THE EFFECT OF ANALOGY-STRUCTURED TEACHING ON STUDENT ACHIEVEMENT IN NINTH-GRADE PHYSICAL SCIENCE

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The purpose of this study is to investigate the effects of using verbal analogies in teaching ninth-grade physical science. The experiment is designed to determine if teaching by analogies is more effective than conventional methods of teaching, and to ascertain the effect of analogies on achievement for different ability levels in different subject areas of physical science.

Students from six ninth-grade physical science classes in five different schools were subjects in this study. Three sections, under three different teachers made up the control group of conventional teaching; three sections, under three different teachers, comprised the experimental group of analogy teaching. All six classes were taught by teachers who were volunteers for this study.

The subjects of this study were administratively grouped according to pre-test results of ETS *Advanced General Science Test*, Part II, which deals with chemistry and physics. High-ability level was defined as being those students who scored in the top third (thirty or more correct responses, out of sixty). The middle-ability level had twenty-one to twenty-nine correct responses, and the low-ability level was the lower third who scored twenty or less on the pre-test.
There were 155 subjects who took the pre-test; however, due to withdrawals, transfers, and absences during the nine-month testing period, only 119 subjects completed the post-test.

As a base for teaching by analogies, nine hundred verbal analogy items were developed for this experiment. Each analogy item was validated by a panel of four experts. Every week, each experimental student, being given approximately thirty minutes to complete the task, responded to a set of twenty-five analogy items. The answer sheets were collected and scored by the researcher, but the students kept the analogy questions. The instructor then discussed each question, the relationships involved, and the correct answer.

Data and treatment were over a nine-month school term. During this time, the analogy students completed about eight hundred of the nine hundred items devised for this experiment. Other than providing for the pre-test and post-test, the control-group teachers instructed students in the accustomed manner.

At the end of the school year, an analysis of covariance with Tukey's Test was used to determine significant differences between the two teaching methods and between the ability levels in chemistry, physics, and overall physical science.

Results of the investigation showed no significant difference between teaching by analogies and traditional methods of teaching. There was an indication that during the nine-month academic year, the low-ability students taught by
analogical and traditional methods improved their overall physical science achievement to a greater degree than did the high-ability students. In the chemistry content, high-ability students gained more from analogical and traditional instruction than did the middle- and low-ability students.

It is recommended that a follow-up test of retention be administered to the students of this study and that a study be made to determine the effectiveness of pictorial analogies as compared to verbal analogies. Also, an investigation should be undertaken to determine whether sex influences the ability to form analogical relationships. Since verbal analogies apparently do not inhibit learning in physical science, this type of analogy could be used as another teaching activity, such as for explanation or end-of-chapter questions.
THE EFFECT OF ANALOGY-STRUCTURED TEACHING ON STUDENT ACHIEVEMENT IN NINTH-GRADE PHYSICAL SCIENCE

DISSERTATION

Presented to the Graduate Council of the North Texas State University in Partial Fulfillment of the Requirements

For the Degree of

DOCTOR OF PHILOSOPHY

BY

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CHAPTER I

INTRODUCTION

The explosion in scientific knowledge has created a backlog of information which doubles about every nine years. It has been difficult for education to keep pace with this rapid accession of scientific facts. Moreover, the mere acquisition of knowledge, without the ability to assimilate it for reasoning and understanding, is useless (7, p. 99).

Traditional methods of teaching physical science rely on objective tests to "cover the subject matter," but this leaves the learner stranded on the lowest level of the cognitive domain (knowledge of specifics). To remedy this situation and to cope better with the knowledge explosion, several methods of organizing and teaching physical science have been proposed. Of these methods, most efforts are aimed at a balance between concept and process (11, p. 698).

Concept teaching is a powerful tool. It permits the student to summarize a great deal of knowledge, and it provides a base for understanding new ideas as they become available (21, p. 3). Basic to teaching by concept, however, is the notion of teaching similar associations, or analogies, because concepts are based on simple relationships and the extrapolations of these relationships. Also, analogies
provide a base for reasoning and are a prerequisite for success in most endeavors (9, p. 678). In any study of science, analogies are often implicit, but students may need more practice in identification and application. When students are taught to rely more on relationships for shaping concepts, then teaching for concepts, or any methodology, may become much more effective.

Statement of the Problem

The problem of this study is to determine the effect of analogy-structured teaching on student achievement in ninth-grade physical science.

Purpose of the Study

The purposes of this study are (1) to analyze the effect upon student achievement in the chemistry content of ninth-grade physical science when analogies are stressed, (2) to analyze the effect upon pupil achievement in the physics content of ninth-grade physical science when analogies are stressed, and (3) to ascertain the effect of analogy-oriented teaching upon the overall academic achievement in ninth-grade physical science.

Relative to this study, the sub-purposes are (1) to offer another teaching tool for ninth-grade physical science, and (2) to develop nine hundred analogy-type items as an initial base for the teaching of analogies in ninth-grade physical science.
Hypotheses

A solution to the problem was sought by testing these hypotheses:

I. Subjects who receive instruction in analogies will show significantly greater mean gains in chemistry content than will subjects using conventional instruction for the following levels:
   A. High-ability-level subjects,
   B. Middle-ability-level subjects,
   C. Low-ability-level subjects.

II. Subjects who receive instruction in analogies will show significantly greater mean gains in physics content than will subjects using conventional instruction for the following levels:
   A. High-ability-level subjects,
   B. Middle-ability-level subjects,
   C. Low-ability-level subjects.

III. Subjects who receive instruction in analogies will show significantly greater overall mean gains in physical science than will subjects using conventional instruction for the following levels:
   A. High-ability-level subjects,
   B. Middle-ability-level subjects,
   C. Low-ability-level subjects.

IV. Within the treatment group receiving instruction in analogies, the high-ability-level students will show
significantly greater mean gains than will the middle- and low-ability-level students in the following:

A. Chemistry content of ninth-grade physical science,
B. Physics content of ninth-grade physical science,
C. Overall physical science.

V. Within the treatment group receiving instruction in analogies, the middle-ability-level students will show significantly greater mean gains than will the low-ability-level students in the following:

A. Chemistry content of ninth-grade physical science,
B. Physics content of ninth-grade physical science,
C. Overall physical science.

Significance of Study

Education has been particularly vulnerable to the overwhelming advance of modern science, for, in addition to keeping pace with new knowledge, it must also educate people to new conditions imposed by science and technology. There have been several proposals for new curricula; for example, the Intermediate Science Curriculum Study (ISCS) uses self discovery, the Physical Science Study Committee (PSCS) advocates concepts in physics, the Chemical Bond Approach Project emphasizes molecular and atomic structures, the Chemical Education Materials Study (CHEMS) uses discovery of principles, and the Princeton Project stresses process. In spite of these new approaches, there has been a steady decline in physical science enrollment in public schools. A survey
by Thompson (15, p. 244) indicates that most students fear low science grades will hinder their chances for college acceptance.

There are many educators and psychologists who strongly favor a conceptual system of teaching so that the learner will have a more "fluid" mind to cope with current and future knowledge. Bruner (2, p. 21) cites concepts for its economy of thought. Woodruff proposes that "Student behavior is most likely to be responsive . . . when priority is given to the most useful instrumental concepts in all fields" (23, p. 95). Voelker points out that science is based on concepts, and that "Teaching for concepts . . . is logical in terms of the nature of the scientific enterprise, learning theory and their inter-relationships" (21, p. 3).

Concepts and scientific theories are fundamentally based on relationships, or analogies. Weiller stresses the role of analogy in the development of theories and states that " . . . only passing comment has been made concerning the value of analogy as a pedagogic tool, a value which may be of prime importance" (22, p. 113). The eminent psychologist William James, a fervent supporter of reasoning by analogies, makes many statements regarding this subject:

Alike in the arts . . . and in science, association by similarity is the prime condition of success.

Men, taken historically, reason by analogy long before they have learned to reason by abstract characters . . . .

The flash of similarity between an apple and the moon, between the rivalry for food in nature and the rivalry for man's selection, was too recondite to have
occurred to any but exceptional minds. Genius [referring to Newton and Darwin] ... is identical with the possession of similar association to an extreme degree (9, pp. 686-688).

Based upon Thorndike's "Theory of Identical Elements" and his "Response by Analogy," the theoretical definition behind analogies is "To any new situation man responds as he would to some situation like it, or like some element of it" (20, p. 28). Bigge points out that "However, elements of similarity between two situations are not necessarily restricted to skills. They may take the form of information, principles, procedures or attitudes" (1, p. 261). Orato criticizes Thorndike's theories and states that "Not a simple succession of elements is transferred, but rather an attitude of response or a way of seeing the same kind of solution for different problems" (16, p. 83). Judd opposes Thorndike's theory on the ground that "Generalization is another name for the relating of experiences in such a way that what is gained at one point will redound to the advantage of the individual in many spheres of thought and action" (10, p. 496). Bigge sums up the disagreement with "Thus, we should recognize that either Thorndike's emphasis upon the commonness of elements or Judd's emphasis on the appropriateness of generalization makes the environment the determining agency in transfer" (1, p. 275).

Teaching by organizing for recognition and utilization of relationships, as such, appears to have been neglected, in spite of its seemingly tremendous potential as a teaching
tool. While not stressed in the classroom, analogical reasoning must often be used by students when responding to some vital tests, such as the College Entrance Examination, the Miller Analogy Test, the Graduate Record Examination, the Medical College Admission Test, or Civil Service Tests.

Lee believes that interrelationships should be a part of the school curricula and that "Teaching the fact that in some way and to some degree, all things are related, stimulates children to look for relationships. And seeing them increases effective learning many fold" (12, p. 14).

In view of the need for more efficient means of handling and teaching science, it appears that analogy-structured teaching might play a very important role in helping educators meet this challenging problem.

Definition of Terms

For the purpose of this study, the following definitions are established:

1. **Analogy** is an association or comparison of similar resemblances between objects, concepts, or positions.

2. **Analogy item** is a type of problem wherein a specific relationship must first be established between two objects, words, or concepts, then transferred or related to two other choices which bear similar relationship.

3. **Analogy-structured-teaching** is teaching which emphasizes and encourages students to study relationships and to use analogies in reasoning.
4. High-ability-level is composed of students who scored in the upper third on ETS Advanced General Science Test, Form A, Part II.

5. Low-ability-level is composed of students who scored in the lower third on ETS Advanced General Science Test, Form A, Part II.

6. Middle-ability-level is composed of students who scored in the middle third on ETS Advanced General Science Test, Form A, Part II.

7. Physical science is a course of study required by the Texas Education Agency of ninth-grade students and which involves introductory chemistry and physics.

8. Similar association is a term coined by William James which has the same meaning as "analogy."

9. Traditional teaching is the method of teaching which relies primarily on the use of a textbook and which does not include any of the newer curricula materials such as PSSC, CHEMS, or ISCS.

Assumptions

The basic assumptions of this study were the following:

1. That the teachers applied analogy instruction to the best of their abilities in the prescribed manner.

2. That the subjects cooperated and performed at their best level.

3. That the analogy items validated by the panel of experts were appropriate for ninth-grade-level instruction.
Limitations of the Study

1. This study was limited to teachers who had at least two years teaching experience in physical science and who were volunteers for this study.

2. This study was limited to ninth-grade students of a large urban area school of North Central Texas.

Instruments

The instrument chosen to measure student achievement in physical science was Part II of the Educational Testing Service's Advanced General Science. It is a forty-minute test on physics and chemistry for eighth- and ninth-grade levels. Almost fifty science teachers from all sections of the country contributed or reviewed items to insure a high degree of content validity. There were 226 national and urban schools which participated in two separate testing programs for this test. It has a reliability of .94.

A primary concern in teaching by analogies is the need for a basic set of analogy items covering all areas of ninth-grade physical science. There are several college-level analogy tests in print, but these are comprehensive and are not designed for any specific subject. Consequently, over nine hundred analogy-items were developed specifically for this study. (See Appendix A.) Each of the items was validated by a panel of experts (See Appendix B.), who used the guideline criteria given in Appendix C.
Procedures for Collecting Data

Sample

Six classes of ninth-grade physical science students from five different schools in a large North Central Texas school district were subjects in this study. The classes were not physically grouped according to IQ, but they were administratively grouped into high-, middle-, and low-ability groups from results of the ETS Advanced General Science Test, Part II. Three classes (seventy-nine students) from three different schools and under three different teachers, comprised the experimental groups. Similarly, seventy-six students made up the control groups.

Procedure

During the summer of 1972, appropriate preliminary measures were taken. Permission to conduct the study was given by the Superintendent and the Director of Curriculum. At an in-service meeting in August, the investigator presented his proposal to the fifteen physical science teachers of the school district. (See Appendix D.) From the ten teachers volunteering to participate in the experiment, the Science Consultant and the investigator selected six teachers on the basis of qualifications, prior performance, cooperativeness, and personal knowledge of capabilities.

The investigator later met with the three experimental teachers to discuss a detailed plan for teaching by analogies.
Treatment of Data

A 3 × 2 analysis of covariance, with pre-test scores as the covariate, was computed to test Hypotheses I, II, and III.

A one-way analysis of covariance was computed to test Hypotheses IV and V.

Tukey's Test for multiple comparisons was computed to specifically identify levels where significant differences were detected.

The level of significance for all five hypotheses was arbitrarily set at the .05 level of confidence.
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CHAPTER II

RELATED LITERATURE

History and Uses of Analogies

Analogies have long been used by mankind in a variety of ways. Lloyd (23, p. 177) states that many anthropologists believe analogies were a very important feature of primitive life, wherein many magical beliefs and practices depended on recognition of resemblances. For example, names of diseases were often taken from things in nature which the disease resembled.

The famed fable teller Aesop, who lived in the sixth century B.C., "... told of sly plots and tricky schemes of men but he made it seem they were the thoughts and words of animals" (40, p. 9). Thus, a similarity was drawn, and a moral taught.

Socrates and Aristotle used analogies to a great extent. In his book Polarity and Analogy, Lloyd discusses analogy in early Greek theory and argument from analogy, called paradigm. He quotes Aristotle: "Paradigm is when the major term is shown to belong to the middle term by means of a term which is like the minor term" (23, p. 407). Although the precise meaning of this remark is unclear, it resembles a common, current form of analogy—A : B :: C : D, which is read, "A is to B, as C is to D."
In the thirteenth century, Thomas Aquinas often spoke of analogy as applied to logic. Bochenski refers to one of Aquinas' texts on analogy which gives two examples of relations of similarities: "SIGHT : EYE--INTELLECT : MIND" and "DIVINE BEING : GOD--CREATURELY BEING : CREATURE." Bochenski concludes that Aquinas attempted to formalize rules for analogy, and this is of "... utmost historical importance as being the first indication of a study of structure, which was to become a main characteristic of modern science" (3, p. 179). However, Harrison believes "... that it will be most unlikely that we will be able to construct some general theory of analogy that will be useful in explaining all of the various particular uses of analogies in all of the various different situations in which one might use, or find, an analogy..." (19, p. 1666).

Hesse explains four concepts of analogy that are precursors of modern scientific explanations. The first is called "analogy of organism" where natural events and human reproduction are explained through analogous relationships in nature. The second is called "analogy of attraction" and stresses the attraction and repulsion between men, as well as between men and nature. The third is analogy by "speech and command" in which a belief develops in the power of blessing or cursing and prayer which is also analogous with petitions to a ruler. Finally, the fourth analogy concept explains various analogies of the human workman, in which
human endeavor is likened to the work of nature. For example, the ancients used the irrigation system to explain the movement of body fluids. Hesse states, "It is the influence of these analogies which has persisted throughout the history of physics." She further explains, "Analogies of this kind help to explain the persistence in physical science of the idea that bodies can act upon one another only by contact" (21, p. 33).

In the seventeenth century, Francis Bacon popularized the works of science and proposed a scientific method involving inductive thinking which relied heavily on analogical reasoning. In the inductive process, one proceeds from a particular to a general conclusion by comparisons and similarities of otherwise diverse phenomena. Doralle (10, p. 71), in his book *Le Raisonnement Par Analogy*, discusses the importance and uses of analogies in scientific work and relates some of the scientific discoveries emanating from analogical reasoning.

In the realm of philosophy, Burrell concludes that "... analogous usage cannot be restricted to the metaphysical and theological domain but pervades our ordinary usage as well" (6, p. 4726). Dorrough (11, p. 1697) believes that philosophical literature is confused about analogies, but that true analogical statements can be verified by meeting certain proposed criteria, such as (A) a particular pattern of sentences, (B) inference,
partitioning, interpretation of a constant term, and an analytical check, and (C) discrimination from similes by use of A and B. In a similar vein, Thomas (38, p. 3036) looks at analogies between words and their meaningfulness in religious discourse, and he attempts to define "something common" as a basis for drawing analogies.

History draws parallels, the Bible is replete with parables, literature uses similes and metaphors, and law has its precedents. Thus, there is a great variegation of analogical usage, and probably not a facet of civilization remains uninfluenced by analogies.

Psychological Aspects of Analogies
As an Aid to Concept Formation

In proposing his Law of Analogy for Learning in Animals, Thorndike states, "... the response made will be that which by original or acquired nature is connected with some situation which they resemble" (39, p. 15). Regarding man and Response by Analogy, he declares, "To any new situation man responds as he would to some situation like it, or like some element of it. In default of any bonds with it itself, bonds that he has acquired with situations resembling it, act" (39, p. 28).

William James (22), in his Principles of Psychology, first published in 1890, discourses at great length on the role of analogies in reasoning. In 1905, Binet used word analogies in measuring intelligence. The famed Miller
Analogies Test (MAT) was devised in 1926 at the University of Minnesota to evaluate a person's ability to pursue graduate study. Freeman evaluates the MAT thusly:

The ability tested by means of these analogies is one factor in the prediction of success in graduate studies; namely, ability to learn verbal and other abstract concepts and course materials. What the analogies do not evaluate (nor do they purport to do so) is original thinking and constructive research ability . . . (13, p. 299).

In the Stanford-Binet Tests for measuring intelligence, Terman and Merrill (37, p. 216) combine the opposites test with the analogies test, where the relationship between the second and fourth of the critical words is that of opposites. For example, "An inch is short; a mile is . . . [long]."

