DOCUMENT RESUME

ED 068 528 TM 001 893

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TITLE The Development and Evaluation of a Diagnostic Testing Model for Junior High Science. Final Report.
INSTITUTION Northwest Educational Cooperative, Arlington Heights, Ill.
SPONS AGENCY Office of Education (DHEW), Washington, D.C. Bureau of Research.
PUB DATE Mar 72
NOTE 56p.

EDRS PRICE MF-$0.65 HC-$3.29
DESCRIPTORS Chemistry; Cognitive Processes; *Concept Formation; Criterion Referenced Tests; *Diagnostic Tests; *Hypothesis Testing; Learning Processes; Measurement Techniques; *Models; Science Tests; Secondary Grades; Taxonomy; Testing; Tests; Transfer of Training
IDENTIFIERS Gagnes Taxonomy; Tylers Model

ABSTRACT

The emphasis in this study is on the development of a diagnostic measurement model for instruction. The content used was junior high science, but the content and subjects were used primarily as a means to an end. The model represents an attempt to incorporate Gagne's learning taxonomy into Tyler's model of the educational act. Focus is on the hypothesis that if a learner can demonstrate the ability to identify new examples of concepts within a verbal statement, all that is required for the learner to gain an understanding of a statement or rule is that he put the concepts together in proper order. Project activities included: (1) structuring a unit of beginning junior high school chemistry beginning with the most basic statement possible and proceeding by adding new statements in such a way that no more than one new concept was added with each statement, (2) constructing a concept test for each of the key concepts within the statement, and (3) constructing a criterion test in which the correct answers involved the positive transfer of the rule or statement. Conclusions include: (1) In nearly every case on the pre-test, the number of students demonstrating the ability to transfer the statement increased with the number of concepts attained within the statement; (2) Teaching the specific concepts missed on the pre-test resulted in a significant percentage of the learners being able to transfer the rules and statements which contain the concepts on the post-test; and (3) The data provides for the kind of systematized instruction represented by the model. Two tests are provided (see TM 001 113 - 114). (Author/CK)

PRJ 0-E-132 NCERD OE-BR

PA24

FINAL REPORT
Project Number 0-E-132

THE DEVELOPMENT AND EVALUATION OF A DIAGNOSTIC TESTING MODEL FOR JUNIOR HIGH SCIENCE

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March, 1972

U.S. DEPARTMENT OF
HEALTH, EDUCATION AND WELFARE

Office of Education

Bureau of Research

INTRODUCTION

The emphasis in this study is on the development of a diagnostic measurement model for instruction. The content used was junior high science, but the content and subjects were used primarily as a means to an end. A good model should work equally well for any subject matter area.

The model differs from the typical model of the "educational act" in that it contains within it a method for coordinating "type" of learning with "type" of objective, as well as "type" of learning with type of "evaluation." More specifically, the model represents an attempt to incorporate Gagne's learning taxonomy into Tyler's model of the educational act.

The project itself focuses on what the writer believes to be the key hypothesis in the Gagne learning hierarchy. The hypothesis is that if a learner can demonstrate the ability to identify new examples of concepts contained within a verbal statement all that is required for the learner to gain an understanding of a statement or rule is that he put the concepts together in the proper order. Understanding of the rule or statement is demonstrated when the learner is able to positively transfer the statement or rule. In the opinion of the writer, concepts, rules and statements form the basis for instruction in all subject matter areas, and if it can be shown that the above hypothesis is true it would have many implications for the teaching-learning process. Theoretically, if a learner cannot positively transfer a statement or rule it is either because he has not attained one or more of the concepts contained within it or he has not put the concepts together in the proper order to form the statement or rule. A teacher who has knowledge regarding what concepts the student had and had not attained would be in a position to design learning experiences to teach that particular concept, get the student to reformulate the statement or rule and then re-evaluate to determine the learner's ability to transfer the principle.

The project activities were concerned with 1) structuring a unit of beginning junior high school chemistry beginning with the most basic statement possible and then proceeding by adding new statements in such a way that no more than one new concept was added with each statement or rule, 2) constructing a concept test for each of the key concepts within the statement or rule (the concept items consisted of questions which required the learners to identify examples and non-examples of the concept), 3) constructing a criterion test in which the correct answers involved the positive transfer of the rule or statement, 4) administering the tests after normal classroom instruction, 5) pretesting to determine the extent to which the learners had attained the concepts, as well as the statements and rules, 6) having the learners go through programmed materials concerned with the identification of examples of the concepts they had missed, as well as some frames concerned with the combining of the concepts to form the rules or statements, 7) post-testing to determine the effect that teaching the missed concepts had on the ability to positively transfer the statement or rule.

The results of the study are not definitive in that we are not able to conclude that all of the students who were able to identify the key concepts within a statement or rule were able to transfer the statement or rule. The data does, however, seem to support the following conclusions:

1. In nearly every case on the pretest the number of students demonstrating the ability to transfer the statement or rule increased with the number of concepts attained within the statement.

2. Teaching the specific concepts missed on the pretest resulted in a significant percentage of the learners being able to transfer the rules and statements which contain the concepts on the post-test.

3. The data provides support for the kind of systematized instruction represented by the model. A much higher than normal percentage of junior high students were able to demonstrate the ability to answer the higher level test items.

4. The model is functional in that teaching the specific concepts that make up the statements and rules does result in the learners' increased ability to transfer them. The extent to which it will function is not clear, but seems to depend upon how well the concept items are formulated and how well the statements and rules are analyzed. The examples and non-examples used to formulate the concept items should be obtained from the students themselves. While the rules and statement should be analyzed to determine the kinds of logical operations involved, reading is also a variable which appeared to affect the results.

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PROBLEM

Education is in need of a workable model for instructional research and evaluation which is parsimonious enough to be used by classroom teachers and which at the same time has implications both for the design of learning experiences and the diagnosis of learning difficulties.

The central focus for change in educational practice during the past decade has been the curriculum. The evidence of this is displayed in the form of the "modern mathematics," the "new physics," the "new biology" and the work in the "new social sciences." Curriculum revision has been carried out, and is still being pushed forward by dedicated groups of university scholars, teachers, and educational research workers. These individuals have caused quite a considerable change in the offerings of the public school.

Curriculum formulation, evaluations and subsequent revisions represent a tremendous task and require the systematic and continuous effort of all available talent. Present efforts in curricular revision have normally focused on "process" and the restructuring of content with an eye toward improving both retention and transfer. The evaluation of these programs has been largely traditional. The test results indicate in general how effective the instruction has been, but do not normally have direct implications for the diagnosis of individual learning problems. There is no systematic evaluation procedure which is designed to both locate holes in learning and directly suggest the learning experiences that individual students need. Diagnostic evaluation procedures would seem to be an essential step in individualizing instruction. The call for a greater amount of "experimental vigor" in curriculum development has been continually emphasized by leading scholars in the area (Gagné, 1965; Bloom, 1956; Cronbach and Suppes, 1969).

Experimental vigor in curriculum development depends upon the development of a model for instructional research which will make possible the diagnosis of learning difficulties, as well as the systematic improvement of instruction by making explicit both the relationship of educational objectives to learning and the relationship of learning to evaluation.

It would probably be more accurate to entitle the following report "Toward a Diagnostic Instructional Research Model," rather than as a "Diagnostic Testing Model for Junior High Science." The title is too specific. Including the word "diagnostic" in the title inevitably widens its scope so that it involves a consideration of the problems of structuring content, and determining behavioral objectives, as well as the diagnostic evaluation of learning outcomes. The subject matter with which this particular report is concerned happens to be science, however, the model would appear to be appropriate for any relatively structured area. Science was selected because of the relative concreteness of the concepts involved. The primary emphasis of this report is on the functioning of the model rather than on science.

The instructional research model which educators are presently using in an attempt to improve instruction is an oversimplification which has tended to focus on behavioral objectives and evaluation to the exclusion of learning. As a result there has been no systematic approach to the improvement of instruction or to the diagnosis of learner problems.

The Problem with the Existing Model

The Original Model

The model which is presently used was described by Tyler (1953) as a model of the "educational act." It was, however, basically an evaluation or measurement model in that it was conceived of in conjunction with the behavioral objectives movement, and had as its primary purpose the coordination of educational objectives with evaluation procedures. Its function was to get teachers to specify their objectives in behavioral form so that their instruction would have direction, and so that it could be evaluated. The model as described by Tyler depicts the "educational act" in four parts as follows:

1. ....determining what changes in students' behavior to try to bring about.

2. ....determine what content and learning experiences can be used that are likely to attain these ends.

3. ....determine an effective organization of these learning experiences so that their cummulative effect will be such as to bring about the desired behavior change in an efficient fashion.

4. ....to appraise the effects of the learning experiences to find out in what ways they have been effective and in what respect they have not produced the results desired.

The general order of the model is, as far as it goes, a good representation of the steps necessary for the systematic improvement of instruction. It is, however, an oversimplification of the "educational act" which does not make adequate use of our accumulated knowledge of learning, and one which has often led to a form of evaluation which is of limited use both for the systematic improvement of instruction and the diagnosis of individual learning problems.

The original model lost much of its acceptance and utility for instructional practice because it contained no provision for relating "type" of educational objective to "type" of learning or for relating "type" of learning to "type" of evaluation.

The model also lost acceptance and utility because it dealt exclusively with the structuring of behaviors without taking into consideration the type of learning involved in the achievement of the behaviors. The lists of behavioral objectives which emerged as a result of the model consisted largely of statements and procedures such as the following:

1. The student will be able to recall Archimedes' principle of floating and sunken objects.

2. The student will be able to use Archimedes' principle to solve problems involving floating and sunken objects.

The lists of behavioral objectives which emerged as a result of the model were usually a set of procedures which if analyzed in terms of the type of learning involved consisted largely of the learning of a stimulus-response chain such that a particular stimulus elicits a particular response which elicits a particular stimulus which elicits a particular response, etc. Because the behaviors involved in the lists of objectives usually required only stimulus-response learning they were subject to the advantages and disadvantages that accompany that form of learning.

