stalactites and Y are stalagmites and they are made of gypsum
B Y are stalactites and X are stalagmites and they are made of gypsum
C X are stalactites and Y are stalagmites and they are made of calcium carbonate
D Y are stalactites and X are stalagmites and they are made of calcium carbonate
E Both X and Y are stalagmites

12 Wood chips are heated in a test tube as shown in the diagram below.



A student made the following observations.

(1) A solid product remains in A which weighs less than the original weight of wood.
(2) A solid product remains in A which weighs more than the original weight of wood.
(3) The liquid product is collected in C.
(4) The liquid product is collected in B.
(5) The gaseous product collected in C will burn
(6) The gaseous product collected in C will not burn

Which of the following statements is true?

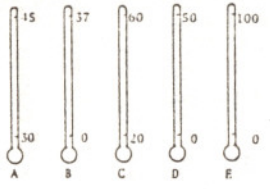
A Statement 1, 2, and 3 are all correct
B Statement 2, 4, and 5 are all correct
C Statement 2, 4, and 6 are all correct
D Statement 2, 3, and 6 are all correct
E Statement 1, 4, and 5 are all correct

1 If you are facing North early in the morning, where is the Sun?

A to your left
B to your right
C behind you
D in front of you
E above you

2 The diagram shows five different Celsius thermometers. The normal human body temperature is 37 °C (degrees Celsius). The body temperature of sick people ranges from about 36 °C to 42 °C. Which thermometer would be most suited for accurately measuring body temperature?

A thermometer A
B thermometer B
C thermometer C
D thermometer D
E thermometer E



3 A dish contains 2 g (grams) of salt dissolved in 8 g of water. The dish of salty water is placed in the Sun. 5 g of the contents of the dish evaporates into the atmosphere. What is in the remaining 5 g of solution?

A 2 g of salt and 3 g of water
B more than 1.5 g of salt and 3.5 g of water
C 1 g of salt and 4 g of water
D 5 g of water only
E less than 0.5 g of salt and 4.5 g of water

4 The table below shows the melting point of five elements.

Element	Melting point
aluminium	660 °C
magnesium	649 °C
iron	1535 °C
lead	327 °C
copper	1083 °C

Samples of all these elements are heated in an oven to a temperature of 1555 °C. If the temperature of the oven is then lowered, which of the samples would solidify first?

A aluminium
B magnesium
C iron
D lead
E copper

5 The table below gives the name, chemical formula and boiling point for some chemicals called alkanes.

Name	Formula	Boiling point
methane	CH_4	- 161 °C
ethane	C_2H_6	- 88 °C
propane	C_3H_8	- 42 °C
pentane	C_5H_{12}	36 °C
hexane	C_6H_{14}	69 °C
heptane	C_7H_{16}	99 °C

Butane, which is an alkane, has a boiling point of 0 °C. What is its chemical formula most likely to be?

A C_8H_{18}
B C_3H_6
C C_3H_8
D C_4H_{10}
E C_5H_{12}

6 The surface of the Earth is not level although weathering and erosion by wind and water have been occurring for millions of years. Which of the following is the best explanation of this observation?

A The sea level keeps changing.
B Movements in the Earth's surface continue to occur.
C There has not been enough time.
D Temperature differences at the Earth's surface are not large enough.
E Wind and water erosion are not strong enough.

7 If equal amounts of the following foods are eaten, which one would provide the most protein for the body?

A sweet potatoes
B bananas
C rice
D bread
E chicken

8 What is the main way that sweating helps your body?

A It cools your body.
B It keeps your skin moist.
C It keeps you from catching cold.
D It gets rid of the salt in your body.
E It gets rid of excess water in your body.

9 The blood has many functions in the human body. Which one of the following is <u>not</u> a function of the blood?

A to digest food
B to protect against disease
C to carry food to the cells
D to carry waste material away from the cells
E to carry oxygen to different parts of the body

10 Why are green plants important to animals?

A Green plants consume both food and oxygen.
B Green plants consume food and give off oxygen.
C Green plants consume food and give off carbon dioxide.
D Green plants produce food and give off oxygen.
E Green plants produce food and give off carbon dioxide.