They emphasize that these tests were extremely satisfactory for many reasons, including scoring objectivity, being self-explanatory, possessing difficulty control, maintaining high interest, having uniformly high correlations, and showing a consistent reflection of mental growth.

Having studied the use of pictorial and verbal analogies in teaching concepts in biology, Dowell (12, p. 34) believes that the use of analogies in aiding concept attainment has been well noted by educators, but that research pertaining to use of analogies in concept formation is scarce.

Woodruff has long been an advocate of learning by concepts and believes that a concept is the " . . . internal mediating variable that accounts for the direction of a person's response to a situation" (43, p. 84). He reveals
three kinds of concepts—process, structure, and quality. Scriven (34, p. 154) has determined that children use all three types of concepts to explain meaning. He points out that categorization serves to decrease the diversity of objects, so that an individual can sort his ideas into functionally significant groupings. Therefore, since analogies go hand-in-hand with categorizations, it appears that analogies may aid in building concepts.

Of Woodruff's second type of concept, structure, Bruner writes that the best argument for concepts and structure to combat the knowledge explosion is "... to cultivate the arts of connecting things that are akin, connecting them into the structure that gives them significance" (5, p. 21).

Butts (7, p. 2418) confirms that concept development is a goal of science instruction, but that student experience alone is not sufficient for concept development. Along similar lines, McCroskey and Coombs (27, p. 338), examining the effects of two types of analogy on attitude change and source credibility, conclude that an analogy helps define the meaning of a message more clearly, and that analogy decreases a receiver's ability to employ "selectivity" as an alternate to attitudinal change.

Smith (35, p. 2595) used analogically coded symbols to test response variables of correctness of concept, speed of concept, certainty of response, and appropriateness of driver action. He concludes that the responses were more positive when greater analogicity was used in the non-verbal messages.
In regard to the analogy tests and the items used in psychological testing, Remmers believes that intelligence and mental ability tests have made more use of analogies than achievement tests have, perhaps because the artificiality of the analogies requires more general mental ability for correct response than specific achievement of instructional objectives does. Analogies do, however, provide a compact way in which to put a question (31, p. 259).

Gentile (17, p. 501), in a study of a testing procedure, reports on the processes used in verbal reasoning analogy-items. His findings indicate that associative relatedness among words in an analogy item is central to the analogy/reasoning process. Sister Josephine (23, p. 237) concludes, after testing preschool children with analogies, that the young child can satisfactorily handle analogies and can transfer his thinking to a greater degree than is usually supposed.

Abou-Allam (1, p. 278), who studied the difficulty of different forms of verbal analogies, reports that a TYPE I (A : B :: C : D) is easiest, while a TYPE III (A : B :: V, W, X, Y : Z) is most difficult; he also concludes that a multiple choice pattern is easiest, while a restricted completion pattern is most difficult.

Finally, Voelker sums up relationships and concepts in teaching science:

Ideas are formulated as relationships between two or more facts are sought; they become part of a body of knowledge and, as such, are tools for future use. As the simpler relationships become intertwined with more and more facts and relationships, there develops a need for an explanation that will encompass them all (41,
Use of Analogies in Teaching

In spite of broad application to science and other disciplines, there is a paucity of literature on how and when to use analogies in teaching, and, in particular, the teaching of science. If analogies are so helpful in developing scientific theory, it would appear that analogies should also help the student of science understand the theory.

Dowell cites a need for further research to properly define the role of analogies in teaching and recommends, among other things:

1. A survey on the nature of types of explanations (including analogical) which teachers and students use.
2. Development of separate analogy tests for elementary and secondary students.
3. A study to determine if analogical teaching is more effective at some grade and age level than others.
4. That science teachers not fear that analogical explanations hinder student understanding (12, p. 77).

Weller also refers to a lack of concern toward the value of analogy in teaching science. He believes that analogy has a very important teaching role, but when analogies are used wrongly, erroneous concepts may result. For example, one may refuse to accept a solution when the analogy does not apply. Secondly, a model may be taken as theory, rather than the model being merely analogous to the theory. However, mindful of these pitfalls, "... a theory may be learned in less time and with fewer misplaced categorizations if an analogy is used." He concludes, "... analogies have a legitimate function as a pedagogic tool...", and "...
with proper precautions, an analogy may be an excellent
time-saving device, but improperly used it may serve equally
well as an obstruction to the learning process" (42, p. 119).

Mill has stated, "There is no word . . . which is used
more loosely, or in a greater variety of senses, than analogy"
(28, p. 393). However, analogies are probably used more for
explanation in a teaching-learning situation than for any
other purpose. For example, in a recent textbook, Physical
Science, by Booth and Bloom (4), there are fifteen pictorial
analogies as well as many other verbal analogies. Virtually
all texts in physical science use the analogy of a rope and
a picket fence to explain polarized light. Goff (18, p. 534)
uses beach sand to explain large numbers and the vastness of
space to students. A gallon jug would contain ninety-three
million grains of sand, and a six-room house filled with sand
represents the miles in a light year (six trillion). Demchik
(8, p. 722) has built an apparatus called an "analogy box" to
teach students the concept of voltage, amperage, and resist-
ance. Martin (26, p. 190), however, takes an opposite view
toward analogies and believes that students are too condi-
tioned to look for similarities, when it would be more bene-
ficial to seek and explain anomalies.

Analogies are used to a great extent in teaching litera-
ture. Moriarty (29, p. 5747A) has studied the uses of analogy
in literature and concludes that there are five purposes to
which the technique of analogy may be put in the study of
literature: rapport between literary works, purposes other than historical investigation, study of literature in relation to other arts, critical understanding and evaluation, and development of universal literary norms. Bivins thinks that analogies are a "pathway to relevance" as "Students love to 'find the parallel' (draw the analogy) between a situation they're reading about and one they have experienced in real life, because doing so draws on their knowledge and makes that knowledge worth something" (2, p. 93). But Bivins does not restrict analogies solely to a verbal teaching tool, because she feels that audio-visual materials produce sounds and pictures that parallel and draw on the emotions. Oliphant (30, p. 60) supports this view and notes the analogy between language and music; he suggests that music, language, and math are analogically linked together. Cautioning not to carry analogy too far, Oliphant contends that analogies can be a stimulating guideline for teaching methods and philosophy.

An early use of analogy in teaching methodology involved "association"—one of Herbart's "five formal steps." In this step, new material was assimilated with the old, and similarities and differences were shown so that the new material could be properly related to the old (14, p. 184).

Rogers believes that for Christian education, analogy has an important implication in teaching-learning and for stimulation of creativity. He states that "... analogy is a logical form ... which has de facto as well as methodological significance in a wide variety of disciplinary
conceptual systems . . . which is a valuable tool for the Christian educator in his theoretical and practical tasks" (33, p. 2768A).

In other areas related to analogy in teaching, Templeton (36, p. 2596) studied the effects of sixth graders' verbal analogizing and their measures of intelligence, achievement, and creative thinking. He concludes that analogizing may cut across a divergency of mental operations, and that analogy is a very effective learning-teaching tool. Gentile (16, p. 145A) found that providing subjects with definitions had a significant effect on the solution of analogy items, and that this effect was independent of occupational prestige level. Roberts (32, p. 2315) looked at children's solutions to analogy problems and showed that grammatical, semantic, and overall correctness increased as a function of age. This would appear to answer Dowell's suggestion (12) that analogies might be more effective at some particular age or some particular situation.

In spite of all the uses of analogy in teaching-learning, there is still no unifying philosophy on where, when, or how to most effectively apply analogies in education. In summarizing the scant literature on analogies, the following general statements might be made:

1. Analogies are used in many subject areas and in a variety of ways.
2. Analogies are extensively used in literature through the simile and metaphor.
3. Analogies that extend to real-life-situations are most effective.

4. Analogies provide a compact way to present a question.

5. The Miller Analogies Test is a good predictor of success in certain endeavors.

6. Analogies are successfully used in some measures of intelligence.

7. Analogical reasoning ability appears to be a function of age.

8. Children at the pre-school level are capable of analogizing.

9. The TYPE I analogy item is easiest to grasp \((A : B :: C : D)\).

10. Science textbooks use verbal and pictorial analogies extensively for explanation.

11. Analogies are useful in theory formation and in scientific reasoning.

12. Analogies are used by the great minds to an extreme degree.

13. The unknown can sometimes be understood only by relating it to the known.

Use of Analogies in Teaching Ninth-Grade Physical Science

Physical Science was instituted in the Texas public schools' curriculum in 1961 as a result of a state education commission set up in 1958-59. During the 1960's and
to the present time, there has been much experimentation with content and teaching of all sciences. Much of the experimentation is aimed at increased efficiency, or teaching more in less time—such as teaching concepts, rather than unrelated inert facts. A recent editorial (15, p. 8A) reports that the focus today is not on the acquisition of facts as much as on acquiring worthwhile methodology. The student who has learned a methodology for self-discovery can continue to seek out the knowledge he needs, throughout a lifetime. Efficiency in teaching is greatly affected by teacher qualifications and teaching methodology. Regarding teacher qualifications, Llarena (24, p. 26) reports on the academic preparation of ninety-three physical science teachers participating in four Cooperative College-School Science 1970 summer workshops. In spite of the fact that physical science deals with "non-living" studies, biology was the most frequent major of the group (25%), with a non-science major second (23%), and agriculture (16%) third. Fourteen percent had no college physics, and five percent had no college chemistry. In semester hours, the mean, median, and mode was 18.2, 14.3, and 4.5, respectively, for chemistry; also, 10.2, less than 4.5, and 4.5, respectively, for physics. Thus, it would appear that for teachers with inadequate preparation in physical science, analogies might prove useful for explanation. Dowell comments on analogies for explanation and defines analogies as "depicting the unfamiliar in terms of the familiar, or as seeking relations between diverse phenomena" (12, p. 18).
Apart from the teaching-learning aspects of analogies in physical science, it would appear that in view of vital, future tests, such as College Entrance Examinations, students need instruction and practice in taking tests of an analogy-type.

In the present study, a suggested curriculum for physical science is shown in Appendix D. The nine hundred analogy-items developed for this study follow this outline, and these items should serve four primary purposes in analogy teaching:

1. To aid in explanation.
2. To encourage students to seek relationships.
3. To transfer learning from the familiar to the unfamiliar.
4. To see a variety of different approaches all relating to a total scheme.

Summary

More efficient teaching requires teaching concepts instead of inert facts. Educators have noted the use of analogies as an aid in concept attainment. Although analogies are widely used in a variety of diverse disciplines, there is no unifying methodology on how or when to use analogies in teaching. Therefore, research is required to better explain the role of analogies in understanding physical science theories and concepts. It is to this end which the present investigation is undertaken.
CHAPTER BIBLIOGRAPHY


CHAPTER III

PROCEDURES FOR OBTAINING AND TREATING DATA

This chapter presents a detailed description of the subjects, the procedures used for collecting data, the methods employed in analyzing the data, and the statistical treatment of the data.

Description of the Subjects

Students from six ninth-grade physical science classes in five different schools in a large North Texas city were subjects in this study. Three sections, under three different teachers, made up the control group of traditional teaching; and three sections, under three different teachers, comprised the experimental group of analogical teaching. All six classes were taught by teachers who were volunteers for this study, and whose final selection was made with the recommendation of the science consultant for the school district. The teaching experience in physical science for the experimental teachers was two, four, and ten years, while the control teachers had four, eight, and ten years.

Random selection of intact classes was not possible because football boys and choral girls favored certain class periods. Therefore, each teacher selected one of
his classes, which, in his estimation, was representative and cooperative for the task at hand.

The classes in physical science of this school system were not grouped according to IQ. Therefore, the subjects of this study were administratively grouped according to results of the Educational Testing Service's _Advanced General Science Test_, Form A, Part II, which deals with chemistry and physics. This pre-test was administered to the six classes during the second week of the fall semester. Out of the original 155 total subjects who took the pre-test, due to withdrawals, transfers, and absences, only 119 subjects completed the post-test (Form B) nine months later. The number of subjects from each school remaining at the completion of the study, by ability levels, is shown in Table I.

**TABLE I**

**DISTRIBUTION BY ABILITY LEVELS OF SUBJECTS WHO TOOK POST-TEST**

<table>
<thead>
<tr>
<th>Level</th>
<th>Number of Subjects From Each School</th>
<th>Number of Subjects From Each School</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In Analogy Group</td>
<td>In Traditional Group</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>C</td>
</tr>
<tr>
<td>High-ability</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Middle-ability</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Low-ability</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>22</td>
</tr>
</tbody>
</table>

High-ability-level was defined as those who scored in the top third (30 or more correct responses, out of 60). The arithmetic mean for this level was 34.7381. The middle-
ability-level had 21 to 29 correct responses and had an arithmetic mean of 25.0500. The low-ability-level was the lower third, who scored 20 or less on the pre-test. The arithmetic mean for this level was 14.3784.

Procedures for Collecting Data

Data and treatment for experimental subjects was extended over a nine-month school term in order to

1. Make a more representative study of physical science as a one-year course.
2. Allow students more opportunity to relate one subject to the other.
3. Provide for overlap in some areas of chemistry and physics.
4. Consider teachers who prefer to teach physics and chemistry as one subject.
5. Permit teacher leeway in choice of which subject area to teach first.
6. Allow for chapter to chapter discontinuity in subject matter of textbook.

The experimental teachers devoted a minimum of one hour each week to instruction in analogies. This was predicated on the premise that two hours each week were mandatorily utilized for laboratory experiments as required by the Texas Education Agency, that one hour each week was used for visual media, and that one hour each week was for lecture and testing, thereby allowing one hour of analogies in lieu of
some other activity. To insure that students in the experimental groups received proper treatment of at least one hour per week of analogical exercises, the three analogy instructors had each student respond to a set of twenty-five analogy-items each week or when, in the instructor's opinion, the unit had been adequately covered. (See Appendix A.) Students were given approximately thirty minutes to respond to the twenty-five items. The answer sheets were collected, but the students retained the analogy questions. The teacher then discussed each question, the relationships involved, and the correct answers. (Refer to Appendix D for examples.)

The researcher personally visited each teacher of analogies at least once every two weeks. A log was kept for each visit to record any problems that might have evolved. The researcher also observed one analogical teaching period for each of the three experimental teachers during the fall and again during the spring semester. These procedures were followed to insure conformity among the experimental teachers.

At each bi-weekly visit, the researcher was given the answer sheets for the analogy items. Each unit, for every student, was graded, and the scores were submitted to the analogy teacher to use at his discretion. The students' answer sheets were filed by the researcher for possible item analysis at a later date.

Out of the thirty-six analogy units available to the three experimental teachers, one teacher was able to cover
thirty-three units during the period of research, a second covered thirty-one units, and the third also covered thirty-one units. Therefore, the analogy students completed about eight hundred of the nine hundred items devised for this experiment.

Other than providing for the pre-test and the post-test, the control group teachers instructed students in the accustomed manner.

Analysis of the Data

At the end of the school year, the results of the pre-test (Form A) and the post-test (Form B) were computer analyzed to study achievements of the ability levels for analogical and traditional teaching methods in chemistry, physics, and overall physical science.

Statistical Treatment

A 3 x 2 analysis of covariance, with the pre-test as the covariate, was computed to test Hypotheses I, II, and III. (See Table II.) Three separate computer analyses were required: one for chemistry content, one for physics content, and one for overall physical science. These analyses tested the mean differences between the two teaching methods and the mean differences between the high-, middle-, and low-ability-level subjects.

A one-way analysis of covariance was computed to test Hypotheses IV and V. These analyses tested the mean
differences between the different ability-levels. Tukey's Test for multiple comparisons was used to find where the significant differences existed.

The .05 level of confidence was required for significance in all analyses.

**TABLE II**

ANALYSIS OF COVARIANCE OUTLINE \((3 \times 2)\) FOR TESTING DIFFERENT TEACHING METHODS FOR DIFFERENT ABILITY LEVELS IN PHYSICAL SCIENCE

<table>
<thead>
<tr>
<th>Ability Level</th>
<th>Analogical Method</th>
<th>Traditional Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Physics</td>
<td>Physics</td>
</tr>
<tr>
<td></td>
<td>Chemistry</td>
<td>Chemistry</td>
</tr>
<tr>
<td></td>
<td>Physical Science</td>
<td>Physical Science</td>
</tr>
<tr>
<td>Middle</td>
<td>Physics</td>
<td>Physics</td>
</tr>
<tr>
<td></td>
<td>Chemistry</td>
<td>Chemistry</td>
</tr>
<tr>
<td></td>
<td>Physical Science</td>
<td>Physical Science</td>
</tr>
<tr>
<td>Low</td>
<td>Physics</td>
<td>Physics</td>
</tr>
<tr>
<td></td>
<td>Chemistry</td>
<td>Chemistry</td>
</tr>
<tr>
<td></td>
<td>Physical Science</td>
<td>Physical Science</td>
</tr>
</tbody>
</table>
CHAPTER BIBLIOGRAPHY


CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

The basic purpose of this study is to determine the effect of analogy-structured teaching on student achievement in ninth-grade physical science. In this chapter, data gathered for high-, middle-, and low-ability students in chemistry content, physics content, and overall physical science content will be presented and discussed. Results for the different teaching methods and for different ability levels will be considered separately.

Findings for Teaching Methods

Research Hypotheses I, II, and III predicted findings for the two different teaching methods. It was anticipated that there would be significant differences between the achievement of subjects who received analogical instruction and those who received traditional instruction. The significant differences were expected to show that high-, middle-, and low-ability students in the analogy group made significantly greater mean gains in their knowledge of chemistry content, physics content, and overall physical science content. The unadjusted means and standard deviations using a $3 \times 2$ analysis of covariance for subjects on each of the quantitative measures are presented in Tables A, B, and C. (See Appendix E.)
Hypothesis I states that subjects in high-, middle-, and low-ability levels who receive analogical instruction will score significantly greater mean gains than will the subjects in the same ability levels who receive traditional instruction in the chemistry content of physical science. A summary of the $3 \times 2$ analysis of covariance data for the chemistry content of physical science is presented in Table III.