One apparent advantage of educational objectives which involve stimulus-response learning is that they are easy to evaluate. This is a characteristic which probably led to those particular objectives being included in the list rather than objectives involving concept learning or problem solving or some other higher form of learning. Once educational objectives which require primarily stimulus-response learning are stated, the method for evaluating them usually becomes apparent. The instructor is then in a position to make inferences about how effective the learning experience was.

Educational objectives which involve stimulus-response learning have a disadvantage because stimulus-response learning does not very adequately account for the types of positive transfer required in the school (i.e., concept generalization, responding to a class of stimuli with a class of response; learning to learn, etc.). The result was that each desired behavior had to be specifically taught. Long lists of behavioral objectives were constructed in an attempt to account for each stimulus situation. It seems, however, that no matter how long the lists were, they were incomplete. The above is evidently what caused Travers (1966) to comment on the vast, unwieldly and unusable nature of the lists of behavioral objectives that have emerged since the beginning of the behavioral objective movement.

Another important disadvantage of educational objectives that require primarily stimulus-response learning springs from the nature of transfer and retention involved in stimulus-response learning. Most educational objectives with which the school is concerned are of a verbal nature. Verbal educational objectives which require stimulus-response learning are highly effected by negative transfer which results from stimulus generalization or interference. Stimulus generalization and interference in turn lead to forgetting. Educators, who are concerned with retention, are not prone to accept as adequate lists of educational behaviors which are not likely to be retained.

The lists of behavioral objectives that evolved as a result of the model usually contained large numbers of objectives that were relatively independent of each other. Although the original model indicates a need to determine an effective organization of the objectives so that their cumulative effect will bring about the desired terminal behavior, most disciplines do not lend themselves to this kind of analysis. The result was the construction of vast lists of behavioral objectives in which each objective appears to be largely independent of the others. Even in those areas such as mathematics where it is possible to structure behaviors in an additive fashion the lists of behaviors that emerged appeared somehow sterile. Intuitively, classroom teachers have recognized that education involves more than just learning a set of procedures that lead to the attainment of a goal. They recognized that even if the procedures can be arranged in an additive fashion from simple to complex the rationale behind the procedures exists as a set of complex conceptual relationships. Educators have been unwilling to accept the fact that because Billy can add two, two digit numbers each of which sums to over ten, he has attained the concept of addition. The lack of acceptance stemmed from a recognition that there was a great deal of very important learning which did not appear to fit the model.

Incorporating the Taxonomy into the Model

(Bloom, et al , 1955) probably as a result of the recognition of the shortcomings of the original model constructed the Taxonomy of Educational Objectives: Cognitive Domain. The Taxonomy fit in with the original instructional model, and allowed the instructor to deal with educational objectives which involved more than just learning a set of procedures. In constructing the Taxonomy the authors provided a means both for classifying and for evaluating the attainment of the kinds of educational objectives felt appropriate for the various disciplines. They analyzed the educational objectives teachers were trying to achieve, and then built a system of categories to house them. The categories were labeled, and an attempt made to specifically define them by specifying the behaviors involved in each. They then went on to suggest the type of test items that would measure each type of behavior.

Adding the Taxonomy to the original instructional research model increased both its relevance and its utility. Educators found the Taxonomy highly useful because it provided them with a means for thinking about, communicating and evaluating educational behaviors that they felt were important. Once it was understood that the educational objectives were constructed using the Taxonomy categories, it was possible to communicate much more specifically to others the goals being sought and type of evaluation procedure used. It was no longer necessary that a behavioral objective involve getting the learner to the point where he could perform a set of procedures. Educators were able to construct behavioral objectives such as the following:

1. The students will have "Knowledge" of Archimedes' principle of floating and sunken objects.

2. The students will be able to "Comprehend" Archimedes' principle of floating and sunken objects.

3. The students will be able to "Apply" Archimedes' principle of floating and sunken objects.

4. The students will be able to "Analyze" communications concerned with Archimedes' principle of floating and sunken objects.

The incorporation of the Taxonomy into the instructional research model added to both its acceptance and utility. It did not, however, solve the primary problems inherent in the model. Educators, who incorporated Taxonomy based educational objectives into the instructional research model, still had very little information regarding the kinds of learning experiences which were likely to lead to the attainment of the objective, and were generally unable to diagnose why students failed to obtain the objective.

Lists of educational objectives in which Taxonomy terms were used were more acceptable to classroom teachers. Including Taxonomy based educational objectives increased the acceptance of the model, but did not give it the scientific precision that it needed. The Taxonomy categories were too broadly defined and lacked a theoretical base.

The broadly based categories often contained such a large number of processes (i.e., the analysis category incorporates the whole area of critical thinking and all of the logical processes involved) that both communication and interpretation of the results was difficult. The Taxonomy is not theory based. It was not constructed in a manner so that it would be consistent either with theories of learning or theories of knowledge. The Taxonomy is a taxonomy of the cognitive domain; however, the authors ignored the basic notions of "concept" and "category" which is at the heart of cognitive learning theory, logic and most discussions about the nature of knowledge. The result is that an educator who incorporates Taxonomy based objectives into the instructional research model has no way of relating educational objectives to either learning theory or research.

Toward a Diagnostic Instructional Research Model

Requirements for the Model

Education is an applied area which essentially means that it is the task of the educator to either extract from the other disciplines or create relationships which are applicable to the teaching-learning situation. What appears to be needed in education is a diagnostic instructional research model which will 1) provide a means for coordinating the work done in the various areas, 2) make possible the systematic improvement of instruction by providing a means for empirically examining the effectiveness of curricular structuring, and 3) provide a means for the diagnostic evaluation of student learning.

An effective instructional research model must be grounded in theory. It must provide a method for coordinating the theoretical formulations and research of philosophers, logicians and psychologists. Models which are either atheoretical or based on the work done in a particular area are likely to be either so broad in scope that they lose their utility or so narrow and constraining that they become sterile.

The model should in so far as possible reflect the thinking of philosophers concerning both the nature of knowledge and logical operations. It should contain within it an acknowledgement of what knowledge is and how it is formulated and structured, as well as an empirical means for working toward a structuring which will promote learning in the most efficient manner. The model should also make possible the incorporation of research data concerned with the performance of logical operations.

The model should also in so far as is possible make optimal use of the learning research done by psychologists. It should be diagnostic in that it should provide both a way of locating the learner within the structure and suggest the next appropriate step to be taken, as well as helping to determine the characteristics of students who do and do not benefit from the suggested kinds of learning experiences.

Rationale for the Model

Diagnostic measurement requires an acknowledgement of the structured nature of content, as well as a recognition of the organized nature of learning. Diagnosis of a student's progress in a subject matter area appears to mean both the locating of his general position within the content structure and determining holes in the learning structure. Conventional measurement procedures which consist of building tests based on a sampling of a universe of content and normatively comparing students contingent upon their performance on these tests will not suffice for diagnostic purposes.

It is suggested by the writer that recent developments in education have made possible a further refinement of the present model which has served for both instructional practice and instructional research for the last half century. Gagne (1965) paved the way for the refinement when he moved away from the trend of forming individual learning theories, and instead moved toward an empirical method of classifying learning into "types" based on the conditions necessary for the learning to occur.

Gagne opened the way for an approach to the development of a diagnostic instructional research model for the various content areas when he developed a hierarchically arranged taxonomy of learning. The taxonomy consisted of eight types of learning which he hypothesized to exist. He based his hypothesis on the conditions necessary for the learning to occur. He concluded that there were eight different kinds of learning, each of which involved different learning conditions. In postulating the eight types of learning he also suggested that the types of learning were hierarchically arranged and differed in terms of the evidence required before a particular type of learning could be said to have occurred. The types of learning were hierarchically arranged in such a way that it was necessary for the lower order learning to be accomplished before the next higher class of learning could occur. The eight types of learning arranged in order from simple to complex along with the behavior change that accompanies each type of learning are shown in Table I-1 on the following page.

TABLE I-1

Type of Learning and Evidence Required for Acknowledging That the Learning Has Occurred

Type of Learning	Evidence that the Learning Has Occurred
1. Signal Learning	The conditioned stimulus alone elicits the response
2. Stimulus Response	The stimulus elicits the response
3. Chaining	Learner can perform the motor chain
4. Verbal Association	Learner can repeat the verbal chain
5. Multiple Discriminate	Learner can provide the appropriate response for the appropriate stimulus
6. Concept Learning	Learner can identify what is and what is not an example of the category
7. Rule Learning	Learner can apply rule
8. Problem Solving	a) Learner can apply the rule b) Learner is better able to formulate and test hypotheses (i.e., solve problems)

When Gagne's eight types of learning are incorporated into the model, it becomes possible to 1) analyze the educational objectives in terms of the kinds of learning required, 2) utilize learning research concerned with that particular kind of learning, and 3) evaluate the attainment of the objective in a manner that is consistent with the kind of learning involved. Adding the learning taxonomy to the instructional research model enables educators to systematically structure educational objectives involving the learning of concepts, principles and rules, as well as the learning of procedures.

METHOD

Science teachers from the school districts in Northwest Cook County, Illinois, participated in a three semester training session which ran from fall, 1970 through summer semester, 1971. The number of science teachers involved varied from eleven the first semester to seven the third semester. The teachers were involved in an attempt to evaluate the basic premise of the diagnostic testing model.