11 A 2 toea coin is put into some concentrated nitric acid in a 50ml beaker. After a few minutes the following observations are made about,

(i) the colour of the gas evolved
(ii) the colour of the solution

Which of the following observations are all correct?

A The gas is colourless; the liquid is brown,
B The gas is brown; the liquid is colourless
C The gas is brown; the liquid is blue
D The gas is colurless; the liquid is shiny

12 When we say that a heavy oil had been "cracked" what do we mean?

A Two oil molecules have combined to form a larger molecule.
B The oil has melted to form a thick liquid.
C A large oil molecule has been split into simpler molecules.
D The oil has been split by a physical change.
E None of the above.

APPENDIX 2

TEACHERS IN THE TABLE - WERE ASSIGNED GRADES ON THE FOLLOWING BASIS

	ALL CORRECT	78 MARKS	MASTER SCIENCE TEACHER M
	UP TO 5 ERRORS	73 TO 77 MARKS	SCIENCE TEACHER GRADE A
S.I.S.S. TESTS 10.6.86	UP TO 10 ERRORS	68 TO 72 MARKS	SCIENCE TEACHER GRADE B
	UP TO 15 ERRORS	63 TO 67 MARKS	SCIENCE TEACHER GRADE C
Data held for each variable.	MORE THAN 15 ERRORS	BELOW 63 MARKS	SCIENCE TEACHER GRADE D

TEACHER	TEST 2M	TEST 2A	TEST 2B	TEST 2C	TEST 2D	TOTAL	GRADE	TEACHER
T1	25	7	9	9	8	58	D	T1
T2	29	12	10	11	11	73	A	T2
T3	29	9	12	11	11	72	B	T3
T4	29	11	12	11	11	74	A	T4
T6	27	12	9	11	12	71	B	T6
T7	29	11	10	11	11	72	B	T7
T8	26	12	7	12	12	69	B	T8
T10	25	12	11	9	11	68	B	T10
T11	30	11	11	11	12	75	A	T11
T12	25	5	10	11	9	60	D	T12
T14	30	12	12	12	12	78	M	T14
T15	29	12	12	12	12	77	A	T15
T16	29	9	10	8	11	67	C	T16
T17	29	12	12	12	10	75	A	T17
T18	24	9	11	11	10	65	C	T18
T19	29	12	9	12	12	74	A	T19
T22	21	8	11	12	11	63	C	T22
T23	26	9	7	11	8	61	D	T23
T24	26	9	7	11	8	61	D	T24
T25	25	11	10	11	10	67	C	T25
T26	30	12	12	11	12	77	A	T26
T28	26	7	8	10	8	59	D	T28
T29	22	10	12	7	11	62	D	T29
T30	30	11	12	11	12	76	A	T30
T31	24	9	11	11	11	66	C	T31
T32	22	9	12	9	11	63	C	T32
T33	29	12	11	12	12	76	A	T33
T35	25	8	9	10	10	62	D	T35
T38	26	10	10	11	11	68	B	T38
T39	25	10	12	9	12	68	B	T39
T40	29	11	11	10	12	73	A	T40
T41	21	6	11	10	9	57	D	T41
T42	24	9	10	10	10	63	C	T42
T43	27	10	9	9	10	65	C	T43
T44	30	12	12	12	12	78	M	T44
T45	28	11	9	12	12	72	B	T45
T46	27	11	8	12	12	70	B	T46
T48	27	11	9	12	12	71	B	T48
T50	28	11	9	12	12	72	B	T50
T51	23	10	11	9	12	65	C	T51
T52	29	12	12	12	12	77	A	T52
T53	22	10	9	11	9	61	D	T53
T54	27	11	12	9	10	69	B	T54
T55	30	12	12	12	12	78	M	T55
T56	27	9	10	11	10	67	C	T56
T58	24	12	9	11	9	65	C	T58
T59	26	11	11	11	12	71	B	T59
T61	12	11	9	12	10	54	D	T61
T62	27	10	11	12	9	69	B	T62
T63	23	9	11	9	11	63	C	T63
T64	30	12	12	12	12	78	M	T64
T65	26	8	11	9	11	65	C	T65
T67	30	12	11	12	12	77	A	T67
T68	29	11	12	12	12	76	A	T68
T69	26	11	10	9	12	68	B	T69
T70	29	10	10	12	12	73	A	T70
T71	27	10	10	12	11	70	B	T71
T72	29	11	12	12	12	76	A	T72
T73	23	8	7	8	8	54	D	T73
T74	27	11	11	12	10	71	B	T74
T75	28	12	12	12	12	76	A	T75
T76	28	11	12	12	11	74	A	T76
T77	23	9	8	9	9	58	D	T77
T78	30	9	11	12	11	73	A	T78
T79	26	9	9	9	10	63	C	T79
T80	27	9	9	10	12	67	C	T80
T81	29	11	11	11	12	74	A	T81
T82	29	11	11	11	12	74	A	T82
T87	28	11	10	10	11	70	B	T87
T89	20	10	8	11	9	58	D	T89