### Table III

A SUMMARY OF THE $3 \times 2$ ANALYSIS OF COVARIANCE IN CHEMISTRY CONTENT OF PHYSICAL SCIENCE

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum Squares</th>
<th>DF</th>
<th>Mean Squares</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rows (levels)</td>
<td>142.1181</td>
<td>2</td>
<td>71.0590</td>
<td>5.9118*</td>
</tr>
<tr>
<td>Columns (methods)</td>
<td>35.0658</td>
<td>1</td>
<td>35.0658</td>
<td>2.9173</td>
</tr>
<tr>
<td>Interaction</td>
<td>4.6826</td>
<td>2</td>
<td>2.3413</td>
<td>0.1948</td>
</tr>
<tr>
<td>Within</td>
<td>1346.2288</td>
<td>112</td>
<td>12.0199</td>
<td>XXX</td>
</tr>
</tbody>
</table>

*Significant at the .05 level of confidence.

These computations show that there is no significant difference between the two teaching methods in the chemistry content of physical science, and that Hypotheses I-A, I-B, and I-C can be rejected.

The significant difference detected within the rows would affect Hypotheses IV and V. These calculations at this point, however, do not specifically determine which ability levels are involved. For this determination, a one-way analysis of covariance, with Tukey's test, is
required. This is shown in the following section which deals with ability levels.

Hypothesis II states that subjects in high-, middle-, and low-ability levels who receive analogical instruction will score significantly greater mean gains in physics than will the subjects in the same ability levels who receive traditional instruction in physics content of physical science. A summary of the $3 \times 2$ analysis of covariance data for the physics content of physical science is presented in Table IV.

TABLE IV
A SUMMARY OF THE $3 \times 2$ ANALYSIS OF COVARIANCE IN PHYSICS CONTENT OF PHYSICAL SCIENCE

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum Squares</th>
<th>DF</th>
<th>Mean Squares</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rows (levels)</td>
<td>65.4828</td>
<td>2</td>
<td>32.7414</td>
<td>2.7060</td>
</tr>
<tr>
<td>Columns (methods)</td>
<td>14.1614</td>
<td>1</td>
<td>14.1614</td>
<td>1.1704</td>
</tr>
<tr>
<td>Interaction</td>
<td>56.1903</td>
<td>2</td>
<td>28.0952</td>
<td>2.3220</td>
</tr>
<tr>
<td>Within</td>
<td>1355.1722</td>
<td>112</td>
<td>12.0998</td>
<td>XXX</td>
</tr>
</tbody>
</table>

These computations show that there is no significant difference between the two teaching methods in the physics content of physical science and that Hypotheses II-A, II-B, and II-C can be rejected.

Hypothesis III states that subjects in high-, middle-, and low-ability levels who receive analogical instruction will score significantly greater mean gains in overall physical science knowledge than will subjects in the same
ability levels who receive traditional instruction in physical science. A summary of the $3 \times 2$ analysis of covariance data for overall physical science is presented in Table V.

**TABLE V**

A SUMMARY OF THE $3 \times 2$ ANALYSIS OF COVARIANCE IN OVERALL PHYSICAL SCIENCE

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum Squares</th>
<th>DF</th>
<th>Mean Squares</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rows (levels)</td>
<td>221.7063</td>
<td>2</td>
<td>110.8531</td>
<td>4.2320*</td>
</tr>
<tr>
<td>Columns (methods)</td>
<td>8.9726</td>
<td>1</td>
<td>8.9726</td>
<td>0.3425</td>
</tr>
<tr>
<td>Interaction</td>
<td>13.5030</td>
<td>2</td>
<td>6.7515</td>
<td>0.2577</td>
</tr>
<tr>
<td>Within</td>
<td>2933.7521</td>
<td>112</td>
<td>26.1942</td>
<td>XXX</td>
</tr>
</tbody>
</table>

*Significant at the .05 level of confidence.

These computations show that there is no significant difference between the two teaching methods in overall physical science, and that Hypotheses III-A, III-B, and III-C can be rejected.

The significant difference detected within the rows would affect Hypotheses IV and V. These calculations at this point, however, do not specifically determine which ability levels are involved. For this determination, a one-way analysis of covariance, with Tukey's test, is required. This is shown in the following section, which deals with ability levels.

**Findings for Different Ability Levels**

Research Hypotheses IV and V predicted findings for the different ability levels. It was anticipated that the analogy
students in the high-ability level would score significantly
greater mean gains than would the analogy students in the
middle- and low-ability levels, in chemistry content, phys-
ics content, and overall physical science content. Similarly,
it was anticipated that the analogy students in the middle-
ability level would score significantly greater mean gains
than would the analogy students in the low-ability levels,
in the same areas of study. To test these hypotheses, a one-
way analysis of covariance and Tukey's Test for multiple com-
parisons was used. The unadjusted means and the standard
deviations for subjects on each of the quantitative measures
are presented in Tables D, E, and F. (See Appendix E.)

A summary of the one-way analysis of covariance for
chemistry content is presented in Table VI.

### TABLE VI

**A SUMMARY OF THE ONE-WAY ANALYSIS OF COVARIANCE**
**IN CHEMISTRY CONTENT OF PHYSICAL SCIENCE**

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>117</td>
<td>1523.6597</td>
<td>XXX</td>
<td>XXX</td>
</tr>
<tr>
<td>Within</td>
<td>115</td>
<td>1385.9302</td>
<td>12.0516</td>
<td>XXX</td>
</tr>
<tr>
<td>Difference</td>
<td>2</td>
<td>137.7295</td>
<td>68.8647</td>
<td>5.7142*</td>
</tr>
</tbody>
</table>

*Significant at the .05 level of confidence.

For significance, $F > 3.07$; therefore, the difference
within the ability levels in chemistry content could have
occurred by chance only five in one hundred times. This also
verifies prior computation from a $3 \times 2$ analysis of covariance.
Tukey's Test was used to determine which ability levels accounted for the difference. Computations for this test, as well as the adjusted means for post-test scores, are shown in Table VII.

**TABLE VII**

**TUKEY'S TEST AND ADJUSTED MEANS FOR POST-TEST SCORES IN CHEMISTRY CONTENT**

<table>
<thead>
<tr>
<th></th>
<th>High</th>
<th>Middle</th>
<th>Low</th>
<th>Adjusted Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>0.0</td>
<td>4.0821*</td>
<td>4.8938*</td>
<td>13.6724</td>
</tr>
<tr>
<td>Middle</td>
<td>-4.0821</td>
<td>0.0</td>
<td>0.8117</td>
<td>10.5426</td>
</tr>
<tr>
<td>Low</td>
<td>-4.8938</td>
<td>-0.8117</td>
<td>0.0</td>
<td>9.9203</td>
</tr>
</tbody>
</table>

*Significant at the .05 level of confidence.

For significance, Tukey's values ≤ 3.36; therefore, the significant differences occur between the high- and middle-ability levels, as well as between the high- and low-ability levels. The adjusted means indicate that, after adjusting the post-test scores, the high-ability students scored higher than the middle- and low-ability students on post-test in chemistry content. Research Hypothesis IV-A can be accepted on the basis of these findings. However, the non-significant findings between middle- and low-ability-level students would lead to rejection of Hypothesis V-A.

A summary of the one-way analysis of covariance for physics content is presented in Table VIII.
TABLE VIII
A SUMMARY OF THE ONE-WAY ANALYSIS OF COVARIANCE
IN PHYSICS CONTENT OF PHYSICAL SCIENCE

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>117</td>
<td>1495.4839</td>
<td>XXX</td>
<td>XXX</td>
</tr>
<tr>
<td>Within</td>
<td>115</td>
<td>1425.2791</td>
<td>12.3937</td>
<td>XXX</td>
</tr>
<tr>
<td>Difference</td>
<td>2</td>
<td>70.2048</td>
<td>35.1024</td>
<td>2.8323</td>
</tr>
</tbody>
</table>

For significance, $F \geq 3.07$; therefore, the calculated $F$ value of 2.8323 would indicate that Hypotheses IV-B and V-B should be rejected.

A summary of the one-way analysis of covariance for overall physical science is shown in Table IX.

TABLE IX
A SUMMARY OF THE ONE-WAY ANALYSIS OF COVARIANCE
IN OVERALL PHYSICAL SCIENCE

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>117</td>
<td>3180.5496</td>
<td>XXX</td>
<td>XXX</td>
</tr>
<tr>
<td>Within</td>
<td>115</td>
<td>2955.7646</td>
<td>25.7023</td>
<td>XXX</td>
</tr>
<tr>
<td>Difference</td>
<td>2</td>
<td>224.7849</td>
<td>112.3925</td>
<td>4.3729*</td>
</tr>
</tbody>
</table>

*Significant at the .05 level of confidence.

For significance, $F \geq 3.07$; therefore, the difference within the ability levels in overall physical science could have occurred by chance only five in one hundred times. This also verifies prior computation from a $3 \times 2$ analysis of covariance. Tukey's Test was used to determine which ability levels accounted for the difference. Computations for this
test, as well as the adjusted means for post-test scores are shown in Table X.

TABLE X

TUKEY'S TEST AND ADJUSTED MEANS FOR POST-TEST SCORES IN OVERALL PHYSICAL SCIENCE

<table>
<thead>
<tr>
<th></th>
<th>High</th>
<th>Middle</th>
<th>Low</th>
<th>Adjusted Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>0.0</td>
<td>-0.2665</td>
<td>-3.4670</td>
<td>23.9815</td>
</tr>
<tr>
<td>Middle</td>
<td>0.2655</td>
<td>0.0</td>
<td>-3.2005</td>
<td>24.4211</td>
</tr>
<tr>
<td>Low</td>
<td>3.4670*</td>
<td>3.2005</td>
<td>0.0</td>
<td>29.7008</td>
</tr>
</tbody>
</table>

*Significant at the .05 level of confidence.

For significance, Tukey's values $\geq 3.36$; therefore, the significant difference occurs between the low- and high-ability levels. The adjusted means indicate that, after adjusting the post-test scores, the low-ability students scored higher than the high-ability students on post-test in overall physical science. Research Hypotheses IV-C and V-C can be rejected. Moreover, the opposite of Hypothesis IV-C is true.

Summary of Findings

Detailed analysis of the statistical treatments for two teaching methods and three ability levels in ninth-grade physical science has been presented in this chapter. Table XI draws together the findings to show the positions of significant differences.
TABLE XI

SUMMARY OF FINDINGS FOR ANALOGICAL AND TRADITIONAL TEACHING IN NINTH-GRADE PHYSICAL SCIENCE FOR HIGH-, MIDDLE-, AND LOW-ABILITY STUDENTS IN CHEMISTRY CONTENT, PHYSICS CONTENT, AND OVERALL PHYSICAL SCIENCE CONTENT

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Chemistry</th>
<th>Physics</th>
<th>Physical Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analogical vs. Traditional, all levels</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
</tr>
<tr>
<td>High- vs. middle-ability levels</td>
<td>*</td>
<td>N.S.</td>
<td>N.S.</td>
</tr>
<tr>
<td>High- vs. low-ability levels</td>
<td>*</td>
<td>N.S.</td>
<td>**</td>
</tr>
<tr>
<td>Middle- vs. low-ability levels</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
</tr>
</tbody>
</table>

*Significant at the .05 level of confidence.

**Low-ability scored higher than high-ability.
CHAPTER BIBLIOGRAPHY


CHAPTER V

SUMMARY, CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

This research study is an investigation of the effects of analogy-structured teaching on student achievement in ninth-grade physical science. This chapter contains a summary of the methods and procedures used to obtain the data, a review of the findings, and conclusions, implications, and recommendations for educational practice and future research.

Summary of Methods and Procedures

One hundred and nineteen students from ninth-grade physical science classes were divided into high-, middle-, and low-ability groups on the results of the Educational Testing Service's Advanced General Science (Form A, Part II). Sixty students comprised the control group, while fifty-nine students made up the experimental group. The experiment extended over a nine-month period to allow full coverage and interaction of all subject areas of physical science. The control group received conventional instruction while the experimental group received analogical instruction for a minimum of one hour each week. Nine hundred analogy questions were specifically developed for this study and were validated by a panel of experts. During the school year,
each student in the experimental group responded to and discussed about eight hundred analogy questions. The analogy answer sheets were graded, and the grades were submitted to the experimental teachers to use at their discretion. At the end of the school year, a post-test was administered to study the gains made by the control and experimental groups.

Five hypotheses were formulated to predict where significant differences among the teaching methods would appear for high-, middle-, and low-ability subjects in chemistry content, physics content, and overall physical science content. A $3 \times 2$ analysis of covariance, with the pre-test as the covariate, was used to establish statistical significance for differences between the teaching methods and between the ability levels. A one-way analysis of covariance with Tukey's Test for multiple comparisons was used to determine where significant differences existed within the ability levels.

Summary of the Findings

In Chapter IV, each hypothesis is considered separately, and tables are given for the analysis of $3 \times 2$ and one-way covariance computations. When the F ratio indicated that the ability levels differed significantly, the data were investigated further by Tukey's Test for multiple comparisons. Results of the investigation can be summarized in the following findings:

1. There was no significant difference between analytical and traditional teaching methods for all ability levels in chemistry content of physical science.
2. There was no significant difference between analogical and traditional teaching methods for all ability levels in physics content of physical science.

3. There was no significant difference between analogical and traditional teaching methods for all ability levels in overall physical science.

4. Within the experimental and control groups, the high-ability-level students achieved greater mean gains in chemistry content than did the middle- and low-ability-level students.

5. Within the experimental and control groups, the low-ability-level students achieved greater mean gains in overall physical science than did the high-ability-level students.

6. Within the experimental and control groups, there was no significant difference in the mean gains of the ability levels in the physics content of physical science.

Conclusions

Analyses of the findings of this study on the effects of analogy-structured teaching on achievement in ninth-grade physical science led to the following conclusions:

1. As measured by standardized tests in print, achievement of students was not significantly improved when students were instructed with verbal analogy items as presented in this study.

2. There was an indication that over a one-year period of study in physical science, low-ability students, taught
with analogical methods, improved their achievement to a
greater degree than did the high-ability students taught
with analogical methods. However, these same results were
also noted for the control group.

3. There was an indication that in certain subject
areas of physical science, such as chemistry, high-ability
students gained more from analogical instruction than did
the middle- and low-ability students. However, these same
results were also noted for the control group.

Implications

The following implications were drawn from the findings
and conclusions of this study:

1. Skill in solving verbal analogy items may have
little to do with a student's ability to grasp a given con-
cept in physical science.

2. While high-ability students may be able to master
certain subject areas more readily because of intelligence
requirements, the notion that high-ability students (ana-
logical and conventional) will always do better is not
entirely supported.

3. The instructional methodology used in this study
may have yielded an improvement, such as retention, which
was not immediately measurable.

4. As measured by written tests, achievement may be
independent of inherent analogical ability or of efforts to
improve this ability.
5. As a formal teaching tool, analogies—and in particular verbal analogies—may be overrated.

Recommendations

1. A follow-up test should be administered on the students of this study to determine how well they retain information, when taught by analogies.

2. A test should be administered to determine if the subject's sex influences his ability to benefit from verbal analogical teaching methods.

3. A study should be made to determine if pictorial analogies are more effective in learning than verbal analogies.

4. Since verbal analogies apparently do not inhibit learning in physical science, this type of analogy could be used as another teaching activity, such as explanation or for end-of-chapter questions.
APPENDIX A

ANALOGY ITEMS
9th GRADE PHYSICAL SCIENCE (INTRODUCTORY CHEMISTRY)
UNIT 1. INTRODUCTION TO PHYSICAL SCIENCE, EXPERIMENTATION
AND TOOLS OF THE SCIENTIST

1. WITCHCRAFT : SUPERSTITION :: SCIENCE : (a) fiction
   (b) space (c) idea (d) knowledge

2. DETECTIVE : CLUES :: SCIENTIST : (a) criminals
   (b) equipment (c) facts (d) computer

3. PHYSICAL SCIENCE : CHEMISTRY :: LIFE SCIENCE :
   (a) meteorology (b) geology (c) biology (d) physics

4. BIOLOGY : BOTANY :: CHEMISTRY : (a) zoology
   (b) astronomy (c) biochemistry (d) microbiology

5. BOTANIST : PLANTS :: CHEMIST : (a) fire (b) water
   (c) substances (d) explosions

6. CASE : EVIDENCE :: EXPERIMENT : (a) instruments
   (b) dissolve (c) idea (d) observations

7. TRIAL : VERDICT :: EXPERIMENT : (a) method (b) question
   (c) conclusion (d) information

8. DIRECTION : GUIDANCE :: PROCEDURE : (a) guess (b) study
   (c) imagination (d) method

9. MATTER : MOLECULES :: MOLECULES : (a) electrons
   (b) protons (c) energy (d) atoms

10. WORK : TOOLS :: EXPERIMENT : (a) saw (b) build
    (c) apparatus (d) plans

11. PLIERS : TONGS :: CONTAINER : (a) beaker (b) measuring
    (c) holding (d) water

12. METER STICK : LENGTH :: BALANCE : (a) poise (b) mass
    (c) analysis (d) scale

13. TIME : CLOCK :: TEMPERATURE : (a) hot (b) mercury
    (c) sweat (d) thermometer
14. METER STICK : GRADUATED CYLINDER :: LENGTH : (a) car (b) volume (c) height (d) student

15. SCIENCE : CHEMISTRY :: SCIENTIST : (a) chemist (b) experimentist (c) alchemist (d) A-bomb

16. SPHERE : CIRCLE :: CUBE : (a) oval (b) ice (c) point (d) square

17. QUESTION : ANSWER :: PROBLEM : (a) observation (b) conclusion (c) experiment (d) work

18. CLAMP : TEST TUBE :: TONGS : (a) meter stick (b) beaker (c) Bunsen burner (d) balance

19. (At earth's surface) VOLUME : CAPACITY :: WEIGHT : (a) balance (b) chemicals (c) mass (d) heavy

20. WATER : BEAKER :: WATER : (a) balance (b) ice (c) flask (d) liquid

21. HYPOTHESIS : PROBLEM :: (a) question : solution (b) conclusion : procedure (c) prediction : weather (d) answer : knowledge