The primary hypothesis upon which the model depends is derived from Gagne's learning taxonomy. In formulating the model, the lower forms of learning were largely ignored because it was felt that at this stage in the development of the diagnostic instructional model attention should be focused upon the kinds of objective with which educators are most concerned. The lower forms are recognized as important for diagnosis of learning difficulties, but were not felt as basic to the model as the levels of multiple discriminate, concept, rule and problem solving. Gagne postulated that if the learner has already attained the concepts that make up a definitional or rule statement all that is required for the meaningful learning of the statement is that the learner put the concepts together in the proper order to form the statement. Attainment of the concepts is demonstrated when the learner is able to recognize unfamiliar examples and non-examples of the concept. Meaningful learning of the definitional and rule statements is evidenced by the learner's ability to pick out examples and non-examples of the defined concept or the learner's ability to extend or apply the rule. Based upon the above, a learner who has already attained the concepts that make up the definitional or rule statements, and has put them together to form the statement, should be able to generalize or transfer the statement without further instruction.

The activities involved in the project were 1) structuring the content (in this case the content was junior high science), 2) formulating behavioral objectives from the content statements, 3) constructing tests to evaluate the learning of the concepts and statements, 4) instructing students in the content in the normal manner and then pretesting with the tests to determine the extent to which the concepts and statements had been attained, 5) teaching students the concepts that they had not attained by means of programmed texts which utilized a series of frames requiring the student to identify what was and what was not an example of a concept, 6) post-testing to determine the extent to which students who had learned the concepts were able to transfer statements containing the concepts.

Structuring Content

The content selected for use in the project was chemistry. Chemistry was selected because it provides a basis for understanding most of the other areas of science, because the content is highly structured, and because the concepts involved are nonarbitrary and relatively concrete.

The structuring of the content was done by ordering descriptive, definitional and rule statements from simple to complex in a manner such that each statement involved either a reordering of concepts learned earlier or the addition of no more than one concept at a time. The structure of the statements with the key concepts studied underlined are shown on the following page. The statements and concepts were used as a basis for developing tests which involved the identification of what was and what was not an example of a concept, the concept test; and the recognition of the statement stated in different ways, the direct extrapolations of the statement and the recognition of when data was consistent with, inconsistent with or irrelevant to the statement, the criterion test.

Formulating Behavioral Objectives

The scientific concepts that made up the descriptive, definitional and rule statements were converted into behavioral objectives which involved the student being able to identify new examples and non-examples of the concept. The behavioral objectives which were derived from the class and relational concepts of "matter" and "mass" are shown below:

> Students will be able to identify new examples of matter.
>
> Students will be able to rank new objects according to their relative mass.

Descriptive, definitional and rule statements were transformed into behavioral objectives which were concerned with the student's ability to make inferences from the statements. Making inferences from the statements was considered to consist of the ability to 1) recognize the statement stated in a different way (i.e., to "translate" or "interpret" it), 2) make a direct extrapolation of the statement (i.e., identify what must follow if the statement is true), 3) recognize when data is consistent with, inconsistent with, or irrelevant to a conclusion.

TABLE II-1

Structure of Statements

1. Matter is anything that has mass and takes up space.

2. Matter is particulate.

3. Adding energy to the particles of matter increases their motion.

4. Adding energy to the particles of matter increases the space between the particles.

5. Increasing or decreasing the energy of the particles causes matter to expand or contract.

6. Increasing the energy of the particles causes matter to change state.

7. Energy added to the particles of matter changes state from a solid, to a liquid, to a gas.

8. Chemical properties of a substance are the characteristics the substance shows when it combines chemically with other substances to form a new compound.

9. An element is a basic kind of matter formed from one kind of particle which cannot be broken down by ordinary means.

10. An atom is the smallest particle of an element that has all of the properties of the element.

11. A molecule is a particle of matter formed when two or more different kinds of atoms combine.

12. A compound is matter formed by molecules consisting of two or more different kinds of atoms.

13. A chemical reaction occurs when atoms combine to form molecules or when molecules break apart into atoms.

14. When elements combine in a chemical reaction to form compounds they lose their physical properties.

15. When compounds break down in a chemical reaction into their elements they lose their physical properties.

16. A mixture results when two or more elements or compounds are stirred together, but do not have a chemical reaction.

TABLE II-1 Continued

17. A solution results when elements or compounds placed in a liquid break down into their particles, and spread evenly throughout the liquid without causing a chemical reaction.

Constructing Tests to Evaluate the Learning of the Concepts and Statements

Concept Items

The behavioral objectives provided the basis for constructing test items. Test items used to measure the attainment of concept objectives were of the example-nonexample variety. Three test items were constructed to measure the attainment of each concept objective. The student had to get two out of the three test items right before he was given credit for the attainment of the concept. The purpose for having three items for each objective was to reduce the probability that the student would get the items right by chance alone. Two sample items used for measuring the attainment of the concepts of space and mass are shown below. See Appendix for the complete tests.

1. Which of the following does NOT occupy space?
   A. Air
   B. Heat
   C. Smoke
   D. Water Vapor

2. Which of the following shows a change in mass?
   A. A meteor flying through space and the meteor on the surface of a planet
   B. A space capsule before and after it is in orbit
   C. A sponge being squeezed into a smaller space
   D. None of the above

The Criterion Test

According to Gagne's learning taxonomy, students who 1) had been able to demonstrate the attainment of the concepts contained within a statement by being able to identify what is and what is not an example of the concepts and 2) had put the concepts together in the proper order to form the statement, should be able to demonstrate their understanding of the statement by being able to transfer or generalize from it.

The criterion tests consisted of three test items for each descriptive, definitional or rule statement. The first item required that the student be able to recognize the statement stated in a different way. A sample item of this type concerned with the definitional statement regarding matter (i.e., Matter is anything that takes up space and has mass) is shown below.

3. Matter is anything that takes up space and has mass. Another way of saying this is:
   A. Matter is anything that has weight.
   B. Matter is anything that occupies space and attracts other objects to it.
   C. Matter is anything that has weight and takes up space.
   D. Matter is anything that takes up space.

The second test item related to each statement required that the student be able to extrapolate or make inferences from the statement. The item from the definitional statement of matter was:

4. If matter is anything that has mass and takes up space which of the following is an example of matter?
   A. Space
   B. A meteor flying through space
   C. Light
   D. X-rays

The third test item related to each statement required that the student be able to recognize when data is consistent with, inconsistent with or irrelevant to the statement. The third item related to the definitional statement of matter is:

5. If light rays could be observed to bend as they passed through the gravitational field of a planet this would be evidence
   A. that light is matter.
   B. that light is not matter.
   C. neither that light is or is not matter.

Pretesting

Students were first given regular classroom instruction over the content and then pretested to determine the extent to which they had attained the concept and criterion objectives.

Pretesting was done to 1)determine the extent to which the students had already attained the concepts and 2) could perform the kinds of inferences required by the criterion test. The pretests were administered to approximately two hundred and fifty junior high school science students. Thereafter, the resulting data were analyzed to determine 1) which concepts each student had not attained and 2) the relationship between the attainment of the concepts contained within a statement and the ability to make inferences from the statement. The student was considered to have meaningfully learned the statement when he got two out of the three criterion items correct.

The Construction of Programmed Text

Programmed textbooks were constructed to both teach the concepts involved in the test and to get the student to put the concepts together in the proper order to form the statements. No other attempt was made to either teach the statements directly or to help the students to learn to transfer the statements.

After the pretests were analyzed to determine which concept each student had or had not attained, the students were assigned a programmed text and directed to go through the frames related to the missed concepts. Each programmed text contained within it a self-test for each concept which was used to indicate when the student had attained the concept.

A problem arose at this point. Either the programmed texts did not do a good job of teaching the concepts or the students did not attend to them. Many students who completed the programmed texts could not answer the concept items on the post-test. Mean scores on the post-tests were appreciably higher than on the pretest, but many students did not demonstrate the hoped for improvement on the individual concepts.

Post-testing

After the students had completed the programmed text sections concerned with the concepts that they had missed on the pretest, they were given the same test as a post-test. The data resulting from administering the post-test were then analyzed in order to determine what effect teaching additional concepts had on the student's ability to answer criterion test items. More specifically, these data were analyzed to determine the effect that teaching the concepts within the statement had on the student's ability to make inferences from that particular statement.

RESULTS

The seventeen statements were analyzed to determine the extent to which the ability to identify examples of the concepts which make up the statements was predictive of the ability to achieve the criterion (i.e., to recognize the statement stated in a different way, to extend or extrapolate the statement, and to recognize when data was consistent with, inconsistent with, or irrelevant to the statement).

Item analysis, correlations and analysis of variance procedures are not adequate methods for examining hierarchical data. The truth of the matter is that there is no really adequate way of analyzing hierarchical data. Various possibilities have been tried beginning with Guttman (1947) scaling techniques, but none seems satisfactory as yet.

In this study we were primarily interested in examining only two "levels" of the Gagne hierarchy by investigating the positive transfer between concept and rule learning. Toward this end, we attempted to analyze the seventeen statements to determine the number and percent of students who achieved one, two or three concepts, and who did or did not attain the criterion on both the pre and the post-tests. To support the contention of the existence of a hierarchy, the effect should be additive (i.e., the percentage of students who attain the criterion should increase with the number of concepts attained). The data were also analyzed to determine the number and percent of students who did and did not attain the criterion for all possible combinations of concepts within a statement.

We were also interested in determining the percent of junior high students who could be brought to a level where they could answer the higher level transfer items on the criterion test. These items are typically very difficult, and the scores of students on tests of this type are characteristically below the fifty percent level. Table III-1 shows 1) the number of students who were able to answer the criterion items on the pretest, 2) the number of additional students who were able to make the transfer after instruction on the missed concepts, and 3) the percent of the total number of students who were able to make the transfer.

The pretest data resulted from the administration of the tests to all students prior to specific instruction on the concepts. In examining the pretest data, we were interested in determining the extent to which students who had attained the criterion had also attained the concepts. We are not examining the effect that teaching the concepts has on improving the student's ability to positively transfer the statements. The question asked of the pretest data was:

> To what extent did the percent of students who were able to positively transfer the statements increase with the number of concepts attained within the statement.