4	MASTER
20	GRADE A
18	GRADE B
15	GRADE C
13	GRADE D

APPENDIX 3

TESTS IN THE SEPARATE SCIENCES
20.08.86

Data held for each variable.

	CHEM TST	PHYS TST	BIOL TST	E.SC TST	TOTAL
T1	15	16	20	8	58
T2	21	22	21	9	73
T3	20	22	21	9	72
T4	20	24	22	8	74
T6	22	21	20	8	71
T7	20	21	22	9	72
T8	19	18	23	9	69
T10	19	21	20	8	68
T11	22	23	21	9	75
T12	16	20	19	7	60
T14	22	24	23	9	78
T15	21	24	23	8	77
T16	17	22	21	8	67
T17	21	24	23	7	75
T18	18	20	18	9	65
T19	20	23	22	9	74
T22	20	16	20	7	63
T23	14	17	21	9	61
T24	14	17	21	9	61
T25	19	20	22	6	67
T26	21	24	23	9	77
T28	12	18	20	9	59
T29	15	20	21	6	62
T30	21	24	23	8	76
T31	19	22	18	7	66
T32	16	17	22	8	63
T33	22	23	23	8	76
T35	19	21	18	4	62
T38	17	20	22	9	68
T39	17	21	23	7	68
T40	21	22	22	8	73
T41	13	18	18	8	57
T42	14	21	21	7	63
T43	17	18	21	9	65
T44	22	24	23	9	78
T45	20	21	22	9	72
T46	20	19	22	9	70
T48	20	21	21	9	71
T50	21	22	22	8	72
T51	20	19	21	5	65
T52	22	23	23	9	77
T53	17	20	15	9	61
T54	18	22	21	8	69
T55	22	24	23	9	78
T56	19	21	19	8	67
T58	20	21	16	8	65
T59	19	22	21	9	71
T61	17	17	15	5	54
T62	17	22	22	8	69
T63	19	19	17	8	63
T64	22	24	23	9	78
T65	19	19	19	8	65
T67	22	23	23	9	77
T68	22	23	23	8	76
T69	20	22	22	7	68
T70	19	22	23	9	73
T71	18	22	21	9	70
T72	22	23	23	8	76
T73	15	16	16	7	54
T74	20	21	22	8	71
T75	21	24	23	8	76
T76	20	24	21	9	74
T77	17	18	17	6	58
T78	20	23	22	8	73
T79	15	19	21	8	63
T80	17	22	19	9	67
T81	20	23	22	9	74
T82	21	22	22	9	74
T87	20	21	21	8	70
T89	15	21	18	4	58