22. PROBLEM : APPARATUS :: OBSERVATIONS : (a) knowledge (b) conclusion (c) science (d) facts

23. STOPPER : FLASK :: COVER GLASS : (a) test tube (b) wide mouth bottle (c) burette clamp (d) gauze pad

24. MATH : NUMBERS AND SHAPES :: CHEMISTRY : (a) composition of matter (b) gold, silver and metals (c) mixing and heating materials (d) atomic and hydrogen bombs

25. INDUCTIVE : DEDUCTIVE :: (a) inside : outside (b) particular to general : general to particular (c) matter to molecules : atoms to elements (d) science to facts : fact to fiction
9th GRADE PHYSICAL SCIENCE (INTRODUCTORY CHEMISTRY)
UNIT 2. MEASUREMENT

1. TEST : ANSWER KEY : MEASUREMENT : (a) comparison to standard (b) ruler (c) length to width (d) short or long

2. ENGLISH SYSTEM : BODILY DIMENSIONS : METRIC SYSTEM :
   (a) height to weight (b) liquid volume (c) ounces (d) multiples of ten

3. LENGTH : MASS :: VOLUME : (a) water (b) time (c) height (d) pint

4. GRAM : MASS :: LITER : (a) volume (b) weight (c) length (d) pounds

5. LENGTH : DISTANCE :: (a) balance (b) mass (c) volume (d) weight : CAPACITY

6. WEIGHT : GRAM :: LENGTH : (a) meter (b) space (c) value (d) volume

7. MILLI : CENTI :: CENTI : (a) dcmi (b) semi (c) hemi (d) deci

8. KILOMETER : MILE :: METER : (a) ounce (b) half mile (c) yard (d) 1/16th inch

9. VOLUME OF SOLID : CC :: VOLUME OF LIQUID : (a) ml (b) gms/cc (c) gm (d) inches

10. CENTIMETER : METER :: (a) meter : yard (b) volume : gram (c) kilometer : mile (d) 1/100th : 1

11. YD : YARD :: CO : (a) cubed cubit (b) centi-centimeter (c) circular centimeter (d) cubic centimeter

12. ONE FOOT : 12 INCHES :: ONE METLR : (a) 100 cm (b) 1 cm (c) 2 cm (d) 1/2 cm

13. QUART : LITER :: PINT : (a) cc (b) 500 ml (c) gallon (d) half pint
14. MM : METER : (a) l : 1000 (b) l : 100 (c) l : 10 (d) l : 1

15. KILOGRAM : GRAM : KILO : (a) volume (b) mass (c) one (d) weight

16. 62.5 POUNDS/CUBIC FOOT : WATER : 1 GM/CC : (a) sq ft (b) lead (c) gallon (d) water

17. CUBE : VOLUME : SQUARE : (a) circle (b) round (c) length (d) area

18. 1 : 0,1 : METER : (a) mm (b) dm (c) cm (d) km

19. RUSSIA : GERMANY : ENGLAND : (a) United States (b) Canada (c) Australia (d) France

20. DIME : 1 MM : TENNIS BALL : (a) 7 km (b) 7 cm (c) 7 mm (d) 7 m

21. 1 LITER : 1 ML : 1000 CC : (a) 1 cc (b) 10 cc (c) 10 ml (d) 100 cc

22. 2.2 POUNDS : 1 KG : 16 OUNCES : (a) 1 gm (b) 100 gm (c) 454 gm (d) 1000 gm

23. 212 DEG. F. : 100 DEG. C. : 32 DEG. F. : (a) 10 deg. C. (b) 4 deg. C. (c) 0 deg. C. (d) 69 deg. C.

24. CG : ML : 1000 CC : (a) 1 liter (b) 0.5 liter (c) 1 pint (d) 2 liters

25. 20 CC WATER : GRADUATED CYLINDER : 20 MG CARBON : (a) beaker (b) flask (c) meter (d) balance
9th Grade Physical Science (Introductory Chemistry)

Unit 3. Measurement (continued)

1. 1000 mm : 1 m :: 1000 mg : (a) 1 mg (b) 1 kg (c) 1 gm (d) 1 cg
2. 1000 mm : 100 cm :: (a) 1000 mm : 1 km (b) 10 dm : 1 m (c) 1 km : 1 dm (d) 1000 m : 100 cm
3. 1000 gm : 1 kg :: (a) 100 cm (b) 1000 mm (c) 10,000 dm (d) 100,000 m : 1 km
4. SQUARE INCHES : AREA :: (a) area squared (b) L x H (c) cubic feet (d) square gallons : VOLUME
5. INCHES : MILLIMETERS :: (a) gallons : cubic centimeters (b) feet : liters (c) pints : kilograms (d) ounces : meters
6. 1 POUND : 16 OUNCES :: (a) 1 gm (b) 1 kg (c) 1 mg (d) 1 decigram : 1000 GRAMS
7. AREA : CM² :: VOLUME :: (a) cm³ (b) cm³ (c) cubic liters (d) millimeters
8. INCH : FOOT :: (a) cm : weight (b) kg : km (c) pint : gallon (d) cc : quart
9. 39.33 INCHES : 1 METER :: (a) 1 inch : 2.54 cm (b) 12.75 inches : 1 mm (c) 99.99 inches : 1 km (d) 78.66 inches : 1 dm
10. 1/8TH INCH : 1 INCH :: 1 MM : (a) 1 cm (b) 1 dm (c) 1 m (d) 1 km
11. 1 MM : 1/1000 M :: 1 M : (a) 1/1000 mm (b) 1/1000 cm (c) 1/10 cm (d) 1/1000 km
12. 55.0 M : 550 DM :: 5500 CM : (a) 5.55 km (b) 55,000 mm (c) 0.55 dm (d) 0.055 mm
13. M : DM :: (a) km (b) m (c) dm (d) cm : MM
14. 1 QUART : 2 PINTS : 1 LITER : (a) 1 ml flask
   (b) two 500 ml flasks (c) five 100 cc. beakers
   (d) 100 cc graduated cylinder

15. KILO : MILLI :: (a) centi : mm (b) 1000 : 1/1000
   (c) deci : 10 (d) cc : ml

16. 3 METERS : 10 FEET :: 400 METERS : (a) 440 yards
   (b) half mile (c) 100 yards (d) 1 mile

17. VOLUME : MILLILITERS :: (a) length (b) weight
   (c) volume (d) mass : CUBIC CENTIMETERS

18. L x W x H : L x W :: VOLUME : (a) measurement
   (b) weight (c) area (d) density

19. \( D = \frac{M}{V} \) :: DENSITY :: M : (a) measurement
   (b) meters (c) mass (d) median

20. BEAM BALANCE : WEIGHT :: GRADUATED CYLINDER :
   (a) mass (b) volume (c) weight (d) length

21. 1 METER : 1 YARD :: 1 KILOMETER : (a) 5/8 mile
   (b) 1000 feet (c) 100 yards (d) 10 miles

22. 2.54 CM : 1 INCH :: 1 METER : (a) 39.33 inches
   (b) 1 foot (c) 10 yards (d) 1000 inches

23. 1 POUND : 454 GRAMS :: 2.2 POUNDS : (a) 1 kg
   (b) 1 mg (c) 10 gm (d) 1000 cc

24. 1/2 LB : 8 OZ :: 1/2 KG : (a) 1 gm (b) 10 gm
   (c) 100 gm (d) 500 gm

25. 1 CC : 1 GM :: 1 LITER : (a) 1 mg (b) 1 gm
   (c) 1 kg (d) 1 ml
1. PHYSICAL CHANGE :: SHAPE :: CHEMICAL CHANGE ::
   (a) length (b) composition (c) state (d) position

2. FILE :: METAL :: FIRE POLISH ::
   (a) wood (b) glass (c) lead (d) heat

3. BRICK :: BUILDING :: ATOM ::
   (a) element (b) solution (c) life (d) compound

4. SOLID :: LIQUID :: GAS ::
   (a) plasma (b) ice (c) heat (d) molecule

5. SOLID :: DEFINITE SHAPE AND VOLUME ::
   (a) crystal (b) liquid (c) ice (d) gas :: INDEFINITE SHAPE AND
   VOLUME

6. AIR :: MIXTURE :: OXYGEN ::
   (a) gas (b) molecule (c) element (d) compound

7. LIQUID :: CONTAINER :: GAS ::
   (a) lighter than air (b) container (c) pressure (d) heat

8. WATER :: ALCOHOL :: HYDROGEN ::
   (a) carbon dioxide (b) fire (c) bomb (d) weld

9. RUSTING IRON :: BURNING WOOD :: SAWING WOOD ::
   (a) cutting paper (b) burning gas (c) lighting match (d) rotting wood

10. COMPOUNDS :: MOLECULES ::
    (a) protons (b) gasoline (c) elements (d) electrons :: ATOMS

11. SOLID :: LEAD :: LIQUID ::
    (a) mercury (b) oxygen (c) silver (d) compound

12. COKE :: BITUMINOUS COAL ::
    (a) black (b) carbon (c) graphite (d) charcoal :: WOOD

13. OXYGEN :: FIRE ::
    (a) heat (b) gas (c) burn (d) oxygen :: LIFE
14. SEDIMENTATION : SUSPENDED SOLIDS :: FILTRATION :
(a) dissolved gases (b) dissolved solids
(c) micro-organisms (d) suspended solids

15. KINETIC ENERGY : POTENTIAL ENERGY :: (a) moving car :
airplane flying (b) falling water : water behind dam
(c) boy running : boy walking (d) fuel : battery

16. RESPIRATION : PHOTOSYNTHESIS :: CARBON DIOXIDE :
(a) water (b) starch (c) sunlight (d) oxygen

17. IRON : RIGID :: (a) chemical : firm (b) ball : circular
(c) rubber : flexible (d) beaker : flask

18. ICE : WATER :: WATER : (a) oxygen (b) liquid
(c) freeze (d) steam

19. STEAM : WATER :: OXYGEN : (a) acid (b) H₂O (c) solid
(d) liquid oxygen

20. SODIUM : SALT :: OXYGEN : (a) acetylene (b) ammonium
(c) water (d) hydrogen

21. GLASS : FRRITTENESS :: (a) melt : flow (b) iron : steel
(c) rubber : elasticity (d) solid : non-breakable

22. ICE : IRON :: WATER : (a) mercury (b) steam (c) copper
(d) chemistry

23. OXYGEN : GASEOUS :: (a) iron : heavy (b) sand : grainy
(c) heavy : light (d) mercury : fluid

24. ACID : ZINC :: LYE : (a) iron (b) living tissue
(c) fluid (d) water

25. ATOM : MOLECULE :: GRAM : (a) liter (b) volume
(c) metric (d) kilogram
UNIT 5. MATTER AND ENERGY (continued)

1. WATER : LIQUID :: AIR : (a) airplane (b) element (c) gas (d) space
2. BOILING : CONDENSATION :: MELTING : (a) water (b) heat (c) solid (d) freezing
3. DEFINITE VOLUME : GASOLINE :: INDEFINITE VOLUME : (a) hydrogen (b) water (c) iron (d) mercury
4. MASS : WEIGHT : (a) gm : lb (b) amount of matter : amount of volume (c) gravity : weightlessness (d) constant : distance from center of earth
5. SOLID : ICE : (a) change of state : matter (b) water : freezing (c) definite volume : indefinite shape (d) gas : steam
6. HYDROGEN, OXYGEN : WATER :: NITROGEN, OXYGEN : (a) air (b) gas (c) volume (d) element
7. ELEMENT : MIXTURE :: OXYGEN : (a) gas (b) salt (c) pure state (d) air
8. METALLIC LUSTER : MALLEABLE :: (a) inert gas (b) poor conductor (c) slightly brittle (d) usually solid : GOOD CONDUCTOR
9. ALUMINUM : COPPER :: (a) carbon (b) iodine (c) iron (d) oxygen : GOLD
10. HYDROGEN, OXYGEN : SODIUM, CHLORIDE :: (a) solids : gases (b) chemicals : compounds (c) water : salt (d) mixtures : compounds
11. METALS : NON-METALS :: (a) malleable : brittle (b) soft : hard (c) silver : shiny (d) melt : non-melt
12. ELEMENT : COMPOUND :: (a) gold : silver (b) one kind of atom : different kinds of atoms (c) semi-conductor : good conductor (d) ease of separation : pure properties
13. AIR :: SEA WATER :: SOIL ; (a) element (b) milk 
   (c) acid (d) molecule

14. MELTING :: FUSION :: BOILING ; (a) steam (b) heating 
   (c) vaporization (d) gaseous

15. GAS TO LIQUID :: LIQUEFACTION :: LIQUID TO SOLID ; 
   (a) solidification (b) condensation (c) liquid to 
   gas (d) aeration

16. PHYSICAL PROPERTY :: CHEMICAL PROPERTY ; (a) odor : 
   color (b) color : white (c) state : combustibility 
   (d) solid : gas

17. CHEMICAL MEANS :: COMPOUNDS :: PHYSICAL MEANS ; 
   (a) atoms (b) molecules (c) elements (d) mixtures

18. COLORLESS, ODORLESS :: OXYGEN ; (a) heavier than air ; 
   pale blue (b) colorless ; odorless (c) non-metal ; 
   solid (d) non-combustibility ; water : HYDROGEN

19. MONATOMIC :: DIATOMIC ; (a) one ; two (b) metals ; 
   non-metals (c) molecular ; non-molecular (d) many ; 
   multiple

20. VARYING PROPORTIONS :: FIXED PROPORTIONS ; (a) water ; 
   liquid (b) molecules : elements (c) mixtures ; compounds 
   (d) atoms : molecules

21. MASS :: VOLUME ; (a) color (b) impenetrability 
   (c) solubility (d) malleability ; INERTIA

22. METALS, NON-METALS :: ELEMENTS :: ELEMENTS, COMPOUNDS ; 
   (a) matter (b) molecules (c) solids (d) states of matter

23. D = M/V ; M = DV :: D = M/V ; (a) V = D/M (b) M = D/V 
   (c) V = DM (d) V = M/D

24. 1 CG OF WATER : 1 GM :: 33 CG OF WATER ; (a) 1/33 pt 
   (b) 33 gm (c) 3.3 oz (d) 0.33 cm

25. ELEMENTS :: COMPOUNDS :: ATOMS ; (a) molecules 
   (b) mixtures (c) liquids (d) solutions
1. **MECHANICAL : HEAT : SOUND ;**
   (a) electrical
   (b) noise
   (c) molecular
   (d) motion

2. **KINETIC : POTENTIAL ;**
   (a) car
   (b) airplane
   (c) atom
   (d) molecule
   (e) motion
   (f) position
   (g) chemical
   (h) light

3. **SUN : NUCLEAR ENERGY ;**
   **ELECTROMAGNETIC WAVES ;**
   (a) sound
   (b) light
   (c) bomb
   (d) chemical

4. **MECHANICAL : SOUND ;**
   (a) power of machines
   (b) radio waves
   (c) tools
   (d) noise
   (e) movement of mass
   (f) molecular vibrations
   (g) elements
   (h) molecules

5. **SOLUTE : SOLVENT ;**
   (a) liquid solution
   (b) solid mixture
   (c) dissolved substance
   (d) dissolving substance
   (e) water
   (f) alcohol
   (g) chemicals
   (h) compounds

6. **DILUTE : CONCENTRATED ;**
   (a) semi-saturated
   (b) saturated
   (c) solution
   (d) solvent
   (e) supersaturated

7. **EVAPORATION : DISTILLATION ;**
   **FILTRATION ;**
   (a) solution
   (b) sedimentation
   (c) liquefaction
   (d) separation

8. **SOLVENT : WATER ;**
   **SOLUTE ;**
   (a) solution
   (b) sugar
   (c) solid
   (d) dissolve

9. **100 DEG. C. : GAS ;**
    **0 DEG. C. ;**
    (a) cold
    (b) 32 deg. F.
    (c) solid
    (d) heat

10. **DEFINITE SHAPE, DEFINITE VOLUME ;**
    **INDEFINITE SHAPE, INDEFINITE VOLUME ;**
    (a) solid
    (b) gas
    (c) liquid
    (d) matter
    (e) mass

11. **SOUND : MOLECULAR VIBRATIONS ;**
    **ELECTRICITY ;**
    (a) volts
    (b) shock
    (c) electron movement
    (d) thunder

12. **SPACE, WEIGHT ;**
    **MATTER ;**
    **SHAPE, VOLUME ;**
    (a) size
    (b) state
    (c) mass
    (d) gravity
13. TEMPERATURE OF MATTER: AVERAGE MOLECULAR SPEED ::
STATE OF MATTER: (a) element (b) molecule
(c) solution (d) temperature

14. MOLECULES-SLOWEST MOTION: MOLECULES-FASTEST MOTION ::
(a) oxygen: water (b) solid: liquid (c) solid: gas
(d) solution: solvent

15. UNEXPLODED ATOMIC BOMB: EXPLODING ATOMIC BOMB ::
(a) potential: kinetic (b) temperature: heat
(c) atoms: elements (d) small energy: great energy

16. (Solubility) NATURE OF SOLUTE: NATURE OF SOLVENT ::
TEMPERATURE: (a) color (b) container (c) area (d) atoms

17. CUTTING WOOD: BREAKING GLASS: DISSOLVING SALT ::
(a) melting ice (b) digesting food (c) burning fuel
(d) rusting iron

18. COFFEE: TEA: SEA WATER: (a) milk (b) wine (c) sugar
(d) distilled water

19. GASOLINE: TURPENTINE: ALCOHOL: (a) salt (b) carbon
(c) helium (d) water

20. GRAINS OF SAND: SUSPENSIONS: (a) solvents: solutes
(b) colloids: colloidal suspensions (c) molecules: compounds
(d) mixtures: matter

21. ATOM: MOLECULE: (a) proton: electron (b) mass: matter
(c) element: compound (d) mixture: solution

22. COMPOUND: MIXTURE: (a) element: compound (b) atom:
electron (c) combined: uncombined (d) solvent: solute

23. LIQUID TO GAS: VAPORIZATION: SOLID TO GAS: (a) fusion
(b) sublimation (c) recondensation (d) distillation

24. MOLECULES CLOSEST TOGETHER: MOLECULES FARthest APART ::
(a) oxygen: water (b) solid: liquid (c) solid: gas
(d) solution: solvent