The post-test data represents the results attained by those students who did not attain criterion for a particular statement on the pre-test. The students failing the criterion on the pretest were given the programmed texts to teach the concepts they had missed, and then given practice putting the concepts together in the proper order to form the statements. The post-test data were analyzed to determine

TABLE III-1

Pre and Post-Test Data: Number and Percent of Students Failing and attaining the Criterion Objective on the Pre and Post-Tests[1]

Statement No.	Pretest (N)	No. Attaining Pretest Criterion	No. Failing Pretest Criterion	Post-test (N)[1]	No. Attaining Post-test Criterion	No. Failing Post-test Criterion	Percent Achieving Criteria Pre & Post
1	285	93	192	192	55	137	52%
2	285	184	101	102	69	32	89%
3	285	122	163	163	45	120	59%
4	285	154	131	131	60	71	75%
5	285	142	143	143	58	85	70%
6	285	74	211	211	65	146	48%
7	285	135	150	150	73	77	73%
8	285	138	147	144	85	62	79%
9	242	78	164	164	62	102	58%
10	242	48	194	194	48	146	40%
11	242	54	188	188	46	142	41%
12	242	130	112	112	55	57	76%
13	242	126	116	116	66	50	78%
14	242	118	124	124	62	62	74%
15	242	95	147	147	72	75	70%
16	242	124	118	118	75	43	79%
17	242	60	182	182	73	109	55%

[1]Only those failing the pretest criterion were included in the post-test analysis.

the effect that this learning had on the ability to answer the criterion items. The resulting data were then analyzed to determine the effect that teaching the key scientific concepts within a statement had on the student's ability to positively transfer the statement.

The post-test data were analyzed in order to determine the effect that attaining one or more of the concepts within a statement had on the student's ability to answer test items requiring the positive transfer of the statements. More specifically, the data were analyzed to determine:

> To what extent the percent of students who moved from not being able to transfer the statements on the pretest to being able to make the transfer on the post-test will increase with the number of concepts attained.

The pre and post-test data for each of the seventeen statements are combined in Tables III-2 through III-17. Caution should be used in interpreting percentages in cells with small numbers of students.

CONCLUSION

The study has yielded no definitive results in that we cannot say that if a student is taught the key concepts that comprise a statement to the point where he can pick out examples of them and then be caused to put the concepts together in the proper order to form the statement, that he will be able to positively transfer the statement. The data show a trend in that direction. However, some students who could not identify examples of the concepts within a statement were able to positively transfer the statement, and others who were able to demonstrate the attainment of the concepts by demonstrating the ability to identify examples of them could not transfer the statement.

The data indicate that systematizing instruction in the manner required by the model results in a much larger proportion of students being able to answer the higher level items than is normally attained. On ten of the seventeen statements, as high as seventy percent of the students were able to attain the criterion after additional instruction on the concepts. While it is possible to attribute the increased percentage attaining the criterion to the programmed instruction on the concepts, it can also be argued that perhaps any additional equally systematized instructional procedure would attain similar results. As has been noted by Gagne (1969), when instruction is highly systematized, individual differences seem to be greatly reduced, and a high percentage of students typically achieve criterion. This study lends further support to that conclusion.

TABLE III-2

Pre and Post-Test Data: Number and Percent of Students Failing and Attaining Criterion for All Combinations of Concepts[1]

Statement 1: Matter is anything that has mass and takes up space.

Number & % Failing and Attaining Criterion	Concept Order (Space, Mass)							
	0 Concepts	1 Concept			2 Concepts			3 Concepts
		Mass	Space		Mass Space			
Pretest	000	001	010	100	011	101	110	111
0	34	81	18		59			
Percent	64%	71%	62%		66%			
1	19	33	11		30			
Percent	36%	29%	38%		34%			
Post-Test	000	001	010	100	011	101	110	111
0	16	43	23		55			
Percent	67%	77%	71%		56%			
1	8	13	6		28			
Percent	33%	23%	29%		44%			

	Number and Percent Attaining the Criterion Objective on Pre and Post-Test			
	0 Concepts	1 Concept	2 Concepts	3 Concepts
Pretest				
Number	19	44	30	
Percent	36%	31%	34%	
Post-Test				
Number	8	21	28	
Percent	33%	25%	44%	

[1] A "1" indicates attainment; a "0" indicates failure of the criterion objective.

TABLE III-3

Pre and Post-Test Data: Number and Percent of Students Failing and Attaining Criterion for All Combinations of Concepts[1]

Statement 2: Matter is particulate.

Number & % Failing and Attaining Criterion	Concept Order (Particulate)							
	0 Concepts	1 Concept			2 Concepts			3 Concepts
		Particle						
Pretest	000	001	010	100	011	101	110	111
0	43	59						
Percent	48%	30%						
1	47	136						
Percent	52%	70%						
Post-Test	000	001	010	100	011	101	110	111
0	21	11						
Percent	54%	18%						
1	18	51						
Percent	46%	82%						

	Number and Percent Attaining the Criterion Objective on Pre and Post-Test			
	0 Concepts	1 Concept	2 Concepts	3 Concepts
Pretest				
Number				
Percent				
Post-Test				
Number				
Percent				

[1] A "1" indicates attainment; a "0" indicates failure of the criterion objective.

TABLE III-4

Pre and Post-Test Data: Number and Percent of Students Failing and Attaining Criterion for All Combinations of Concepts[1]

Statement 3: Adding energy to the particles of matter increases their motion.

Number & % Failing and Attaining Criterion	Concept Order (Energy, Particles)							
	0 Concepts	1 Concept			2 Concepts			3 Concepts
		Particle Energy			Particle Energy			
Pretest	000	001	010	100	011	101	110	111
0	0	7	52		93			
Percent	100%	88%	62%		50%			
1	0	1	27		94			
Percent	0%	13%	34%		50%			
Post-Test	000	001	010	100	011	101	110	111
0	1	4	43		72			
Percent	50%	80%	91%		65%			
1	1	1	4		39			
Percent	50%	20%	9%		35%			

	Number and Percent Attaining the Criterion Objective on Pre and Post-Test			
	0 Concepts	1 Concept	2 Concepts	3 Concepts
Pretest				
Number	0	28	94	
Percent	0%	32%	50%	
Post-Test				
Number	8	5	39	
Percent	33%	10%	35%	

[1]A "1" indicates attainment; a "0" indicates failure of the criterion objective.

TABLE III-5

Pre and Post-Test Data: Number and Percent of Students Failing and Attaining Criterion for All Combinations of Concepts[1]

Statement 4: Adding energy to the particles of matter increases the space between the particles.

Number & % Failing and Attaining Criterion	Concept Order (Energy, Particles, Space)							
	0 Concepts	1 Concept			2 Concepts			3 Concepts
		Space/Particulate/Energy			Space Particle/	Space Energy/	Particle Energy	Space Particle Energy
Pretest	000	001	010	100	011	101	110	111
0	6	4	2	24	5	22	20	48
Percent	100%	80%	100%	73%	83%	48%	49%	33%
1	0	1	0	9	1	24	21	98
Percent	0%	20%	0%	27%	17%	52%	51%	67%
Post-Test	000	001	010	100	011	101	110	111
0	2	3	3	1	11	16	15	20
Percent	100%	100%	100%	50%	69%	73%	50%	37%
1	0	0	0	1	5	6	14	34
Percent	0%	0%	0%	50%	31%	27%	48%	63%

	Number and Percent Attaining the Criterion Objective on Pre and Post-Test			
	0 Concepts	1 Concept	2 Concepts	3 Concepts
Pretest				
Number	0	1	46	98
Percent	0%	4%	50%	67%
Post-Test				
Number	0	1	25	34
Percent	0%	13%	37%	63%

[1]A "1" indicates attainment; a "0" indicates failure of the criterion objective.

The pretest results indicate that in nearly every case the number of students who were able to make inferences from the statements increased with the number of concepts attained. When exceptions do exist, it is usually in cases where the number of students represented within a cell is small and the percentages are spuriously high. It is impossible to infer any kind of cause and effect relationship from the above because we do not know whether the students are able to make the transfer because they have attained the concepts or if bright students who are able to make the transfer just happen to have attained the concepts.

The post-test data indicates that when learners who had failed the criterion on the pretest are given instruction by means of programmed texts in which the learner is taught only the concepts he did not know on the pretest, the result is that a significant percentage attain the criterion on the post-test.

Questions remain regarding why students who were not able to identify examples of the concepts were able to transfer the statements, as well as why students who had apparently attained the key concepts within the statement were not able to make the transfer.

Theoretically, the concept test should predict the results on the criterion test to the extent that the tests require the same skills and abilities. Based on the above, students who have not attained the concepts should not be able to transfer the statement. Some of them appear to be able to make the transfer involved in the criterion tests without having attained the concepts. The number of students who are in this category is not large, and can probably be explained by measurement error and the chance involved in the multiple-choice items. Other students who appear to have attained all of the prerequisite concepts still are not able to make the required transfer. There appears to be several possible reasons for this. First, the discriminations required by the concept items may not be the discriminations that are important for the use of the concept within the statement. To the extent that the above is true, the concept items would not predict performance on the criterion test. Second, the transfer test may require a logical operation that is not required by the concept items. This also would effect the ability of the concept test to predict the criterion test. Third, some of the concepts that make up the statements were not included in the concept test; and to the extent that these are important to the transfer of the statement, prediction would be inhibited. A fourth variable that was felt to effect the results was reading. Concept items were typically very short and required only limited reading while the transfer items on the criterion test were longer, more complex and involved more reading. Fifth, the items which comprised the criterion test required that the student be able to recognize

TABLE III-6

Pre and Post-Test Data: Number and Percent of Students Failing and Attaining Criterion for All Combinations of Concepts[1]

Statement 5: Increasing or decreasing the energy of the particles causes matter to expand or contract.