APPENDIX 4 TABLES OF DISTACTORS CHOSEN BY TEACHERS FOR ALL TESTS

TEST 2M

QUESTION NUMBER	TOPIC	DISTRACTORS					NO ATTEMPT	TOTAL ERRORS
		A	B	C	D	E		
1	E	(70)	-	-	-	-	-	0
2	E	-	7	(60)	1	2	2	10
3	B	3	(55)	2	-	9	1	15
4	E	(68)	1	-	1	-	-	2
5	E	1	3	5	(60)	1	-	10
6	E	(58)	1	1	4	6	-	12
7	E	1	1	-	(67)	1	-	3
8	B	(67)	2	-	1	-	-	3
9	B	2	-	2	(66)	-	-	4
10	B	(63)	2	1	2	1	1	7
11	B	(63)	-	1	5	-	1	7
12	B	1	3	(58)	8	1	-	12
13	B	1	2	-	(53)	13	1	17
14	B	-	(66)	2	2	-	-	4
15	B	-	-	(69)	1	-	-	1
16	B	2	-	-	(67)	-	1	3
17	C	5	(60)	1	2	1	1	10
18	C	5	12	6	5	(42)	-	28
19	C	1	1	-	-	(68)	-	2
20	C	(63)	3	4	-	-	-	7
21	P	1	-	(66)	-	3	-	4
22	P	(56)	1	1	1	1	-	4
23	P	10	(51)	3	4	-	2	19
24	P	6	10	(48)	4	-	2	22
25	P	7	(58)	3	-	-	2	12
26	P	(65)	5	-	-	-	-	5
27	P	1	1	(68)	-	-	-	2
28	P	(69)	-	1	-	-	-	1
29	P	3	-	2	(64)	1	6	6
30	P	1	1	-	(68)	-	-	2

TEST 2A

QUESTION NUMBER	TOPIC	DISTRACTORS					NO ATTEMPT	TOTAL ERRORS
		A	B	C	D	E		
1	B	3	(67)	-	-	-	-	3
2	B	2	-	2	1	(85)	-	5
3	B	-	9	2	(53)	6	-	17
4	P	(67)	-	1	-	1	1	3
5	C	1	(68)	-	-	1	-	2
6	C	11	(34)	14	5	5	1	36
7	P	-	2	6	(62)	-	-	8
8	C	-	10	4	(56)	-	-	14
9	P	-	-	-	-	(70)	-	0
10	P	6	5	4	3	(52)	-	18
11	C	1	-	4	-	(65)	1	5
12	C	-	-	4	(65)	1	-	5

TEST 2B

1	B	2	1	(67)	-	-	-	3
2	B	-	5	6	-	(57)	2	13
3	C	-	1	1	-	(68)	-	2
4	P	-	1	-	(68)	1	-	2
5	P	2	62	-	4	2	-	8
6	C	1	-	-	-	(69)	-	1
7	P	(67)	1	2	-	-	-	3
8	P	6	1	(51)	1	10	1	19
9	P	1	23	(41)	-	2	3	29
10	P	7	-	(61)	-	2	-	9
11	C	3	5	(57)	1	4	-	13
12	C	6	-	(56)	-	5	3	14

TEST 2C

QUESTION NUMBER	TOPIC	DISTRACTORS					NO ATTEMPT	TOTAL ERRORS
		A	B	C	D	E		
1	C	(57)	1	1	6	4	1	13
2	C	1	2	1	(64)	1	1	6
3	C	-	(63)	6	-	1	-	7
4	P	4	2	1	1	(61)	1	9
5	P	1	(67)	2	-	-	-	3
6	E	3	9	(58)	-	-	-	12
7	B	1	(62)	6	1	-	-	8
8	B	9	-	3	(57)	1	-	13
9	B	-	-	-	-	(70)	-	0
10	B	-	(69)	1	-	-	-	1
11	C	1	1	(64)	3	-	1	6
12	C	3	1	2	4	(60)	-	10

TEST 2D

1	C	5	(63)	1	1	-	-	7
2	P	(57)	2	-	4	7	-	13
3	C	(63)	4	3	-	-	-	7
4	C	-	1	(57)	12	1	-	13
5	C	1	2	2	(84)	1	-	6
6	E	1	(58)	2	1	7	1	12
7	B	-	-	-	-	(70)	-	0
8	B	(63)	1	-	1	4	1	7
9	B	(68)	1	-	-	-	1	2
10	B	-	-	1	(68)	1	-	2
11	C	3	1	(64)	1	-	1	6
12	C	-	2	(65)	1	1	1	5

NB: In the tables above :-

1. The distractors circled represent the correct answers
2. E stands for Earth Science Questions
3. P stands for Physcis Questions
4. C stands for Chemistry Questions
5. B stands for Biology Questions