25. SEDIMENTATION, FILTRATION: SUSPENSIONS: AERATION,
CHLORINATION: (a) bacteria (b) solutions (c) H₂O
(d) suspensions
1. GREEK ATOM : DALTON ATOM :: BOHR ATOM (a) nuclear atom (b) Franklin atom (c) quantum atom (d) Edison atom

2. WATER : HYDROGEN AND OXYGEN ATOMS :: ATOM : (a) atomic (b) and hydrogen bombs (b) electrons, protons and neutrons (c) solids, liquids and gases (d) compounds

3. ELECTRONS : PROTONS :: (a) spinning : revolving (b) negative : positive (c) charged : uncharged (d) electricity : conductor

4. EARTH : SUN : (a) proton (b) electron (c) neutron (d) atom : NUCLEUS

5. PATH : ORBIT :: SHELL : (a) energy level (b) circular (c) direction (d) speed

6. + : - :: ELECTRON : (a) neutron (b) zero (c) proton (d) charge

7. POSITIVE : NEGATIVE :: (a) neutron : nucleus (b) orbit : shell (c) + : - (d) atom : molecule

8. PROTON : POSITIVE :: NEUTRON : (a) proton (b) positive (c) negative (d) neutral

9. PROTON : NUCLEUS :: ELECTRON : (a) neutral (b) neutron (c) shell (d) atom

10. PROTON : NUCLEUS : (a) neutron : nucleus (b) neutron : electron (c) atoms : elements (d) orbits : orbitals

11. ORBIT : SHELL :: ORBITAL : (a) nucleus (b) sub-shell (c) pairs (d) electron

12. PROTON : ELECTRON :: (a) 1 : 2 (b) 8 : 2 (c) 18 : 32 (d) 1800 : 1

13. K : FIRST :: P : (a) last (b) tenth (c) middle (d) sixth
14. PROTON : ATOMIC NUMBER :: ELECTRON : (a) neutron
   (b) number of atoms (c) nucleus (d) atomic number

15. ELEMENT : NUMBER OF ELECTRONS :: ISOTOPE OF THE
    ELEMENT : (a) different number of electrons
    (b) different number of protons (c) different
    number of neutrons (d) different atomic number

16. ATOMIC NUMBER OF AN ATOM : NUMBER OF PROTONS ::
    MASS NUMBER OF ATOM : (a) sum of protons and neutrons
    (b) difference between number of protons and neutrons
    (c) sum of protons and electrons (d) neutrons in nucleus

17. PROTON : 1 AMU :: ELECTRON : (a) 0 amu (b) 1 amu
   (c) 2 amu (d) 7 amu

18. PROTON : 1 AMU :: NEUTRON : (a) 0 amu (b) 1 amu
   (c) 2 amu (d) 4 amu

19. (For H) AN-1 :: NUMBER OF PROTONS :: AW-1 : (a) number
    of neutrons-1 (b) number of neutrons-0 (c) number
    of electrons-2 (d) number of electrons-0

20. H-1 : He-4 :: 1,0 : (a) 1,1 (b) 2,2 (c) 3,1 (d) 4,0

21. H : 1 :: C : (a) 2 (b) 4 (c) 12 (d) 20

22. \( _1^1 e^0 \) : ELECTRON :: \( _1^1 H \) : (a) hydrogen (b) proton
    (c) neutron (d) nucleus

23. NUCLEUS : MOST DENSE PART OF ATOM :: (a) proton
    (c) neutron (c) shell (d) atomic number : LEAST
    DENSE PART OF ATOM

24. SUB-LEVELS : SUB-SHELLS :: ORBITALS : (a) shell
    (b) s,p,d,f : (c) atomic numbers (d) K,L,M,N

25. \( _1^1 e^0 \) : ELECTRON :: \( _6^7 n \) : (a) neutron (b) nitrogen
    (c) nucleus (d) proton
1. S : P : : D : (a) s (b) e (c) f (d) x

2. K : 2 ELECTRONS : : L : (a) 1 proton (b) 3 electrons (c) 6 electrons (d) 12 neutrons

3. (H-1, O-16) O_2 : H_2O : : 32 : (a) 18 (b) 10 (c) 3 (d) 2

4. (H-1, O-16) (For H_2O) H : O : : 1 : (a) 1 (b) 2 (c) 8 (d) 32

5. (H-1, O-16) H_2O : H_2O_2 : : 1 : (a) 2 (b) 4 (c) 8 (d) 16

6. ALLOTROPE : ISOTOPE : : DIAMOND : (a) carbon-14 (b) graphite (c) bone black (d) charcoal

7. FIRST ENERGY LEVEL : 2 ELECTRONS : : LAST ENERGY LEVEL : (a) 0 protons (b) 1 neutron (c) 7 shells (d) 8 electrons

8. 2 : DEUTERIUM : : 3 : (a) tritium (b) neuterium (c) sodium (d) helium

9. He : NOBLE GAS : : MERCURY : (a) shiny compound (b) mercurial thermometer (c) liquid metal (d) silvery mixture

10. (C-12, O-16) CO : 28 : : CO_2 : (a) 3 (b) 32 (c) 44 (d) 56

11. SUM OF AMU OF ATOMS IN MOLECULE : RELATIVE WEIGHT OF ATOMS : : (a) grams : ounces (b) molecular weight : atomic weight (c) atomic number : number of electrons (d) protons : neutrons

12. K : N : : 9 : (a) v (b) f (c) a (d) x

13. (2H_2O) MOLECULES : ATOMS : : (a) 2 : 1 (b) 2 : 2 (c) 2 : 6 (d) 1 : 1
14. $S : 1 :: P : (a) 2 (b) 3 (c) 8 (d) 18$

15. THIRD ENERGY LEVEL : 18 :: 3 SUB-LEVEL : (a) 1 (b) 2 (c) 3 (d) 18

16. MAIN ENERGY LEVEL : PRINCIPAL QUANTUM NUMBER :: SUB-LEVEL : (a) one (b) K shell (c) orbital (d) higher energy

17. H₂O : O :: (a) molecule : atom (b) liquid : oxygen (c) water : gas (d) compound : molecule

18. (ATOMIC WEIGHT — ATOMIC NUMBER) : NEUTRONS :: (NEUTRONS + PROTONS) : (a) atomic number (b) atomic weight (c) molecular weight (d) nucleus protons

19. $(n^2)$ SECOND ENERGY LEVEL : THIRD ENERGY LEVEL :: (a) 2 : 3 (b) 4 : 6 (c) 4 : 9 (d) 5 : 15

20. $L, S : 3, P :: 5, D : (a) 2, a (b) 4, k (c) 6, x (d) 7, f

21. AMU : RELATIVE WEIGHT :: AK : (a) protons (b) atoms (c) neutrons (d) nucleus

22. H : DEUTERIUM :: H : (a) heavy water (b) element (c) molecule (d) tritium

23. NEUTRON : NO CHARGE :: (a) nucleus (b) proton (c) atom (d) electron : NO CHARGE

24. SHORTAGE OF ELECTRONS : SURPLUS OF ELECTRONS :: (a) no charge : electricity (b) positive : negative (c) neutron : electron (d) energy : low energy

25. LIKES : UNLIKES :: (a) positive : neutral (b) repel : attract (c) electron : proton (d) atom : molecule
9th GRADE PHYSICAL SCIENCE (INTRODUCTORY CHEMISTRY)
UNIT 9. PERIODIC CHART, CHEMICAL BONDING
(Students should refer to periodic chart)

1. MENDELEEV : ATOMIC WEIGHT : MODERN PERIODIC TABLE :
   (a) atomic number (b) number of neutrons (c) solids
   and gases (d) atomic particles

2. PERIOD : GROUP :: (a) atoms : molecules (b) elements :
   compounds (c) metals : non-metals (d) rows : columns

3. PERIODIC CHART : GROUPS :: (a) elements : similar
   elements (b) groups : periods (c) isotopes : ions
   (d) metals : non-metals

4. METALS : NON-METALS :: (a) period : group (b) left :
   right (c) heavy : light (d) alloys : compounds

5. ATOMIC NUMBER : PROTONS :: PERIOD : (a) electrons
   (b) shells (c) isotopes (d) ions

6. ELEMENTS WITH ATOMIC NUMBER 92 AND BELOW : ELEMENTS
   BEYOND ATOMIC NUMBER 92 :: (a) liquids : gases
   (b) metals : non-metals (c) natural : man-made
   (d) isotopes : atoms

7. MAJOR GROUP : TRANSITION GROUP :: (a) heaviest :
   lightest (b) largest : smallest (c) solids : liquids
   (d) A : B

8. NUMBER OF ELECTRONS IN OUTER SHELL : NUMBER OF SHELLS :
   (a) lending : borrowing (b) Roman numerals : quantum
   number (c) covalence : electrovalence (d) metals : non-metals

9. He : Ne :: Ar : (a) H (b) Be (c) O (d) Kr

10. PERIODS : 7 :: MAIN GROUPS : (a) 2 (b) 8 (c) 10 (d) 18

11. NOBLE GASES : ALKALI METALS :: (a) groups : columns
    (b) horizontal : vertical (c) right : left (d) liquids :
    solids

12. ALKALI METALS : AKALINE EARTH METALS :: (a) shiny metals
    (b) heavy liquids (c) fuels (d) halogens : INERT GASES
13. IA, IIA, IIIA : VA, VIA, VIIA :: (a) active : inactive (b) metals : non-metals (c) covalence : electrovalence (d) solids : gases

14. MOST METALLIC : LEAST METALLIC :: (a) iron : copper (b) sodium chloride : sugar (c) cesium : fluorine (d) mercury : iodine

15. ELEMENTS : ISOTOPES : ATOMS : (a) molecules (b) ions (c) electrons (d) charges

16. ELECTRONS IN OUTER SHELL : GROUP NUMBER :: NUMBER OF SHELLS : (a) covalent (b) electrovalent (c) activity (d) period

17. OUTER SHELL INCOMPLETE : ACTIVE :: OUTER SHELL COMPLETE : (a) combining (b) inert (c) infused (d) metal

18. LEND : BORROW :: (a) positive valence : negative valence (b) liquids : solids (c) ion : isotope (d) salt : sugar

19. INERT ELEMENTS : GROUP IA ELEMENTS :: (a) gases : solids (b) covalent : electrovalent (c) plus valence : minus valence (d) heaviest : lightest

20. ACTIVE GASES : INACTIVE GASES :: (a) O : H (b) heavy : light (c) diatomic : monatomic (d) plus 2 : plus 1

21. N : H :: Hg : (a) Ne (b) Na (c) Br (d) K

22. ALL ELEMENTS GROUP IIA : 2 :: ALL ELEMENTS PERIOD 2 : (a) diatomic (b) 2 (c) 4 (d) bi-molecular

23. IA : +1 VALENCE :: IVA : (a) +4 valence (b) ±4 valence (c) 0 valence (d) -1 valence

24. ATOMS : ELEMENTS :: MOLECULES : (a) isotopes (b) ions (c) neutrons (d) compounds

25. COVALENCE : ELECTRON SHARING :: ELECTROVALENCE : (a) proton transfer (b) neutron sharing (c) proton sharing (d) electron transfer
1. MONOMER : POLYMER : (a) single molecule (b) ionic molecule (c) acidic molecule (d) metallic molecule; COMBINATION OF SIMPLE MOLECULES

2. GROUP IA : +1 ; GROUP 0 : (a) O (b) -1 (c) +2 (d) +4

3. LEND : BORROW : (a) active : inactive (b) metal : non-metal (c) iron : tin (d) ion : atom

4. COVALENCE : COVALENT COMPOUNDS ; ELECTROVALENCE : (a) shared compounds (b) molecular compounds (c) ionic compounds (d) simple compounds

5. IA : 1 ELECTRON : O : (a) 0 electrons (b) 1 electron (c) 4 protons (d) 8 electrons

6. PERIOD : PRINCIPAL QUANTUM NUMBER : VALENCE : (a) plus or minus (b) electrons (c) atomic number (d) oxidation state

7. LOSE : GAIN ; OXIDATION : (a) oxygen (b) burning (c) freeing (d) reduction

8. ELECTRONS TRANSFERRED : ELECTRONS SHARED : (a) atoms (b) metalloids (c) oxidation (d) ionic : COVALENT

9. B : 11 ; O : (a) 12 (b) 15 (c) 16 (d) 2

10. Na : Cl : (a) napalm : charcoal (b) sodium : chlorine (c) nitrate : chromalloy (d) naptha : ionic compound

11. Na : ATOM ; NaCl : (a) element (b) mixture (c) salt (d) ionic compound

12. NaCl : H₂O : (a) solution : mixture (b) metal : non-metal (c) ionic : electrovalent (d) ionic : covalent

13. ELECTROVALENCE : IONIC ; GROUP : (a) element (b) IA (c) family (d) transition
14. Na : Cl : (a) element : salt (b) solid : liquid (c) metal : non-metal (d) solute : solvent
15. Na : Cl : (a) plus : minus (b) 1 : 2 (c) compound : mixture (d) 0 valence : -2 valence
16. 7 ELECTRONS IN OUTER SHELL : -1 :: 3 ELECTRONS IN OUTER SHELL : (a) 0 (b) +2 (c) +3 (d) +8
17. ALL ELEMENTS GROUP IIA : 2 ELECTRONS :: ALL ELEMENTS IN PERIOD 2 : (a) diatomic (b) 2 shells (c) 4 protons (d) 8 neutrons
18. HIGH BONDING ENERGY : LOW BONDING ENERGY :: (a) stable : unstable (b) metals : non-metals (c) valence : electrons (d) compounds : mixtures
19. TIN + COPPER : ALLOY :: ELEMENT + OXYGEN : (a) burn (b) oxide (c) ionic (d) gas
20. NaCl : LiF :: H₂O : (a) CO₂ (b) CaO (c) MgNe (d) KI
21. NON-BONDING : TWO PLUS VALENCE ELEMENTS :: BONDING : (a) two minus valence elements (b) two inert elements (c) plus valence and minus valence elements (d) 0 and plus valence elements
22. METAL : NON-METAL :: (a) plus : minus (b) minus : minus (c) 0 : plus (d) plus : plus
23. NON-BONDING : Ne and H :: BONDING : (a) Ca and K (b) O and Ar (c) C and O (d) Li and Na
24. Li : 3 :: Na : (a) plus 1 (b) 2 (c) 23 (d) 11
25. Na - e → Na⁺ : Cl + e → Cl⁻ :: (a) molecules : compounds (b) oxidation : reduction (c) sodium : chlorine (d) electrons : protons
1. Naming elements) LATIN NAMES : PLANETS : PLACES : (a) chemicals (b) elements (c) groups (d) scientists

2. OXYGEN : GASEOUS : (a) solid : light (b) mercury : liquid (c) iron : heavy (d) sand : grainy

3. ICE : IRON : WATER : (a) mercury (b) elements (c) copper (d) chemical

4. OZONE : O : DIAMOND : (a) glass (b) jewel (c) ruby (d) carbon

5. O : COLORLESS, ODORLESS, TASTELESS : H : (a) heavier than air (b) inert (c) liquid (d) colorless, odorless, tasteless

6. H : C : (a) electrovalent : covalent (b) water : poison (c) gas : liquid (d) one bond : four bonds

7. VALENCE ELECTRONS : OUTER ENERGY LEVEL : BONDING ELECTRONS : (a) inner shell (b) outer energy level (c) sub-orbitals (d) nucleons

8. (NaCl) SODIUM ION : CHLORINE ION : (a) solid : salt (b) covalence : sharing (c) positive : negative (d) neutral : neutral

9. COVALENT MOLECULE : SHARING ELECTRONS : IONIC MOLECULE : (a) electrostatic forces (b) positive (c) ions (d) atoms

10. LITER : 1000 CC : GMW : (a) atomic weight (b) mole (c) molecular weight (d) volume

11. (H) ATOMIC NUMBER : 1 : AVOGADRO'S NUMBER : (a) 1 (b) 2 (c) 1000 (d) $6.02 \times 10^{23}$

12. N₂O : PLUS 1 : NO₂ : (a) plus 2 (b) minus 2 (c) zero (d) plus 4

13. (O₂) AW : 16 : MW : (a) 16 (b) 17 (c) 32 (d) 0
14. \( \text{OH, NO}_3^- : \text{MINUS 1 :: CO}_2, \text{SO}_4^2- : (a) \text{plus 1 (b) plus 2 (c) minus 2 (d) minus 3} \)

15. \( \text{O}_2 : 22.4 \text{ LITERS :: CO}_2 : (a) 23.6 \text{ liters (b) 22.4 liters (c) 250.88 \text{ liters (d) 44 liters}} \)

16. \( \text{(NH}_3^+ \text{) 6.02 x 10}^{23} \text{ MOLECULES :: 4 x 6.02 x 10}^{23} \text{ ATOMS :: 6.02 x 10}^{23} \text{ N ATOMS : (a) 3 H atoms (b) 6.02 x 10}^{23} \text{ H atoms (c) 3 x 6.02 x 10}^{23} \text{ H atoms (d) 18.06 H atoms}} \)

17. \( \text{(Zn + H}_2\text{SO}_4) \text{ H-\text{SO}_4^2- BOND :: BROKEN :: SO}_4^2- \text{ BOND : (a) breaks (b) remains intact (c) changes ions (d) broken by Zn}} \)

18. \( \text{Cl}_2 : \text{Cl}^+: \text{Cl}^- :: \text{H}_2 : (a) 2\text{H} (b) \text{H}^+\text{H}^-(c) \text{H}^+\text{H}^- (d) \text{H}^+\text{H}^-) \)

19. \( \text{H}_2\text{O} : \text{H}_2\text{O} :: \text{H}_2\text{C} : (a) 2\text{HC} (b) \text{H}_2\text{C} (c) \text{CH}_4 (d) \text{CH}_2 \)

20. \( \text{Na : SODIUM ATOM :: Na : (a) valence (b) sodium ion (c) sodium molecule (d) sodium positron}} \)

21. \( \text{NUCLEUS : BINDING ENERGY :: MOLECULE : (a) atomic energy (b) compound (c) chemical bond (d) electrovalence}} \)