Number & % Failing and Attaining Criterion	Concept Order (Expand-Contract, Energy) 0 Concepts	1 Concept: Energy	1 Concept: Expand-Contract	1 Concept	2 Concepts: Energy, Expand-Contract	2 Concepts	2 Concepts	3 Concepts
Pretest	000	001	010	100	011	101	110	111
0	8	52	7		76			
Percent	73%	58%	88%		43%			
1	3	37	1		101			
Percent	27%	42%	13%		57%			
Post-Test	000	001	010	100	011	101	110	111
0	4	18	4		59			
Percent	100%	72%	67%		55%			
1	0	7	2		49			
Percent	0 %	28%	33%		45%			

Number and Percent Attaining the Criterion Objective on Pre and Post-Test

	0 Concepts	1 Concept	2 Concepts	3 Concepts
Pretest				
Number	3	38	101	
Percent	27%	39%	57%	
Post-Test				
Number	0	9	49	
Percent	0%	30%	45%	

[1]A "1" indicates attainment; a "0" indicates failure of the criterion objective.

the statement when it was presented in a different way, make inferences from the statements or be able to recognize when data were consistent with, inconsistent with or irrelevant to a conclusion. These three items vary in difficulty, and may very well require different processes on the part of the student. The criterion items were selected because they represent behavior that science teachers feel is important, but they each appear to require different processes on the part of the learner. The heterogeneous criterion that we were trying to predict reduced the degree of prediction possible with the concept test.

The diagnostic measurement model appears to make possible the systematic improvement of instruction. The complete study shows that there is a strong relationship between the ability to identify examples of the concepts and being able to transfer a statement containing the concepts. Curriculum development and evaluation is an on-going task. The model provides a way for systematically improving it. The writer feels that the approach is fruitful.

The project was too limited in scope to arrive at any definite conclusions regarding how large a percentage of junior high science students could logically be expected to reach criterion under optimal conditions. Much work needs to be done to determine the discrimination that the students have and have not made regarding the concepts, as well as determining how these discriminations relate to the transfer of the statements containing them. The approach used in this study was for the instructions to determine the examples of the concepts used in the test. A more fruitful approach would be to examine the conceptions the students have to determine what they think are examples and non-examples of the category. Another approach that would appear to be beneficial would be to gather more information from the students regarding their thinking on the transfer item. We know very little about what effect the logical operations involved in the criterion test had on the performance of the students. It may be that for most students the operations did not involve a problem. However, we need to know more about the characteristics of the students for whom the operations did constitute a problem. We also need to know more about the effect of reading on the attainment of the criterion. It may be that a model such as the one used in this study is appropriate for students of higher verbal ability, but not for those of lower ability. Future studies should gather more data regarding the characteristics of the students who do and do not appear able to achieve the transfer criterion. Alternative approaches may be needed for them.

TABLE III-7

Pre and Post-Test Data: Number and Percent of Students Failing and Attaining Criterion for All Combinations of Concepts[1]

Statement 6: Increasing the energy of the particles causes matter to change state.

Number & % Failing and Attaining Criterion	Concept Order (Change state, Energy, Particles) 0 Concepts	1 Concept Particle/Energy		1 Concept Change State	2 Concepts Particle Energy	2 Concepts Particle Change-State	2 Concepts Energy Change-State	3 Concepts Particle Energy Change-State
Pretest	000	001	010	100	011	101	110	111
0	8	7	46	2	115	0	15	18
Percent	89%	88%	73%	100%	74%	0%	94%	58%
1	1	1	17	0	41	0	1	13
Percent	11%	13%	27%	0%	26%	0%	6%	42%
Post-Test	000	001	010	100	011	101	110	111
0	2	4	30	90	2	0	2	18
Percent	100%	100%	70%	71%	100%	0%	40%	62%
1	0	0	13	37	0	1	3	11
Percent	0%	0%	30%	29%	0%	100%	60%	38%

Number and Percent Attaining the Criterion Objective on Pre and Post-Test

	0 Concepts	1 Concept	2 Concepts	3 Concepts
Pretest				
Number	1	18	42	13
Percent	11%	25%	24%	42%
Post-Test				
Number	0	50	4	11
Percent	0%	29%	50%	38%

[1] A "1" indicates attainment; a "0" indicates failure of the criterion objective.

REFERENCES

Bloom, B.S., et al., Taxonomy of Educational Objectives: Cognitive Domain, New York: David McKay Company, 1956

Cronbach, Lee and Suppes, P., Research for Tomorrow's Schools, Toronto, Canada, The Macmillan Co., 1969

Gagné, Robert, The Conditions of Learning, New York, Holt, Rinehart and Winston, 1965

Gagné, Robert, "Learning Hierarchies," Educational Psychologist, 3:6-9, 1969

Guttman, L.A., "The Cornell Technique for Scale and Intensity Analysis," Educational and Psychological Measurement, 7:247-280, 1947

Travers, R.M.W., "Toward Taking the Fun Out of Building a Theory of Instruction," Teachers College Record, October, 1966

Tyler, R.W., "The Function of Measurement in Improving Instruction," Educational Measurement, (E. F. Lindquist, Editor), American Council on Education, 1953

TABLE III-8

Pre and Post-Test Data: Number and Percent of Students Failing and Attaining Criterion for All Combinations of Concepts[1]

Statement 7: Energy added to the particles of matter changes state from a solid, to a liquid, to a gas.

Number & % Failing and Attaining Criterion	Concept Order (Physical Property, Energy Particulate)							
	0 Concepts	1 Concept			2 Concepts			3 Concepts
		Particle/Energy/Change-State			Particles Energy	Particle Change, State	Energy Change-State	Particles Energy Change-State
Pretest	000	001	010	100	011	101	110	111
0	8	6	42	0	84	0	2	8
Percent	73%	86%	58%	0%	53%	0%	33%	29%
1	3	1	31	0	75	1	4	20
Percent	27%	14%	42%	0%	47%	100%	67%	71%
Post-Test	000	001	010	100	011	101	110	111
0	3	0	18	3	7	0	35	11
Percent	100%	0%	69%	60%	43%	0%	44%	44%
1	0	0	8	2	4	0	45	14
Percent	0%	0%	31%	40%	57%	0%	56%	56%

	Number and Percent Attaining the Criterion Objective on Pre and Post-Test			
	0 Concepts	1 Concept	2 Concepts	3 Concepts
Pretest				
Number	3	32	80	20
Percent	27%	40%	48%	71%
Post-Test				
Number	0	10	49	14
Percent	0%	31%	54%	56%

[1] A "1" indicates attainment; a "0" indicates failure of the criterion objective.

APPENDIX

TABLE III-9

Pre and Post-Test Data: Number and Percent of Students Failing and Attaining Criterion for All Combinations of Concepts[1]

Statement 8: Chemical Properties of a substance are the characteristics the substance shows when it combines chemically with other substances to form a new compound.

Number & % Failing and Attaining Criterion	Concept Order 0 Concepts	1 Concept Chem-Property	1 Concept Change/State	1 Concept Compound	2 Concepts Chem-prop/Change-State	2 Concepts Chem-prop Compound	2 Concepts Change/Compound/State	3 Concepts Chem-prop Change-State Compound
Pretest	000	001	010	100	011	101	110	111
0	9	99	1	1	19	11	0	4
Percent	56%	51%	50%	100%	51%	46%	0 %	40%
1	7	96	1	0	18	13	0	6
Percent	44%	49%	50%	0%	49%	54%	0 %	60%
Post-Test	000	001	010	100	011	101	110	111
0	3	0	1	34	11	7	1	6
Percent	43%	0%	50%	39%	46%	45%	100%	60%
1	4	0	1	54	13	9	0	4
Percent	57%	0%	50%	61%	54%	55%	0%	40%

Number and Percent Attaining the Criterion Objective on Pre and Post-Test

	0 Concepts	1 Concept	2 Concepts	3 Concepts
Pretest				
Number	9	97	31	6
Percent	56%	49%	50%	60%
Post-Test				
Number	7	59	22	4
Percent	44%	65%	54%	40%

[1]A "1" indicates attainment; a "0" indicates failure of the criterion objective.

MATTER TEST

Concepts

1. Which of the following does not occupy space?

   A. Air
   B. Heat
   C. Smoke
   D. Water vapor

2. Which of the following occupies space?

   A. X-rays
   B. Energy
   C. Air
   D. Heat

3. Which of the following occupies space?

   A. oxygen
   B. X-rays
   C. Ultra violet light
   D. Heat

4. Which of the following has the greater mass?

   A. A cubic inch of carbon
   B. A cubic inch of lead
   C. A cubic inch of air
   D. They all have the same mass

5. Which of the following shows a change in mass?

   A. A meteor flying through space and the meteor on the surface of a planet
   B. A space capsule before and after it is in orbit
   C. A sponge being squeezed into a smaller space
   D. None of the above

6. Which of the following does not have mass?

   A. A magnetic field
   B. A rising Balloon
   C. A floating bubble
   D. A meteor in space.

7. Which of the following is particulate?

   A. Air
   B. Density
   C. A vacuum
   D. Heat

8. Which of the following is particulate?

   A. Ultra violet light
   B. Electricity
   C. A pail of sand
   D. X-rays

TABLE III-10

Pre and Post-Test Data: Number and Percent of Students Failing and Attaining Criterion for All Combinations of Concepts[1]

Statement 9: An element is a basic kind of matter formed from one kind of particle which cannot be broken down by ordinary means.

Number & % Failing and Attaining Criterion	Concept Order (Element) 0 Concepts	1 Concept			2 Concepts			3 Concepts
		Element						
Pretest	000	001	010	100	011	101	110	111
0	90	74						
Percent	70%	65%						
1	39	39						
Percent	30%	35%						
Post-Test	000	001	010	100	011	101	110	111
0	36	66						
Percent	67%	60%						
1	18	44						
Percent	33%	40%						

Number and Percent Attaining the Criterion Objective on Pre and Post-Test

	0 Concepts	1 Concept	2 Concepts	3 Concepts
Pretest				
Number	39	39		
Percent	30%	35%		
Post-Test				
Number	18	44		
Percent	33%	40%		

[1]A "1" indicates attainment; a "0" indicates failure of the criterion objective.

9. Which of the following is <u>NOT</u> particulate?

A. Copper
B. Carbon
C. Calcium
D. Heat

10. Which of the following is a form of energy?

A. Light
B. Rock
C. Wood
D. Metal

11. Which of the following is <u>NOT</u> a form of energy?

A. Moon beams
B. Sun beams
C. Steel beams
D. X-rays

12. Which of the following is a form of energy?

A. Heat
B. Water
C. Smoke
D. Paper

13. Which of the following is <u>NOT</u> an example of expansion or contraction?

A. A piece of concrete buckling in the sun
B. A mercury thermometer
C. The cracking of a rock beside a camp fire
D. Sand being sifted

14. Which of the following is an example of either expansion or contraction?

A. Boiling water
B. A ball in flight
C. A car speeding up
D. A slipper

15. Which of the following is <u>NOT</u> an example of expansion or contraction?

A. Ice melting
B. A thermometer falling indicating a colder temperature
C. A tree growing by adding water or fertilizer

16. Which of the following is an example of matter changing state?

A. Burning wood
B. Melting ice
C. Iron rusting
D. Toast burning

TABLE III-11

Pre and Post-Test Data: Number and Percent of Students Failing and Attaining Criterion for All Combinations of Concepts[1]

Statement 10: An atom is the smallest particle of an <u>element</u> that still has all of the properties of the element.

Number & % Failing and Attaining Criterion	Concept Order (Element) 0 Concepts	1 Concept			2 Concepts			3 Concepts
		Element						
Pretest	000	001	010	100	011	101	110	111
0	108	86						
Percent	84%	76%						
1	21	27						
Percent	16%	24%						
Post-Test	000	001	010	100	011	101	110	111
0	55	91						
Percent	82%	72%						
1	12	36						
Percent	18%	28%						

Number and Percent Attaining the Criterion Objective on Pre and Post-Test

	0 Concepts	1 Concept	2 Concepts	3 Concepts
Pretest				
Number	21	27		
Percent	16%	24%		
Post-Test				
Number	12	36		
Percent	18%	28%		

[1]A "1" indicates attainment; a "0" indicates failure of the criterion objective.

17. Which of the following is an example of matter changing state?

A. Water going over a dam
B. A light bulb burning
C. A candle burning
D. Water being absorbed by a plant

18. Which of the following is an example of matter changing state?

A. Clothes drying
B. Gasoline burning
C. Sharpening a knife
D. Sifting sand

19. Which of the following is <u>NOT</u> a physical property?

A. Solid state
B. Changing rapidly into a gas
C. Melting point
D. Burns rapidly

20. Which of the following is <u>NOT</u> a physical property?

A. Weight
B. Height
C. Hardness
D. Freezing point
E. All of the above are physical properties

21. Which of the following is a physical property?

A. Ability to react with nitric acid
B. Ability to burn
C. Ability to conduct electricity
D. Ability to explode

Principles

22. Matter is anything that takes up space and has mass. Another way of saying this:

A. Matter is anything that has weight.
B. Matter is anything that occupies space and attracts other objects to it.
C. Matter is anything that has weight and takes up space.
D. Matter is anything that takes up space.

23. If matter is anything that has mass and takes up space which of the following is an example of matter?

A. Space
B. A meteor flying through space
C. Light
D. X-rays

24. If light rays could be observed to bend as they passed through the gravitational field of a planet this would be evidence

A. that light is matter.
B. that light is not matter.
C. neither that light is or is not matter.

TABLE III-12

Pre and Post-Test Data: Number and Percent of Students Failing and Attaining Criterion for All Combinations of Concepts[1]

Statement 11: A molecule is a particle of matter formed when two or more different kinds of atoms combine.

Number & % Failing and Attaining Criterion	Concept Order (Atoms) 0 Concepts	1 Concept			2 Concepts			3 Concepts
		Atoms						
Pretest	000	001	010	100	011	101	110	111
0	77	111						
Percent	88%	72%						
1	11	43						
Percent	13%	28%						
Post-Test	000	001	010	100	011	101	110	111
0	23	119						
Percent	77%	75%						
1	7	39						
Percent	23%	25%						

Number and Percent Attaining the Criterion Objective on Pre and Post-Test

	0 Concepts	1 Concept	2 Concepts	3 Concepts
Pretest				
Number	11	43		
Percent	13%	28%		
Post-Test				
Number	7	39		
Percent	23%	25%		

[1] A "1" indicates attainment; a "0" indicates failure of the criterion objective.

25. Matter is particulate. Another way of saying this is:

A. Matter is energy.
B. All matter is made up of small particles.
C. Light is not matter.

26. If matter is particulate then

A. there must be space between the particles.
B. the particles must be in motion.
C. heat must be made of particles.

27. If a man fills a glass so full of hot water that he cannot add another drop, and then finds that he is able to slowly add 2 spoons of sugar without causing the water to spill over this is evidence that

A. Matter is particulate.
B. Matter is not particulate.
C. Neither that matter is nor is not particulate.

28. The motion of the particles of matter increases when the energy is added. Which of the following means the same as the above:

A. When you add energy the particles of matter move more slowly.
B. When you add energy to the particles of matter their motion increases to a point and then remains constant.
C. When you add energy to the particles of matter they expand.
D. As you add energy to the particles of matter their motion increases a given amount for each unit of energy.

29. A bottle of perfume is in each of four different rooms. If the rooms were the same size you would expect the odor of the perfume to reach the farthest corner of which room first.

A. Room "A" which is 60 degrees.
B. Room "B" which is 70 degrees.
C. Room "C" which is 100 degrees.
D. Room "D" which is 0 degrees.

30. Mr. Oho froze a bottle of water and saw that the level of the ice in the bottle was higher than the water was in the beginning. This evidence

A. is consistent with the idea that adding energy causes matter to expand.
B. is inconsistent with the idea that adding energy causes matter to expand.
C. is related to the idea that adding energy causes matter to expand

31. Adding energy to the particles of matter increases the space between the particles. Which of the following means the same as the above:

A. Adding energy causes the particles of matter to move farther apart.
B. Decreasing the energy of the particles causes the particles to move apart.
C. Adding energy causes the particles of matter to move closer together.

32. If adding energy to the particles of matter increases the space between the particles of matter you would expect

A. a balloon rising in the sky to break.
B. a balloon laying in the sun to expand.
C. a balloon in a vacuum to expand.

TABLE III-13

Pre and Post-Test Data: Number and Percent of Students Failing and Attaining Criterion for All Combinations of Concepts[1]

Statement 12: A compound is matter formed by <u>molecules</u> consisting of two or more different kinds of <u>atoms</u>.

Number & % Failing and Attaining Criterion	Concept Order (molecule, atom) 0 Concepts	1 Concept			2 Concepts			3 Concepts
		atom	molecule		atom molecule			
Pretest	000	001	010	100	011	101	110	111
0	28	19	19		46			
Percent	49%	61%	45%		41%			
1	29	12	23		66			
Percent	51%	39%	55%		59%			
Post-Test	000	001	010	100	011	101	110	111
0	13	7	3		34			
Percent	81%	63%	50%		47%			
1	3	4	3		39			
Percent	19%	37%	50%		53%			

Number and Percent Attaining the Criterion Objective on Pre and Post-Test

	0 Concepts	1 Concept	2 Concepts	3 Concepts
Pretest				
Number	29	35		
Percent	51%	48%		
Post-Test				
Number	3	7		
Percent	19%	41%		

[1] A "1" indicates attainment; a "0" indicates failure of the criterion objective.

33. Mr. Oho placed drops of food coloring in four jars containing equal amounts of water. He then observed the length of time it took the food coloring to spread evenly throughout the containers. He recorded the data as shown below:

	Temperature	Time
Container "A"	50 degrees	15 sec.
Container "B"	60 degrees	12 sec.
Container "C"	70 degrees	9 sec.

The evidence is

A. consistent with the idea that adding energy increases the space between the particles.
B. inconsistent with the idea that adding energy increases the space between the particles.
C. not related to the principle that increasing the energy increases the space between the particles.

34. Increasing or decreasing the energy of the particles causes the matter to expand or contract. Which of the following means the same as the above?

A. When energy is added to the particles of the object the object will take up more space than it did before.
B. When energy is added to the particles of an object the object will take up less space than it did before.
C. When energy is added to the particles the object will take up more space than it did before, but when energy is removed the object will contract.
D. Adding energy to matter causes matter to break down into its basic particles.

35. If you filled a jar with water and then placed a tight cover on it and heated it you could expect

A. the level of water in the jar to fall.
B. the jar to explode.
C. the water in the jar to all turn to steam.
D. the water in the jar to contract.

36. Mr. Oho used a tire pump to pump up a tire and noticed that as he forced more and more air into the tire the temperature of the tire increased. This evidence

A. supports the idea that increasing or decreasing the energy of the particles causes the matter to expand or contract.
B. shows that the principle cannot be true.
C. is inconsistent with the idea that increasing or decreasing the energy of the particles causes matter to expand or contract.
D. may be correct but isn't directly related to the idea that increasing or decreasing the energy of the particles causes matter to expand or contract.

37. Energy added to the particles of matter tends to change its state from a solid, to a liquid, to gas, to plasma. Which of the following means the same as the above?