22. \( \text{H}_2\text{O} : \text{WATER :: O:-C::O :: (a) carboxyl (b) carbogen (c) carboxide (d) carbon dioxide}} \)

23. \( \text{H}_2\text{H} : \text{HYDROGEN :: H::O :: (a) oxygen (b) hydrogen (c) helium (d) chlorine}} \)

24. \( \text{Na ATOM : 11 PROTONS AND 11 ELECTRONS :: Na ION : (a) 10 protons and 10 electrons (b) 10 protons and 11 electrons (c) 11 protons and 10 electrons (d) 11 protons and 11 electrons}} \)

25. \[
\begin{array}{c}
1s \\
\hline
\bullet - \\
1p \\
\hline
\end{array}
\]

\( : \text{H :: 2s} \)

\[
\begin{array}{c}
1s \\
\hline
\bullet - \\
2p \\
\hline
\end{array}
\]

\( : (a) \text{oxygen (b) helium (c) nitrogen (d) sodium} \)
9th GRADE PHYSICAL SCIENCE (INTRODUCTORY CHEMISTRY)
UNIT 12. ACIDS, BASES AND SALTS

1. ACIDS : BASES : SALTS : (a) atoms (b) solutions (c) solvents (d) oxides

2. INCOMPLETE OUTER ORBITS : COMPLETE OUTER ORBITS : (a) salts : acids (b) atoms : ions (c) molecules : compounds (d) acids : bases

3. ELECTROLYTES : ACIDS, BASES AND SALTS : NON-ELECTROLYTES : (a) sodium chloride, ocean water (b) distilled water, carbon compounds (c) weak acids (d) lye, sodium hydroxide

4. ACIDS, BASES, SALTS : INORGANIC : (a) carbon compounds (b) monomers (c) diatomic molecules (d) water, alcohol : ORGANIC

5. LESS STABLE : MORE STABLE : (a) atoms : ions (b) metals : compounds (c) solutions : mixtures (d) ionic : electrovalent

6. ATOMS : IONS : (a) electrons : protons (b) acids : bases (c) neutral : charged (d) molecules : atoms

7. SAME NUMBER PROTONS AND ELECTRONS : ATOMS : EXCESS OR DEFICIENCY OF ELECTRONS : (a) molecules (b) protons (c) compounds (d) ions

8. LOSE ELECTRONS : GAIN ELECTRONS : (a) ions : atoms (b) charged : uncharged (c) positive : negative (d) acids : bases

9. ELECTROLYTE : NON-ELECTROLYTE : (a) acid : base (b) solvent : solution (c) conductor : non-conductor (d) electrons : protons

10. ELECTROLYTE : NON-ELECTROLYTE : (a) strong : weak (b) ions : atoms (c) solvent : solution (d) complex molecules : simple molecules

11. ELECTROLYTE : ACID : NON-ELECTROLYTE : (a) base (b) salt (c) distilled water (d) salt solution
12. PROTON DONOR : PROTON ACCEPTOR :: (a) H₂O : O
(b) HCl : NaOH (c) weak : strong (d) atom : molecule

13. ACID : BASE :: (a) electrolyte : non-electrolyte
(b) liquid : solid (c) red : blue (d) alcohol : citric

14. ACID : H :: BASE : (a) HCl (b) Ca (c) OH (d) Ne

15. ACID : BLUE LITMUS :: BASE : (a) hydroxide paper
(b) colorless phenolphthalein (c) black litmus (d) lye

16. HYDRONIUM : HYDROXYL :: (a) atom : ion (b) H₃O⁺ ; OH⁻
(c) H : O (d) liquid : solution

17. NON-ELECTROLYTE : ELECTROLYTE :: HYDROGEN :: (a) salt
(b) oxygen (c) carbon (d) sugar

18. ACID : HYDRONIUM ION :: BASE :: (a) hydrogen ion
(b) hydrogen gas (c) sodium ion (d) hydroxide ion

19. HYDRONIUM : HYDROXYL :: (a) positive : negative
(b) salt : solution (c) OH : OL (d) liquid : gas

20. ELECTROLYTE : NaCl :: NON-ELECTROLYTE :: (a) NaOH
(b) HCl (c) CH₃OH (d) HNO₃

21. ACID : ACTIVE METAL :: HYDROGEN (a) salt (b) water
(c) hydroxide (d) gas

22. (H₂ + Cl₂) : ACID :: (H₂O + CO₂) (a) acid (b) base
(c) salt (d) hydrogen

23. OH : BITTER :: BLUE : (a) slippery (b) pH-1 (c) salt
(d) red

24. VINEGAR : LEMON :: SODA WATER :: (a) alcohol (b) water
(c) zinc oxide (d) aspirin

25. NaOH : CAUSTIC SODA :: SODIUM HYDROXIDE :: (a) base
(b) lye (c) hydroxyl (d) Na
9th GRADE PHYSICAL SCIENCE (INTRODUCTORY CHEMISTRY)
UNIT 13. ACIDS BASES AND SALTS (continued)

1. NaOH : HCl : NaCl : (a) MgO (b) ClO (c) He (d) NaH

2. SODIUM CHLORIDE : SODIUM CARBONATE : MAGNESIUM SULFATE : (a) hydrogen chloride (b) sodium hydroxide (c) copper sulfate (d) hydrogen oxide

3. LITMUS PAPER : pH PAPER : METHYL ORANGE : (a) vinegar (b) oxide (c) pH 7 (d) phenolphthalein

4. pH 2 : RED : pH 7 : (a) yellow (b) blue (c) red (d) white

5. pH 8 : BLUE : pH 13 : (a) red (b) blue (c) yellow (d) green

6. H₂CO₃ : HCl : HNO₃ : (a) H₂SO₄ (b) NaOH (c) NH₄OH (d) CuSO₄

7. HNO₃ : NITRIC : H₂SO₄ : (a) carbonic (b) tannic (c) acetic (d) sulfuric

8. OCEAN WATER : DISTILLED WATER : (a) electrolyte : non-electrolyte (b) fuel : oil (c) solution : suspension (d) compound : element

9. H₂SO₄ : ACTIVE METALS : NaOH : (a) living tissue (b) inert gases (c) salts (d) most solids

10. NaOH : KOH : Mg(OH)₂ : (a) HCl (b) NaCl (c) MgSO₄ (d) Ca(OH)₂

11. CARBONIC : COCA COLA : CITRIC : (a) hydrochloric (b) copper (c) vinegar (d) lemon

12. (Na + Cl) : SALT : (H + Cl) : (a) salt (b) chlorox (c) acid (d) chlorohydrogen
13. SOUR : RED ;; NEUTRALIZE BASE : (a) pH 10 (b) slippery (c) hydrogen ion freed (d) blue flame

14. VINEGAR : ACETIC ;; MURIATIC : (a) magnesium sulfate (b) sodium chloride (c) zinc oxide (d) hydrochloric

15. MILK OF MAGNESIA : VINEGAR ;; LYE : (a) citric (b) salt (c) NaOH (d) sodium chloride

16. NaCl : CuSO₄ :: MgSO₄ : (a) HCl (b) Ca(OH)₂ (c) N₂ (d) Na₂CO₃

17. SULFURIC ;; HYDROCHLORIC :: CITRIC : (a) lye (b) alcohol (c) ammonia water (d) lactic

18. MgSO₄ : EPSOM SALT :: NaCl : (a) sodium carbonate (b) sal ammoniac (c) baking soda (d) table salt

19. HYDROCHLORIC ACID : ZINC :: LYE : (a) living tissue (b) iron (c) salt (d) carbon compound

20. ACID : SOUR :: SODIUM HYDROXIDE : (a) sweet (b) lye (c) caustic (d) iodized

21. RED ;; BLUE : SOUR : (a) bitter (b) sweet (c) wet (d) slippery

22. SLIPPERY ;; SOAPY : CAUSTIC : (a) causing (b) acting (c) burning (d) indicator

23. HYDROCHLORIC ;; SODIUM CARBONATE : BORIC : (a) copper sulfate (b) distilled water (c) potassium hydroxide (d) sulfuric acid

24. pH 7 to pH 1 : ACIDITY INCREASE :: pH 7 to pH 14 : (a) base decrease (b) salinity increase (c) alkalinity increase (d) neutrality constant

25. H, NON-METAL : ACID RADICAL, METAL : (a) acid ; base (b) base ; salt (c) salt ; water (d) acid ; salt
9th GRADE PHYSICAL SCIENCE (INTRODUCTORY CHEMISTRY)
UNIT 14. CHEMICAL REACTIONS, FORMULAS AND EQUATIONS

1. **BESSEMER : STEEL :: BLAST FURNACE :** (a) alloy (b) zinc (c) iron (d) aluminum
2. **AMALGAM : MERCURY :: BRASS :** (a) silver (b) gold (c) copper (d) tin
3. **COKE : BITUMINOUS COAL ::** (a) graphite (b) boneblack (c) charcoal (d) pine : WOOD
4. **ALUMINUM : BAUXITE :: IRON :** (a) galena (b) metal (c) hematite (d) steel
5. **HYDROGEN : GAS ::** (a) beryllium (b) magnesium (c) radium (d) salt : COMPOUND
6. **COHESION : LIKE MOLECULES ::** (a) subhesion (b) adhesion (c) diffusion (d) porosity : UNLIKE MOLECULES
7. **GASOLINE : PETROLEUM :: METAL :** (a) liquid (b) mine (c) ore (d) bronze
8. **BRASS : COPPER :: PEWTER :** (a) lead (b) zinc (c) silver (d) bronze
9. **ACTIVE GAS : TWO ATOMS :: INACTIVE GAS :** (a) one atom (b) two atoms (c) two molecules (d) three molecules
10. **SLOW OXIDATION : RAPID OXIDATION :** (a) water : oxygen (b) rust : flame (c) oxide : oxate (d) element : compound
11. **ADHESION : WATER MOLECULES :: COHESION :** (a) neon atoms (b) mercury molecules (c) tape (d) liquid
12. **HEAT : MERCURIC OXIDE :: ELECTROLYSIS :** (a) electrons (b) electricity (c) water (d) elements
13. DESTRUCTIVE DISTILLATION : COAL :: FRACTIONAL DISTILLATION : (a) coke (b) water (c) steam (d) crude oil

14. PHENOLPHTHALEIN : BASE :: LIMEWATER : (a) water (b) alcohol (c) carbon dioxide (d) hydrogen

15. ICE : WATER :: DRY ICE : (a) liquid (b) cold (c) H₂O (d) carbon dioxide

16. STEEL : COMPOUND :: IRON : (a) hard (b) element (c) alloy (d) mixture

17. GASOLINE : PETROLEUM :: SUGAR : (a) oil (b) salt (c) plant (d) sweet

18. HYDROCARBON : C₆H₁₄ :: CARBOHYDRATE : (a) C₁₁H₂₂ (b) C₁₂H₂₂O₁₁ (c) C₂H₂ (d) NaCl

19. CO : CARBON MONOXIDE :: Co : (a) copper (b) cobalt (c) carbon oxide (d) chromate

20. MONATOMIC : DIATOMIC :: (a) neon : hydrogen (b) sodium : chlorine (c) oxygen : nitrogen (d) potassium : helium

21. OXYGEN : HYDROGEN :: NITROGEN : (a) chlorine (b) mercury (c) magnesium (d) silicon

22. SOUR MILK : LACTIC ACID :: RUST : (a) brown (b) paint (c) iron oxide (d) tin can

23. ACTIVE METAL : STRONG ACID :: SALT : (a) base (b) oxide (c) hydrogen (d) different metal

24. OXYGEN : HYDROGEN :: HELIUM : (a) sodium (b) acid (c) water (d) argon

25. ATOM : ELEMENT :: MOLECULE : (a) compound (b) mixture (c) isotope (d) liquid
1. SYMBOL : ATOM : FORMULA : (a) element (b) compound (c) solid, liquid, gas (d) equation

2. MONO- : ONE : TETRA- : (a) three (b) four (c) five (d) seven

3. SYMBOL : ATOM : FORMULA : (a) solution (b) liquid (c) group of symbols (d) equation

4. SEDIMENTATION : FILTRATION : SEDIMENT : (a) filter (b) residue (c) mud (d) filter paper

5. FORMULA : COMPOSITION : EQUATION : (a) molecules (b) solves (c) equals (d) chemical changes

6. LOWER VALENCE : HIGHER VALENCE : (a) metal : non-metal (b) atoms : compounds (c) plus : minus (d) -ous : -ic

7. PER- : MORE ATOMS : (a) bi- (b) min- (c) hypo- (d) ox- : LESS ATOMS

8. TWO ELEMENTS : -IDE : (a) oxides and bases react (b) merthiolate (c) compound and one base (d) three elements, one being O : -ATE

9. (Under heat) MERCURIC OXIDE : POTASSIUM CHLORATE : (a) O : O (b) potassium oxide : chloride (c) elements : compounds (d) formula : equation

10. LITMUS : ACID : GLOWING SPLINT : (a) compounds (b) oxygen (c) bases (d) salts

11. OXIDATION RATE : OXYGEN : CHEMICAL REACTION RATE : (a) neutralizer (b) gas (c) change (d) catalyst

12. H AND NON-METAL : ACID : (a) zinc oxide paste (b) oxygen and another element (c) solvent (c) oxidation : OXIDE
13. EXOTHERMIC : ENDOThERMIC: (a) heat given off: heat taken in (b) thermometer: temperature (c) hot: cold (d) fast burning: slow burning

14. POTASSIUM CHLORIDE : POTASSIUM AND CHLORINE: (a) potassium chloride and oxygen (b) potash plus chlorine (c) phosphate, chlorine and oxygen (d) salt

15. CARBON: DIAMOND: OXYGEN: (a) coal (b) fire (c) oxide (d) ozone

16. SYMBOL: FORMULA: (a) molecules: compounds (b) liquid: fluid (c) solute: solvent (d) name of element: name of compound

17. H₂O : H₂O₂: (a) hydrogen oxide: hydrogen peroxide (b) liquid: solid (c) ions: atoms (d) salt: base

18. FERRIC PLUS 3: FERROUS: (a) plus 1 (b) plus 2 (c) 0 (d) plus 5

19. CHLOROPHYLL: PHOTOSYNTHESIS: ENZYME: (a) digestion (b) color (c) plant (d) gum

20. METALS: NON-METALS: (a) -um, -ium: -ine, -gen (b) per-: hypo- (c) ions: atoms (d) smooth: rough

21. ATOM: SUBSCRIPT: RADICAL: (a) molecules (b) number (c) coefficient (d) subscript

22. SILICON: GLASS: (a) hydrogen: oxygen (b) water: ice (c) clear: transparent (d) iron: steel

23. COFFEE: CAFFEINE: TOBACCO: (a) cigarette (b) filter (c) cancer (d) nicotine

24. GRAPHITE: CARBON: (a) charcoal: coal (b) mercury: quicksilver (c) atoms: ions (d) anthracite: coal

25. RESPIRATION: CARBON DIOXIDE: PHOTOSYNTHESIS: (a) carbon dioxide (b) chlorophyll (c) oxygen (d) sunlight
UNIT 16. CHEMICAL REACTIONS, FORMULAS AND EQUATIONS

(continued)

1. SINGLE REPLACEMENT : DOUBLE REPLACEMENT :: (a) mono : bi (b) reacting : non-reacting (c) valence : covalence (d) analysis : synthesis

2. ANALYSIS : DECOMPOSE :: COMBINE : (a) single replacement (b) double replacement (c) synthesis (d) hydrogen

3. COEFFICIENTS : MOLECULES :: SUBSCRIPTS : (a) periodic chart (b) atoms (c) formulas (d) equations

4. \( 2H_2O \) 2 : WATER :: 2 : (a) H (b) O (c) 4 (d) solution

5. COMPOSE : SYNTHESIS :: (a) decompose (b) single replacement (c) double replacement (d) bonding : ANALYSIS

6. HgCl₂ : MERCURIC CHLORIDE :: HgCl₂ : (a) mercury and chlorine (b) hydrogen chlorine (c) mercuric chloride (d) hydrogen bichlorate

7. DISTILLATE : DISTILLATION :: (a) filter (b) filament (c) filtrate (d) fractional : FILTRATION

8. (For single replacement) LEFT SIDE : ELEMENT, COMPOUND :: RIGHT SIDE : (a) compound, compound (b) element, compound (c) element, element (d) atom, molecule

9. \( Fe + S \rightarrow FeS \) Fe, S : ELEMENTS :: FeS : (a) chemicals (b) elements (c) compound (d) equation

10. \( Fe + S \rightarrow FeS \) : (a) direction (b) moves (c) indicates (d) to yield

11. \( 2H_2 + O_2 \rightarrow 2H_2O \) 2 DIATOMIC MOLECULES H : 1 DIATOMIC MOLECULE O :: 4 ATOMS H : (a) 2 compounds (b) one subscript (c) one coefficient (d) 2 atoms O

12. \( Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2 \) ATOMS ON LEFT SIDE :: ATOMS ON RIGHT SIDE :: (a) elements : compounds (b) 8 : 8 (c) acids : bases (d) metal : acid
13. \[ 2H_2O \rightarrow 2H_2 + O_2 ; \quad 2H_2 + O_2 \rightarrow 2H_2O \] (a) single replacement; double replacement (b) water; gases (c) decomposition; synthesis (d) water; O and H

14. \( (NO_3)_2 \) OXYGEN: 6 ATOMS; NITROGEN: (a) 2 atoms (b) 1 atom (c) 4 atoms (d) 6 atoms

15. \( SO_2 \) SULFUR DIOXIDE; \( SO_3 \): (a) sulfur oxide (b) sulfurous oxide (c) sulfur trioxide (d) triple compound

16. (Double replacement) LEFT SIDE: TWO COMPOUNDS; RIGHT SIDE: (a) element and compound (b) element and element (c) two elements (d) two compounds

17. \( OH \); NO\(_3\); CO\(_3\): (a) H\(_2\)O (b) O\(_2\) (c) N\(_2\)H (d) SO\(_4\)