A. Removing energy from matter changes its state from a solid, to a liquid, to a gas, to plasma.
B. Removing energy from matter changes its state from a gas, to a liquid, to plasma, to a solid.
C. Adding energy to the particles of matter will change it to a different <u>kind</u> of matter.
D. Adding energy to the particles of matter will cause matter to change its for

TABLE III-14

Pre and Post-Test Data: Number and Percent of Students Failing and Attaining Criterion for All Combinations of Concepts[1]

Statement 13: A chemical reaction occurs when atoms combine to form molecules or when molecules break apart into atoms.

Number & % Failing and Attaining Criterion	Concept Order (Chemical reaction, molecule, atom)							
	0 Concepts	1 Concept			2 Concepts			3 Concepts
		chem-reaction	molecule	atom	atom molecules	atom chem-reaction	molecule chem-reaction	
Pretest	000	001	010	100	011	101	110	111
0	30	13	18	11	13	6	8	17
Percent	64%	62%	56%	52%	45%	60%	38%	28%
1	17	8	14	10	16	4	13	44
Percent	36%	38%	44%	48%	55%	40%	67%	72%
Post-Test	000	001	010	100	011	101	110	111
0	5	5	5	3	6	5	6	14
Percent	72%	60%	56%	50%	40%	63%	27%	36%
1	2	4	4	3	9	3	16	25
Percent	28%	40%	44%	50%	60%	37%	73%	64%

Number and Percent Attaining the Criterion Objective on Pre and Post-Test

	0 Concepts	1 Concept	2 Concepts	3 Concepts
Pretest				
Number	17	35	33	44
Percent	36%	43%	55%	72%
Post-Test				
Number	2	11	28	25
Percent	28%	44%	62%	64%

[1] A "1" indicates attainment; a "0" indicates failure of the criterion objective.

38. If you removed all of the energy from the particles of the air in a container you would expect to have

A. air in a liquid state.
B. plasma.
C. air in a solid form.
D. a gas

39. Mr. Oho added pressure to a gas and noted that it finally turned into a liquid and gave off heat. How is this evidence related to the principle that adding energy to the particles of matter changes its form from a solid, to a liquid, to a gas, to plasma. This evidence

A. cannot be right if the principle is right.
B. could be true, but is unrelated to the principle.
C. is consistent with the principle.

40. Physical properties are the characteristics of matter which can be observed through the five senses. Which of the following means the same as the above? Physical properties are

A. properties we can see.
B. properties we can feel.
C. the characteristic manner in which matter combines with other matter.
D. characteristics of matter we can observe through our senses.

41. Which of the following is not a physical property of matter?

A. Weight.
B. Hardness.
C. Ability to combine with other substances.
D. Odor.

42. Mr. Oho noted that a physical property of ether was its ability to change rapidly from a liquid to a gas. Mr. Oho then placed a liquid substance in a cup and noted a few minutes later that the substance was gone. The above is evidence

A. that the substance was ether.
B. that the substance was not ether.
C. that the substance could be ether.
D. which neither supports or denies the idea that the substance is ether.

43. Chemical properties of a substance are the characteristics the substance shows when it combines with other substances to form a new substance. Which of the following means the same as the above: Chemical properties are the

A. characteristics of a substance that determine the way it reacts with other substances.
B. properties a substance shows when heated.
C. properties of a substance which can be observed by the five senses.

44. Which of the following shows a chemical property?

A. Iron melting.
B. Chlorine escaping into the air.
C. Hydrogen burning to form water.
D. Lead weighs more than copper.

45. Mr. Oho said that one of the chemical properties of a substance is its ability to combine with other substances and form new substances. Which of the following provides the best evidence of this property?

A. It has a low boiling point.
B. It changes rapidly into a gas.
C. It combines with oxygen to form water.
D. It is often found in a pure state in nature.

TABLE III-15

Pre and Post-Test Data: Number and Percent of Students Failing and Attaining Criterion for All Combinations of Concepts[1]

Statement 14: When elements combine in a chemical reaction to form compounds they lose their physical properties.

Number & % Failing and Attaining Criterion	Concept Order (chemical reaction, compounds)							
	0 Concepts	1 Concept			2 Concepts			3 Concepts
		Compounds	Chem-reactions		Compounds Chem-reaction			
Pretest	000	001	010	100	011	101	110	111
0	39	25	27		33			
Percent	57%	81%	51%		37%			
1	29	6	26		57			
Percent	43%	19%	49%		63%			
Post-Test	000	001	010	100	011	101	110	111
0	12	13	8		25			
Percent	67%	43%	63%		38%			
1	6	17	3		40			
Percent	33%	57%	27%		62%			

	Number and Percent Attaining the Criterion Objective on Pre and Post-Test			
	0 Concepts	1 Concept	2 Concepts	3 Concepts
Pretest				
Number	29	32	33	
Percent	43%	38%	37%	
Post-Test				
Number	6	20	40	
Percent	33%	50%	62%	

[1]A "1" indicates attainment; a "0" indicates failure of the criterion objective.

TABLE III-16

Pre and Post-Test Data: Number and Percent of Students Failing and Attaining Criterion for All Combinations of Concepts[1]

Statement 15: When compounds break down in a chemical reaction into their elements they lose their physical properties.

Number & % Failing and Attaining Criterion	Concept Order (Chemical reaction, Elements)							
	0 Concepts	1 Concept			2 Concepts			3 Concepts
		Elements	Chem-reaction		Elements Chem-reaction			
Pretest	000	001	010	100	011	101	110	111
0	40	26	37		44			
Percent	59%	84%	70%		49%			
1	28	5	16		46			
Percent	41%	16%	30%		51%			
Post-Test	000	001	010	100	011	101	110	111
0	13	19	8		35			
Percent	62%	63%	72%		39%			
1	5	11	3		53			
Percent	38%	37%	28%		71%			

	Number and Percent Attaining the Criterion Objective on Pre and Post-Test			
	0 Concepts	1 Concept	2 Concepts	3 Concepts
Pretest				
Number	28	21	46	
Percent	41%	22%	51%	
Post-Test				
Number	5	14	53	
Percent	38%	34%	71%	

[1] A "1" indicates attainment; a "0" indicates failure of the criterion objective.

ELEMENTS AND COMPOUNDS

Concepts

1. Which of the following is an element?

   A. Water
   B. Air
   C. Chlorine
   D. Salt

2. Which of the following is an element?

   A. Oxygen
   B. Carbon dioxide
   C. Rust
   D. Gasoline

3. Which of the following is an element?

   A. Paint
   B. Steel
   C. Iron
   D. Carbon monoxide

4. Which of the following is an atom?

   A. (H)
   D. (O)(H)(O)
   C. (Na)(Cl)
   D. (Cl)(Zn)(Cl)

5. Which of the following is an atom?

   A. (Cl)(Cu)(Cl)
   B. (Cl)(Ca)(Cl)
   C. (S)
   D. (O)(S)(O)

6. Which of the following is an atom?

   A. (Fe)(S)
   B. (H)(Cl)
   C. (C)(O)
   D. (C)

7. Which of the following is a molecule?

   A. (C)
   B. (H) (H)
   C. (Pb)
   D. (Na)(Cl)

8. Which of the following is a molecule?

   A. (Zn)
   B. (H)
   C. (Hg)(Cl)(Cl)
   D. (Cu)

9. Which of the following is not a molecule?

   A. (S)
   B. (Fe)(S)
   C. (Cl)(Cl)
   D. (Cl)(Cl)(C)(Cl)(Cl)

TABLE III-17

Pre and Post-Test Data: Number and Percent of Students Failing and Attaining Criterion for All Combinations of Concepts[1]

Statement 16: A mixture results when two or more elements or compounds are stirred together, but do not have a chemical reaction.

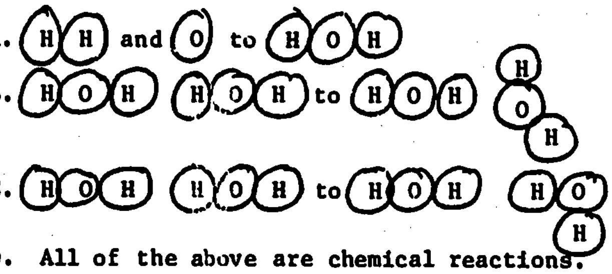
Number & % Failing and Attaining Criterion	Concept Order (Chemical reaction, Compound, Element) 0 Concepts	1 Concept			2 Concepts			3 Concepts
		Element/	Compound/	Chem-reaction	Element/Compound/	Element chem-reaction/	Compound chem-reaction	Element Compound chem-reaction
Pretest	000	001	010	100	011	101	110	111
0	31	10	17	14	13	4	10	19
Percent	66%	48%	52%	67%	45%	40%	48%	31%
1	16	11	15	7	16	6	11	42
Percent	34%	52%	47%	33%	55%	60%	52%	69%
Post-Test	000	001	010	100	011	101	110	111
0	4	2	6	3	3	3	9	8
Percent	67%	33%	60%	43%	22%	43%	39%	21%
1	2	4	4	4	11	4	14	30
Percent	33%	67%	40%	57%	78%	57%	61%	79%

Number and Percent Attaining the Criterion Objective on Pre and Post-Test

	0 Concepts	1 Concept	2 Concepts	3 Concepts
Pretest				
Number	16	32	33	42
Percent	34%	26%	21%	69%
Post-Test				
Number	2	12	29	30
Percent	33%	52%	66%	79%

[1]A "1" indicates attainment; a "0" indicates failure of the criterion objective.

10. Which of the following changes is an example of a chemical reaction?

A. B. C.


D. All of the above are chemical reactions.

11. Which of the following changes is an example of a chemical reaction?

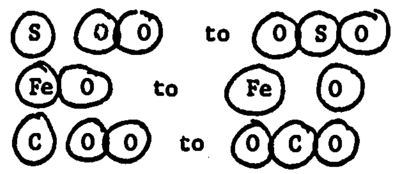
A. 

B.  spreading through the air.

C.  pressed together as shown 

D. All of the above are chemical reactions.

12. Which of the following changes is a chemical reaction?

A. B. C.


D. All of the above are chemical changes.

Principles

13. An element is a basic kind of matter formed from one kind of particle which cannot be broken down by ordinary means. Which of the following means the same as the above?

A. Elements break down into compounds by ordinary means.
B. An element is made of just one kind of substance.
C. All elements are made up of one kind of particle and cannot be changed into other substances by ordinary means.
D. Each element is made up of its own kind of particle and cannot be changed into other substances by ordinary means.

14. If uranium is an element then uranium

A. cannot be combined with other elements.
B. cannot be changed to lead chemically.
C. can be changed into lead by ordinary means.

TABLE III-18

Pre and Post-Test Data: Number and Percent of Students Failing and Attaining Criterion for All Combinations of Concepts[1]

Statement 17: A solution results when elements or compounds placed in a liquid break down into their particles, and spread evenly throughout the liquid without causing a chemical reaction.

Number & % Failing and Attaining Criterion	Concept Order (Chemical reaction, Compounds, Elements)							
	0 Concepts	1 Concept			2 Concepts			3 Concepts
		Element	Compound	Chemical Reaction	Element/Compound	Element/chem-reaction	Compound/chem-reaction	Elements Compounds Chem-reaction
Pretest	000	001	010	100	011	101	110	111
0	36	17	27	16	23	8	14	41
Percent	77%	81%	84%	76%	79%	80%	67%	67%
1	11	4	5	5	6	2	7	20
Percent	23%	19%	16%	24%	21%	20%	33%	33%
Post-Test	000	001	010	100	011	101	110	111
0	8	6	7	13	18	3	23	41
Percent	89%	60%	58%	72%	69%	37%	61%	58%
1	1	4	5	5	8	5	15	30
Percent	11%	40%	42%	28%	31%	63%	39%	42%

Number and Percent Attaining the Criterion Objective on Pre and Post-Test

	0 Concepts	1 Concept	2 Concepts	3 Concepts
Pretest				
Number	11	14	15	41
Percent	23%	19%	25%	58%
Post-Test				
Number	1	14	28	30
Percent	11%	35%	64%	42%

[1] A "1" indicates attainment; a "0" indicates failure of the criterion objective.

15. Mr. Oho passed an electric current through a substance and caught the gases that came off at each pole. He was able to identify the two gases that came off at each pole as hydrogen and oxygen. The substance Mr. Oho passes the electric current through

A. was an element.
B. was not an element.
C. cannot be determined from the information given.
D. could be an element and could be a compound.

16. An atom is the smallest particle of an element that still has all of the properties of the element. Which of the following means the same as the above? An atom is the smallest particle of

A. matter that still has the characteristics of the matter.
B. matter.
C. an element which still has the same properties as the element.
D. a substance which has the same physical and chemical properties as the substance.

17. An atom is the smallest particle of an element that still has all of the properties of the element. If the above is true and a piece of an element is cut in half, then cut in half again and again and the process is never stopped you would expect

A. at some point you would no longer be cutting the element in half.
B. to be cutting the element in half all of the time.
C. that the particles would always retain their particles.

18. Mr. Oho observed that an atom of the element uranium gave off radiation. After it stopped giving off radiation, he noted that all the properties of the particle had changed. The above is evidence that the final particle is

A. no longer an atom.
B. no longer an atom of uranium.
C. an atom of uranium but it is no longer radioactive.

19. A molecule is a particle of matter formed when two or more different atoms combine. Which of the following means the same as the above?

A. Two or more different kinds of atoms always form a molecule.
B. Two or more different kinds of atoms can chemically combine to form a molecule.
C. Atoms form molecules.
D. Molecules form atoms.

20. Two or more different kinds of atoms can combine chemically to form a molecule. If the above is true then atoms of elements X and Y

A. will form a molecule XY.
B. cannot form a molecule XY.
C. may or may not form a molecule XY.

21. A compound is matter formed by molecules consisting of two or more different kinds of atoms. Which of the following means the same as the above?

A. All of the particles in a compound are molecules.
B. Matter formed by two or more different atoms is a compound.
C. A compound is composed of molecules which are composed of different kinds of atoms.
D. Compounds are formed by similar atoms which form molecules.

22. A compound is formed by molecules consisting of two or more different kinds of atoms. If the above is true which of the following is a compound?

A. The element Florine.
B. Iron sulfide formed by chemically combining iron and sulfur.
C. Air which contains the uncombined elements nitrogen, oxygen and hydrogen.
D. Hydrogen gas which is composed of hydrogen molecules.

23. Mr. Oho continously divided a piece of table salt. On the last division he noted that he did not have salt any more, but had instead an atom of sodium, an active metal and an atom of chlorine, a poisonous gas. This evidence

A. supports the idea that compounds are composed of molecules.
B. is inconsistent with the idea that compounds are composed of molecules.
C. neither supports nor denies the idea that compounds are formed of molecules.

24. A chemical reaction occurs when atoms combine to form molecules or when molecules break apart into atoms. Which of the following means the same as the above? Chemical reactions occur when

A. atoms combine to form molecules.
B. molecules break apart.
C. elements combine to form compounds or when compounds break apart into elements.
D. compounds combine to form elements or when elements break apart into compounds.

25. Which of the following is not a chemical reaction?

A. Carbon combining with oxygen to form carbon dioxide.
B. A uranium atom being split.
C. Water breaking down into hydrogen and oxygen.
D. Mercury combining with oxygen to form mercuric oxide.

26. Mr. Oho burned hydrogen in a container and noticed that water formed on the inside of the container. This evidence

A. supports the conclusion that a chemical reaction has taken place.
B. suggests that a chemical reaction has not taken place.
C. neither supports nor denies that a chemical reaction has taken place.

27. When elements combine chemically to form compounds they lose their physical properties. Which of the following means the same as the above?

A. Elements retain their properties when they form compounds.
B. Elements retain their chemical properties when they form compounds.
C. Elements lose their physical characteristics when they react chemically.
D. Elements are recognizable in compounds.

28. When elements combine chemically to form compounds they lose their physical properties. If the above is true then

A. the hydrogen in water will not act like hydrogen gas.
B. the chlorine in salt will act like the gas chlorine.
C. iron sulfide will be much like iron.
D. hydrogen chloride will combine the physical properties of hydrogen and chlorine.

29. Mr. Oho combined the poisonous gas chlorine with the very light explosive gas hydrogen and got a liquid which reacted violently with many metals. This evidence

A. supports the idea that elements lose their physical properties when they combine to form compounds.
B. is inconsistent with the idea that elements lose their physical properties when they combine to form compounds.
C. neither supports nor denies the idea that elements lose their physical properties when they combine to form compounds.

30. When compounds break down chemically into their elements they lose their physical properties. Which of the following means the same as the above? When a compound breaks apart

A. the elements keep the physical properties of the compound.
B. the elements appear the same as they did in the compound.
C. into elements the elements each acquire their own characteristics.
D. they still have the physical properties of the compound.

31. When compounds break down chemically they lose their physical properties. If this is true you would expect the blue stones of the copper sulfate compound to break down chemically into

A. blue copper powder and sulfate stones.
B. blue sulfur stones and blue copper stones.
C. copper with a similar weight as the copper sulfate.
D. copper and sulfur with the properties of sulfur.
E. none of the above.

32. Mr. Oho put sugar into hot water. He then boiled the liquid away and tasted what remained. He found that it tasted like sugar. This evidence

A. supports the idea that when a compound breaks down chemically they lose their chemical properties.
B. is inconsistent with the idea that when a compound breaks down chemically it loses its physical properties.
C. neither supports nor denies the idea that when a compound breaks down chemically it loses its physical properties.

33. When two or more elements or compounds are stirred together but do not combine chemically the result is a mixture. Which of the following <u>means the same</u> as the above?

A. Mixtures are compounds.
B. Mixtures are formed when substances are stirred together.
C. When substances are stirred together but do not react chemically a mixture is formed.
D. If substances react chemically a mixture is formed.

34. When two or more elements or compounds are stirred together but do not combine chemically the result is a mixture. Which of the following is a mixture?

A. Gold which if formed from one kind of atom.
B. Air which has molecules of nitrogen, oxygen and hydrogen spread throughout it.
C. Copper sulfate which is formed of copper sulfate molecules.
D. Carbon dioxide which is formed from molecules of carbon dioxide.

35. Mr. Oho began freezing a gas in a sealed container and noted that part of the gas froze at -50 degrees, another part froze at -75 degrees and another part froze at -100 degrees. This evidence suggests

A. that the gas is a mixture.
B. that the gas is not a mixture.
C. neither that the gas is nor is not a mixture.

36. A solution results when an element or a compound placed in a liquid breaks down into its particles and the particles spread evenly throughout the liquid without causing a chemical reaction. Which of the following means the same as the above?

A. Solutions are mixtures involving chemical reactions.
B. A solution is a liquid mixture with the particles spread evenly throughout it.
C. A solution results when two compounds or elements in a liquid state are poured together.
D. A solution is a liquid compound.

37. A solution results when an element or compound placed in a liquid breaks down into its particles and the particles spread evenly throughout the liquid without causing a chemical reaction. Which of the following formed a solution?

A. Liquid "A" which turned cloudy when a substance was added to it.
B. Liquid "B" which smoked when a substance was added to it.
C. Liquid "C" which remained clear but tasted like the substance added to it.
D. Liquid "D" which changed from blue to red when a substance was added to it.

38. Mr. Oho added one liquid to another in a container. He then shook the container and noticed little drops of the first liquid spread throughout the second liquid. This evidence

A. indicates a solution has been formed.
B. indicated that a solution has not been formed.
C. neither indicates that a solution has been formed nor that a solution has not been formed.