18. STEAM; WATER: O\(_2\); (a) H (b) ice (c) liquid (d) LOX

19. O\(_2\) ; O\(_3\); (a) 0; 0 (b) element; atom (c) gas; liquid (d) oxygen; ozone

20. HEAT; RATE OF REACTION; H\(_2\)O\(_2\): (a) rate of reaction (b) compound (c) equation (d) H\(_2\)SO\(_4\)

21. ZINC, ACID; HYDROGEN; VINEGAR, BAKING SODA: (a) carbon dioxide (b) acid (c) base (d) metal

22. \( \equiv \rightarrow \); (a) neutralization; reaction (b) solid; liquid (c) slow; fast (d) reversible; irreversible

23. GLOWING SPLINT; OXYGEN; IODINE; (a) wounds (b) alcohol (c) solvent (d) starch

24. \( 2Na + Cl_2 \rightarrow 2NaCl \); Zn + S \( \rightarrow \) 2ZnS: (a) balanced; unbalanced (b) single replacement; double replacement (c) salt; acid (d) base; hydroxide

25. \( 2Na + Cl_2 \rightarrow 2NaCl \); 2Hg + O\(_2\) \( \rightarrow \) 2HgO: (a) single replacement; single replacement (b) synthesis; synthesis (c) analysis; analysis (d) analysis; single replacement
1. CHEMICAL CHANGE : OUTER SHELL :: NUCLEAR CHANGE :
   (a) atomic  (b) nucleus  (c) energy  (d) hydrogen bomb

2. BÉCQUEREL  ::  CURIE  ::  RUTHERFORD  :
   (a) Edison  (b) Pasteur  (c) Franklin  (d) Fermi

3. Radium  ::  Uranium  ::  Thorium :
   (a) cadmium  (b) krypton  (c) potassium  (d) hydrogen

4. GEIGER COUNTER  ::  FILM  ::  ELECTROSCOPE :
   (a) flashlight  (b) laser  (c) cloud chamber  (d) radar

5. ALPHA  ::  BÉTA  ::  GAMMA :
   (a) gamma  (b) neutron  (c) positive  (d) nuclear  (e) radiation

6. BÉCQUEREL  ::  RADIOACTIVITY  ::  CURIE :
   (a) radium  (b) X-ray  (c) gamma ray  (d) Geiger counter

7. ALPHA  ::  BÉTA  ::  GAMMA :
   (a) nuclear  (b) radioactivity  (c) laser  (d) X-ray

8. \( E = mc^2 \)  M  ::  MASS  ::  C :
   (a) cyclotron mass  (b) velocity of light  (c) centimeters  (d) centrifugal

9. BÉTATRON  ::  CYCLOTRON  ::  SYNCHROTRON :
   (a) electron  (b) Van der Graaf generator  (c) accelerator

10. INSTABLE ATOM  ::  FISSION  ::  MASS DEFEET :
    (a) U-238  (b) energy change  (c) atomic  (d) stable atom

11. BÉTATRON  ::  ELECTRONS  ::  CYCLOTRON :
    (a) protons  (b) neutrons  (c) X-rays  (d) gamma rays

12. NUMBER OF RADIATIONS  ::  CURIE  ::  ENERGY OF RADIATIONS :
    (a) X-rays  (b) radioactivity  (c) Roentgen  (d) betas

13. RADIOISOTOPES  ::  RADIOACTIVE ELEMENTS  ::  PROTONS,
    NEUTRONS :
    (a) electrons  (b) radiation  (c) nucleons  (d) atoms
14. UNCONTROLLED CHAIN REACTION: A BOMB :: CONTROLLED CHAIN REACTION: (a) reactor (b) H bomb (c) physical change (d) fission

15. ALPHA: SHEET OF PAPER :: BETA: (a) moderator (b) Geiger counter (c) fast to slow (d) 1 mm Al

16. C-14: CARBON ISOTOPE :: $^{4}\text{He}$: (a) hydrogen energy (b) atomic weight (c) alpha particle (d) proton

17. $^{235}\text{U}$: URANIUM :: $^{0}\text{He}$: (a) neutron (b) Neptunium (c) neutralization (d) zero nucleus

18. (Half life is 8 days for initial 10 gram sample)
   8 DAYS: 5 GM :: 24 DAYS: (a) 4 gm (b) 2.5 gm (c) 1.25 gm (d) 0.67 gm

19. COOLING SYSTEM: CONTROL ROD :: MODERATOR: (a) reactor (b) accelerator (c) shield (d) critical mass

20. ALPHA: Hs :: BETA: (a) gamma (b) X-ray (c) electron (d) neutron

21. BORON: CONTROL ROD :: GRAPHITE: (a) fission (b) reactor (c) moderator (d) shield

22. CATALYST: MODERATOR: (a) accelerate; faster (b) speed up; slow down (c) greater; smaller (d) neutral; negative

23. MLV: BEV :: (a) mass energy velocity; basic energy velocity (b) mevatron; bevatron (c) million electron volts; billion electron volts (d) mass escape velocity; beta escape velocity

24. NUCLEAR: HEAT: (a) reactor; light (b) chemical; bomb (c) electrical; light (d) sound; physical

25. POTASSIUM-40: CARBON-14: (a) inorganic; organic (b) radiation; radioactive (c) plant; animal (d) age of earth; age of fossils
1. URANIUM : FISSION ; HYDROGEN ; (a) radiation (b) fission (c) fusion (d) bomb

2. FISSION : FUSION ; (a) U isotope ; H isotope (b) Co ; Cu (c) X-ray ; radium (d) alpha ; beta

3. H BOMB : FUSION ; SUN ; (a) fission (b) light (c) heat (d) fusion

4. (Half life-2 days, 16 gm sample) 8 GM ; 1 GN :: 2 DAYS ; (a) 4 days (b) 6 days (c) 8 days (d) 10 days

5. _0^n_ ; NEUTRAL ; _-1^e_ ; (a) neutral (b) negative (c) energy (d) zero

6. (For mass number) _0^n_ ; _-1^e_ ; (a) 0 ; -1 (b) 1 ; 0 (c) 0 ; 0 (d) 1 ; 1

7. DIFFERENT COMPOUNDS ; CHEMICAL CHANGES ; DIFFERENT ELEMENTS ; (a) physical change (b) chain reaction (c) transmutation (d) transfer of electrons

8. FISSION : FUSION ; (a) splitting ; bombarding (b) radioactive ; non-radioactive (c) atomic isotope (d) chain ; controlled

9. NUCLEAR : A BOMB ; THERMONUCLEAR ; (a) reactor (b) transmutation (c) A bomb plus H bomb (d) alpha disintegration into beta

10. SUSPENSION ; SEDIMENT ; RADIOACTIVE DEBRIS ; (a) Geiger counter (b) fusion (c) fall out (d) nuclear blast

11. ANTI-PROTON ; POSITRON ; NEUTRINO ; (a) meson (b) neutron (c) electron (d) betatron

12. X-ray ; BONES ; RADIOACTIVE IODINE ; (a) thyroid (b) teeth (c) eyes (d) salt
13. ULTRA-VIOLET : X-RAY : GAMMA : (a) alpha (b) laser (c) scintillation (d) cosmic

14. (92U238) MASS NUMBER : 238 : NUMBER OF NEUTRONS : (a) 92 (b) 330 (c) 146 (d) 238

15. FISSION : REACTOR : FUSION : (a) cyclotron (b) hydrogen (c) transmutation (d) sun

16. U-234 : ISOTOPES : U-235 : (a) isotope (b) compound (c) radioactive (d) critical mass

17. RELATIVITY : EINSTEIN : TRANSFORMATION : (a) Bohr (b) Fermi (c) Steinmetz (d) Oppenheimer

18. CATALYST : CHANGE : ACCELERATOR : (a) reactor (b) inertia (c) particle motion (d) gas

19. FISSION : NEUTRON : CHAIN REACTION : (a) atoms (b) critical mass (c) nuclear energy (d) electron

20. CRITICAL MASS : FISSION : (a) 100,000,000 deg. C. (b) attractive forces (c) maximum temperature (d) transmutation : FUSION

21. ULTRA-VIOLET : X-RAY : X-RAY : (a) gamma (b) alpha (c) bone (d) infra-red

22. (Fusion) H : He : (a) O : H (b) mass : energy (c) nuclear : atomic (d) chain reaction : splitting nucleus

23. 1 ELECTRON AND 1 PROTON : H ATOM : 2 PROTONS AND 2 NEUTRONS : (a) H bomb (b) transmutation (c) alpha particle (d) fission

24. REPULSION FORCES : LIKE CHARGES : BINDING FORCES : (a) alpha particles (b) nucleons (c) fission (d) sun

25. FUSION : FISSION : (a) merging into one : splitting (b) atoms split : compounds combine (c) isotopes increase : radioactive elements settle (d) molecules : compounds
9th Grade Physical Science (Introductory Physics)

Unit 1: Magnetism and Static Electricity

1. Chemistry: Matter: Physics: (a) conclusions
   (b) science (c) invention (d) energy

2. Science: Physics: Physics: (a) electricity
   (b) chemistry (c) medicine (d) equations

3. Magnetic N. Pole: Compass: Magnet: (a) needle
   (b) magnetism (c) electricity (d) horse shoe magnet

4. N. Pole to N. Pole: Repel: S. Pole to S. Pole:
   (a) magnet (b) metal (c) attract (d) repel

5. Magnetic N. Pole: Geographic N. Pole: Magnetic N.:
   (a) S. Pole (b) true N. (c) attraction (d) repulsion

6. Compass: Vertical Axis: Dipping Needle: (a) vertical
   axis (b) horizontal axis (c) Earth's axis (d) magnet

7. Magnetism: Compass: Electromagnetism: (a) metal
   (b) doorbell (c) bar magnet (d) dipping needle

8. Electricity: Copper: Magnetism: (a) air (b) iron
   (c) water (d) non-conductor

9. Unlike Poles: Attract: Like Poles: (a) dislike
   (b) match (c) resemble (d) repel

10. Magnetism: Lodestone: Electromagnetism: (a) N. Pole
    (b) protons (c) unlike poles (d) electromagnet

11. To Magnetize: Electricity: To Make Static Electricity:
    (a) magnets (b) automobile (c) poles (d) friction

12. N. Pole of Magnet: S. Pole of Magnet: (a) horse shoe
    magnet: bar magnet (b) unlike: positive (c) like poles:
    negative charges (d) positive charge: negative charge
13. STATIC : CURRENT :: NON-MOVING : (a) switch (b) stationary (c) glass rod (d) flowing

14. RUG : SHOES :: HAIR : (a) air (b) straight (c) comb (d) magnetize

15. POSITIVE : NEGATIVE :: (a) deficiency of electrons ; surplus of electrons (b) conductor ; non-conductor (c) magnetic substance ; non-magnetic substance (d) static electricity ; current electricity

16. POSITIVE : + :: NEGATIVE : (a) — (b) 0 (c)→ (d) neutral

17. POSITIVE-POSITIVE : REPEL ; (a) N. Pole-N. Pole ; repel (b) N. Pole-S. Pole ; repel (c) S. Pole-S. Pole ; attract (d) negative-N. Pole ; attract

18. — — : (a) unlike ; like (b) 1 : 2 (c) N. Pole ; S. Pole (d) attract ; repel

19. — — : (a) like ; unlike (b) attract ; repel (c) negative ; negative (d) like ; attract

20. VAN DER GRAFF : ELECTROSTATIC GENERATOR :: WIMSHURST : (a) electromagnetism machine (b) electroscope indicator (c) electrostatic generator (d) electrolysis apparatus

21. HOUSE : LIGHTNING ROD :: GASOLINE TRUCK : (a) road (b) automobile (c) drag chain (d) engine

22. EARTH'S MAGNETISM : MAGNETIC COMPASS :: ELECTROMAGNET'S MAGNETISM : (a) telephone (b) light (c) static electricity (d) polars

23. NEGATIVE STATIC CHARGE : WOOL :: POSITIVE STATIC CHARGE : (a) paper (b) copper (c) silk (d) string

24. POSITIVE : GLASS :: NEGATIVE : (a) paper (b) iron (c) copper (d) rubber

25. ELECTRICAL SHOCK : INSULATION :: LIGHTNING STRIKE : (a) kite (b) thunder (c) lightning rod (d) static electricity
1. MAGNETISM : STATIC CHARGE :: (a) compass : magnet (b) unlike : repel (c) compass : pith ball (d) magnet : discharge

2. CHARGE : INDUCTION :: MAGNETIZE : (a) heating (b) attracting (c) discharging (d) induction

3. CONDUCTOR : NON-CONDUCTOR :: SILVER : (a) copper (b) glass (c) iron (d) steel

4. LODESTONE : MAGNET :: (a) current electricity (b) magnetism (c) thunderstorm (d) automobile : ELECTROSTATIC GENERATOR

5. MAGNETIZE : MOLECULAR ALIGNMENT :: CHARGE : (a) attract (b) electron transfer (c) atomic discharge (d) declination

6. MAGNETISM : COMPASS :: (a) static electricity (b) iron (c) electromagnet (d) domain : ELECTROSCOPE

7. MAGNETIC FIELD : IRON FILINGS :: ELECTRIC FIELD : (a) electricity (b) battery (c) domains (d) pith ball

8. MAGNETIC : NON-MAGNETIC :: IRON : (a) steel (b) copper (c) nickel (d) alnico

9. MAGNETIZE : INDUCTION, STROKING :: DEMAGNETIZE : (a) positive, negative (b) heating, beating (c) charge, discharge (d) attraction, repulsion

10. LIGHTNING : STRIKE :: ELECTRICAL : (a) measure (b) shock (c) static (d) attraction

11. POSITIVE, NEGATIVE : N. POLE, S. POLE :: (a) 2 : 1 (b) static : current (c) minor : major (d) charge : polarity

12. RUBBER : GLASS :: (a) wax : copper (b) iron : wood (c) porcelain : plastic (d) metals : sulfur
13. **Conduction**: Same Charge :: Induction: (a) Same charge (b) positive charge (c) neutral (d) opposite charge

14. **Electricity**: Car Battery :: Static Electricity: (a) magnet (b) condenser (c) discharge (d) neutral

15. **Electric Field**: Magnetic Field : (a) electric lines of force (b) magnetic lines of force (c) conductor (d) non-conductor (e) repel; attract

16. **Magnetism**: Magnet :: Static Electricity: (a) battery (b) thunderstorm (c) magnetic north (d) attraction

17. **Rubber Rod, Wool, Friction**: Static Electricity: (a) magnet (b) insulator (c) electric field (d) electroscope (e) electromagnetism

18. **(For Two Pith Balls)** Attract: Positive-Negative :: Attract: (a) positive-positive (b) negative-negative (c) neutral-negative (d) neutral-neutral

19. **Excess of Electrons**: Negative Charge :: Equal Number Protons, Electrons: (a) positive charge (b) negative charge (c) neutral (d) static charge

20. **Electron Spin**: Magnetism :: Electron Exchange: (a) static electricity (b) copper (c) attraction (d) magnetism

21. **Static**: Current :: (a) electricity : magnetism (b) friction : rubbing (c) non-conductor : conductor (d) copper : silver

22. **(Rubber Rod Rubbed with Fur)** Rod: Negative :: Fur: (a) negative (b) positive (c) neutral (d) slightly negative

23. **Static**: Current :: Friction: (a) alternator (b) wire (c) charge (d) electrical

24. **Electrical Conductor**: Magnetic Conductor :: (a) charge: discharge (b) plastic : rubber (c) copper : iron (d) like; unlike

25. | (a) current | static |
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<tr>
<td>(b) strong</td>
<td>weak</td>
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<tr>
<td>(c) magnet</td>
<td>electromagnet (d) attract; repel</td>
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1. WATER : PIPE :: ELECTRICITY : (a) power (b) light (c) wire (d) magnetism

2. — — : SWITCH :: — V — : (a) current (b) resistance (c) lightning (d) battery

3. DRY CELL : WET CELL :: (a) flashlight ; generator (b) transistor radio ; car (c) power ; electricity (d) light ; heat

4. PRIMARY CELL : FLASHLIGHT :: SECONDARY CELL : (a) EMF cell (b) transistor cell (c) student cell (d) lead storage cell

5. DRY CELL : ZINC AND CARBON :: WET CELL , (a) water and acid (b) zinc and copper (c) iron and steel (d) acid and base

6. AMPERE : VOLT :: OHM : (a) newton (b) Einstein (c) watt (d) Edison

7. SAL AMMONIAC PASTE : SULFURIC ACID :: (a) copper : insulator (b) chemical : electricity (c) static : current (d) dry cell : wet cell

8. OPEN CIRCUIT : CLOSED CIRCUIT :: (a) inner circuit : outer circuit (b) round : square (c) off : on (d) high voltage : low voltage

9. CURRENT STRENGTH : AMPMETER :: EMF : (a) voltmeter (b) ohms (c) kilowattmeter (d) power meter

10. CURRENT STRENGTH : AMPERE :: RESISTANCE : (a) current (b) electricity (c) wire (d) ohm

11. POTENTIAL DIFFERENCE : EMF :: RATE OF FLOW OF ELECTRIC CHARGES : (a) battery (b) circuit (c) ohm (d) current

12. OHM : RESISTANCE :: WATT : (a) power (b) work (c) current (d) potential

5.
13. \( I = V/R \)  
   (a) repulsion  
   (b) resistance  
   (c) reflection  
   (d) reaction

14. \( I : V/R :: R : \)  
   (a) V/I  
   (b) VI  
   (c) I/V  
   (d) I(V)

15. (Resistance of wire conductor)  
   LENGTH : CROSS SECTIONAL AREA : MATERIAL :  
   (a) strength  
   (b) hardness  
   (c) roundness  
   (d) temperature

16. WATER PRESSURE : VOLTAGE :: RATE OF FLOW OF WATER :  
   (a) current  
   (b) ohms  
   (c) resistance  
   (d) EMF

17. WATER PRESSURE : VOLTAGE :: OPENING OF WATER FAUCET :  
   (a) kilowatt  
   (b) cell  
   (c) resistance  
   (d) battery

18. CLOSED : OPEN :  
   (a) fast : slow  
   (b) volts : ohms  
   (c) series : parallel  
   (d) current : no current

19. CHEMICAL CELL : THERMOCOUPLE :: PHOTOCURRENT CELL :  
   (a) piezoelectric cell  
   (b) EMF cell  
   (c) reaction cell  
   (d) equal cell

20. CHEMICAL CELL : CHEMICAL ACTION :: THERMOCOUPLE :  
   (a) physical action  
   (b) molecular spin  
   (c) heat  
   (d) temperature pair

21. PHOTOCURRENT CELL : LIGHT :: PIEZOELECTRIC CELL :  
   (a) heat  
   (b) pressure  
   (c) switch  
   (d) power

22. SAFETY VALVE : HOT WATER HEATER :  
   (a) water : steam  
   (b) conductor : non-conductor  
   (c) water : electricity  
   (d) fuse : motor

23. (Type of circuit) TV : TOASTER :: HOUSE LIGHTS :  
   (a) car headlights  
   (b) fuse  
   (c) flashlight  
   (d) switch

24. (For resistors) SERIES : PARALLEL :  
   (a) part : whole  
   (b) sum : sum of reciprocals  
   (c) smaller : larger of two  
   (d) average : one half

25. (Two 1.5 volt cells) SERIES : PARALLEL :  
   (a) 1.5 : 1.5  
   (b) 1.5 : 3.0  
   (c) 3.0 : 1.5  
   (d) 0 : 1.5
9th GRADE PHYSICAL SCIENCE (INTRODUCTORY PHYSICS)
UNIT 4. HEAT FROM ELECTRICITY

1. COPPER : NICHROME :: (a) metal : non-metal
   (b) conductor : insulator (c) electricity : charge
   (d) low resistance : high resistance

2. TOASTER : PERCOLATOR :: STOVE :: (a) TV (b) radio
   (c) flat iron (d) switch

3. TOASTER : NICHROME WIRE :: INCANDESCENT LIGHT ::
   (a) light switch (b) tungsten wire (c) socket
   (d) copper wire

4. LOOSELY HELD OUTER ELECTRONS :: TIGHTLY HELD OUTER
   ELECTRONS :: (a) poor conductor : insulator
   (b) wire : metal (c) current : electricity (d) copper : nichrome

5. SMALL DIAMETER FILAMENT :: LARGE DIAMETER FILAMENT ::
   (a) more heat : less heat (b) fast electrons : slow
   electrons (c) soft metal : hard metal (d) nichrome : copper

6. LOW MELTING POINT :: HIGH MELTING POINT ::
   (a) fuse (b) thermostat (c) switch (d) ground wire : LIGHT BULB

7. VOLTAGE : VOLT :: POWER :: (a) ampere (b) current
   (c) watt (d) EMF

8. CIRCUIT BREAKER : FUSE :: (a) reset : replace
   (b) open : close (c) conductor : non-conductor
   (d) complete circuit : incomplete circuit

9. \[(P = VI) \Rightarrow P = VI = I \times (a) \text{ PV} (b) \text{ V/P} (c) \text{ V(P)} (d) \text{ P/V}\]

10. 1000 MILLIAMS = 1 AMP :: 746 WATTS ::
    \[(a) \text{ 0.746 kilowatts} (b) \text{ 7.46 kilowatts} (c) \text{ 74.6 kilowatts} (d) \text{ 746000 kilowatts}\]

11. \[110 = 220 :: (a) \text{ two wires : three wires} (b) \text{ AC : DC}\]
    \[(a) \text{ single : double} (c) \text{ ohms : volts}\]

12. PATH OF ELECTRONS :: CIRCUIT :: PATH OF LEAST RESISTANCE ::
    (a) conductor (b) faster electrons (c) short (d) series
13. FUSE: SERIES: (a) appliances (b) wall outlets (c) ammeter (d) circuit breaker; SERIES

14. \( I = \frac{V}{R} \): 10V, 5 OHMS: 2 AMPS; 2V, 2 OHMS: (a) 0 amps (b) 1 amp (c) 2 amps (d) 4 amps

15. POWER: WATT: ENERGY: (a) kilowatt-hour (b) heat (c) kinetic (d) work

16. BURNED OUT FILAMENT OF LIGHT BULB: FUSE: CIRCUIT BREAKER: (a) incandescent light bulb (b) neon (c) switch (d) nichrome

17. HIGH RESISTANCE: LOW RESISTANCE: (a) high power (b) low power (c) AC (d) DC (c) AC (d) more heat; less heat

18. MACHINE FRICTION: OIL: ELECTRICAL FRICTION: (a) plastic (b) more current (c) resistance (d) good conductor

19. \( P = VI \): 10V, 2 AMPS: 20 WATTS; 20V, 5 AMPS: (a) 4 watts (b) 15 watts (c) 25 watts (d) 100 watts

20. (Resistance of wire) DECREASE DIAMETER; INCREASE RESISTANCE; DECREASE TEMPERATURE: (a) decrease current (b) decrease resistance (c) increase ohms (d) increase resistance

21. UNINSULATED WIRE: SHORT CIRCUIT: OVERLOADED CIRCUIT: (a) current flow (b) high resistance (c) series circuit (d) blown fuse

22. 40 MPH, 30 MPH ZONE: SPEEDING; 20 AMP CURRENT; 15 AMP FUSE: (a) high resistance (b) overloaded circuit (c) circuit breaker (d) faster current

23. NEON GAS: NEON LIGHT: ARGON GAS: (a) indirect light (b) incandescent light (c) soft light (d) night light

24. EDISON LAMP: MODERN LIGHT BULB: (a) glass (b) antique (c) filament (d) carbon: TUNGSTEN

25. EXCESSIVE CURRENT: OVERLOADED CIRCUIT: OVERHEATING: (a) poor conductor (b) loose connection (c) fire (d) switch
1. DIRECTION OF CURRENT : DIRECTION OF MAGNETIC LINES OF FORCE :: (a) north : south (b) repel : attract (c) thumb : fingers (d) battery : compass

2. AC : DC :: (a) acceleration current (b) absolute current (c) atomic current (d) alternating current : DIRECT CURRENT

3. MAGNETIC FIELD OF SOLENOID : MAGNETIC FIELD OF BAR MAGNET :: MAGNETIC FIELD OF CONDUCTING WIRE ; (a) parallel (b) north-south (c) weak to strong (d) concentric circles

4. GENERATOR : MECHANICAL ENERGY :: MOTOR : (a) power (b) voltage (c) heat friction (d) electrical energy

5. OERSTED : FARADAY :: LEHNZ : (a) Einstein (b) Pasteur (c) Ohms (d) Salk

6. OERSTED : SOLENOID :: FARADAY : (a) TV (b) generator (c) electromagnet (d) electricity

7. CAR BATTERY : 12 V :: CAR'S INDUCTION COIL : (a) 24 V (b) 12 x number of spark plugs (c) 20,000 V (d) 6 amps

8. DC : BATTERY :: AC : (a) power plant generator (b) current switch (c) ammeter in series (d) galvanometer

9. POTENTIAL ENERGY : COAL :: HYDROELECTRIC POWER : (a) AC (b) falling water (c) battery (d) chemical energy

10. ELECTROMAGNET : SOLENOID :: COIL ; (a) armature (b) wire (c) magnetism (d) direction

11. AMMETER : CURRENT :: GALVANOMETER : (a) minute current (b) large voltage (c) ohms (d) power

12. DC : INDUCTION COIL :: AC : (a) transformer (b) primary (c) electrical (d) fuse

13. STEP-UP VOLTAGE : TRANSFORMER :: STEP-DOWN VOLTAGE : (a) voltmeter (b) transformer (c) generator (d) fuse
14. PRIMARY, 10 TURNS : SECONDARY, 5 TURNS :: (a) 100 V : 50 V (b) 10 V : 50 V (c) 5 V : 15 V (d) 1 V : 2 V

15. (Transformation of energy) MECHANICAL : ELECTRICAL :: (a) electron flow : current (b) AC : DC (c) power : energy (d) heat : light

16. BRUSHES : ARMATURE :: FIELD MAGNET :: (a) slip rings (b) bearings (c) ammeter (d) current

17. NUMBER OF COILS OF WIRE : STRENGTH OF SOLENOID :: (a) magnet (b) magnitude of current (c) insulation (d) direction of current flow : STRENGTH OF SOLENOID

18. ELECTROMAGNET : VOLTOMETER :: (a) amperes (b) current (c) direction of current flow (d) electromagnet : AMMETER

19. CURRENT : MAGNETIC FIELD :: WIRE CUTTING MAGNETIC LINES OF FORCE :: (a) induced current (b) storage battery (c) door bell (d) circuit

20. STEP-UP TRANSFORMER : INCREASE V, DECREASE I :: STEP-DOWN TRANSFORMER : (a) increase AC, decrease DC (b) decrease V, increase I (c) increase R, decrease P (d) increase ohms, increase EMF

21. NUMBER OF TURNS OF WIRE : INDUCED CURRENT :: (a) kind of insulation (b) speed at which magnetic lines of force are cut (c) use made of current (d) arrangement and number of molecules involved : INDUCED CURRENT

22. SLIP RING : SPLIT RING :: (a) current : electricity (b) field magnet : permanent magnet (c) AC : DC (d) voltage : amperage

23. NUMBER OF TURNS OF WIRE : SPEED WITH WHICH CONDUCTOR IS MOVED :: STRENGTH OF MAGNETIC FIELD :: (a) magnitude of EMF (b) direction of current flow (c) angle conductor cuts magnetic field (d) induction in relation to conduction

24. AMOUNT OF CURRENT : AMMETER :: (a) voltmeter (b) open circuit (b) presence or absence of current (c) generator : GALVANOMETER

25. VOLTOMETER : AMMETER :: (a) series : parallel (b) AC : DC (c) current : induced current (d) ohms : resistance
UNIT 6. WAVE MOTION AND SOUND

2. AIR : SOUND :: VACUUM : (a) noise (b) music (c) pitch (d) silence

2. ELECTRICITY : COPPER :: SOUND : (a) air (b) ear (c) music (d) transistor

3. ENERGY : PHYSICS :: SOUND : (a) ear (b) acoustics (c) hi-fi (d) noise

4. TRANSVERSE : LONGITUDINAL :: (a) with : against (b) soft : loud (c) across : along (d) short : long

5. TRANSVERSE WAVE : LONGITUDINAL WAVE :: (a) light wave : radio wave (b) music : noise (c) wave : surf (d) water wave : sound wave

6. \( V = f L \) \( V \) : VELOCITY :: \( f \) : (a) few (b) fathom (c) fast (d) frequency

7. \( V : f L :: f : (a) V/L \) (b) \( L/V \) (c) \( L/V \) (d) \( V(L) \)

8. COMPRESSION : RAREFACTION :: (a) wave length : height (b) frequency : amplitude (c) pitch : frequency (d) crest : trough

9. COMPRESSION : RAREFACTION :: (a) loud note : soft note (b) high sound : low sound (c) molecules close : molecules far (d) bel : decibel

10. COMPRESSION : RAREFACTION :: (a) higher pressure : lower pressure (b) frequency : amplitude (c) pitch : wave length (d) musical sound : noise sound

11. AIR : SOUND CONDUCTOR :: LIQUID : (a) non-conductor of sound (b) least efficient conductor of sound (c) better sound conductor (d) best sound conductor
12. GOOD CONDUCTOR OF SOUND : POOR CONDUCTOR OF SOUND ::
   (a) sawdust : sponge (b) steel : rubber (c) vacuum :
   cork (d) radio waves : air

13. SOUND PRODUCER : SOUND REPRODUCER :: (a) violin : piano
   (b) tape deck : record (c) vacuum : air (d) larynx : ear

14. (Rating of sound conductor) SOLID : LIQUID :: GAS :
   (a) wood (b) iron (c) vacuum (d) mercury

15. 1090 FT/SEC : 0 DEG C :: 1140 FT/SEC : (a) 212 deg C
   (b) 25 deg C (c) -10 deg C (d) -32 deg C

16. 1100 FT/SEC : AIR :: 4800 FT/SEC : (a) vacuum (b) moon
   (c) outer space (d) water

17. SONIC : 1100 FT/SEC :: SUPER SONIC :: (a) 3 ft/min
    (b) 32 ft/sec (c) 1800 ft/sec (d) 5280 ft/min

18. (Time between lightning and thunder) 5 SEC : 1 MILE ::
    15 SEC : (a) 1 1/2 miles (b) 2 miles (c) 3 miles
    (d) 20 miles

19. VIBRATIONS : SOUND :: VIBRATIONS PER SECOND :: (a) loud
    (b) frequency (c) air (d) velocity

20. \( \frac{\text{amplitude}}{\text{area}} \) :: (a) amplitude : area
    (b) soft : loud (c) small : large (d) high pitch : low pitch

21. \( \frac{\text{soft}}{\text{loud}} \) :: (a) soft : loud (b) frequency : pitch
    (c) harmony : music (d) amplitude : length

22. PITCH : FREQUENCY :: LOUDNESS :: (a) length (b) trans-
    verse wave (c) longitudinal wave (d) amplitude

23. LIGHT : REFLECTION :: SOUND :: (a) music (b) radio
    (c) echo (d) longitudinal wave

24. LONGITUDINAL : DIRECTION OF WAVE MOTION :: TRANSVERSE :
    (a) right angles to wave motion (b) amplitude motion
    (c) opposite motion (d) speed of motion

25. SOUND REFLECTING : BRICK WALL :: SOUND ABSORBING :
    (a) concrete wall (b) wood panel wall (c) metal wall
    (d) acoustical ceiling
UNIT 7. WAVE MOTION, SOUND AND MUSICAL SOUNDS

1. LARYNX : EAR :: (a) record : hi-fi (b) vacuum : air (c) amplitude : compression (d) soft : loud

2. AUDIBLE RANGE : 50 TO 15,000 VPS :: ULTRA-SONIC RANGE :
   (a) below 50 VPS (b) 1100 VPS (c) 0 to 10 VPS (d) above 15,000 VPS

3. VPS : VIBRATIONS PER SECOND :: CPS : (a) centimeters per second (b) controls per second (c) cycles per second (d) charges per second

4. RUSTLE OF LEAVES : WHISPER :: JET ENGINE : (a) quiet (b) loud (c) noise (d) jack hammer

5. VPS : PITCH :: DECIBELS : (a) frequency (b) loudness (c) tone (d) quality

6. TUNING FORK : VIBRATIONS :: SOUNDING BOARD : (a) ultra-sonic (b) forced vibrations (c) soundness (d) frequency

7. (For maximum resonance with a given tuning fork) THE LENGTH OF AN OPEN TUBE : THE LENGTH OF A CLOSED TUBE :: (a) 5 (b) 4 (c) 3 (d) 2 : 1

8. (Doppler Effect) 1500 FT/SEC TO 1200 FT/SEC : 256 VPS TO 200 VPS :: CHANGE IN RELATIVE MOTION : (a) change in velocity (b) change in air (c) change in pitch (d) change in noise

9. MUSIC : NOISE :: (a) regular vibrations : irregular vibrations (b) loud : quiet (c) frequency : amplitude (d) high decibels : low decibels

10. LOOSE : THICK :: (a) thin : short (b) high : low (c) wave length : amplitude (d) piano : violin

11. TIGHT : HIGH :: LOOSE : (a) tone (b) low (c) pitch (d) quality
12. SHORTER STRING: HIGHER FREQUENCY :: GREATER TENSION::
(a) lower frequency (b) higher frequency (c) same frequency (d) one half frequency

13. (Frequency of violin string, 30 cm long is 288 vps)
288 vps = 30 cm :: 320 vps = (a) 27 cm (b) 30 cm
(c) 33 cm (d) 36 cm

14. CONSTRUCTIVE INTERFERENCE : DESTRUCTIVE INTERFERENCE ::
(a) lower sound : softer sound (b) many vps : few vps
(c) high frequency : low frequency (d) crest : trough

15. MIDDLE C = 256 vps :: C ONE OCTAVE HIGHER : (a) 528 vps
(b) 1100 vps (c) 512 vps (d) 264 vps

16. (512 vps - 256 vps) :: HARMONY :: (256 vps - 240 vps):
(a) beat (b) frequency (c) high key (d) tone

17. PITCH, INTENSITY, OVERTONE: SOUND CHARACTERISTICS ::
DENSITY, ELASTICITY :: (a) transverse sound wave
(b) sound conducting qualities (c) frequency of sound
(d) pitch of sound

18. BARITONE : TENOR :: (a) wave length : frequency
(b) pitch : Doppler (c) low : high (d) loud : soft

19. PERCUSSION INSTRUMENT : VIBRATING SURFACE :: WIND INSTRUMENT : (a) vibrating string (b) vibrating air column (c) vibrating sound (d) lower pitch

20. PERCUSSION: DRUM :: BRASS : (a) violins (b) trombone (c) harmony (d) overtones

21. CLARINET : WOODWIND :: PIANO : (a) upright (b) string (c) pianist (d) percussion

22. VIBRATOR : VIBRATIONS : RESONATOR : (a) frequency (b) pitch (c) amplifications (d) tone

23. CREST : TROUGH :: (a) high : low (b) loud note : soft note (c) more air molecules : fewer air molecules (d) pitch : frequency

24. FRET : LENGTH OF STRING :: TRUMPET VALVE : (a) sound (b) length of air column (c) length of beat (d) pitch

25. RESONATOR IN PIANO : SOUNDOING BOARD :: RESONATOR IN CLARINET : (a) valve (b) air column (c) pitch (d) wave
9th GRADE PHYSICAL SCIENCE (INTRODUCTORY PHYSICS)
UNIT 8. LIGHT, ILLUMINATION, REFLECTION AND REFRACTION

1. PITCH : HEARING :: COLOR : (a) brightness (b) darkness (c) eyes (d) sight

2. PROJECTOR : SCREEN :: EYE : (a) pupil (b) cornea (c) lens (d) retina

3. TRANSPARENT : TRANSLUCENT :: TRANSLUCENT : (a) invisible (b) white (c) glass (d) opaque

4. BLACK : WHITE :: (a) light : sight (b) color : spectrum (c) absorb : reflect (d) moon : sun

5. OPAQUE : METAL :: TRANSPARENT : (a) light (b) darkness (c) glass (d) black

6. BULB : LIGHT :: (a) mirror : image (b) film : camera (c) sun : moon (d) sight : see

7. INCANDESCENT : TUNGSTEN :: NEON : (a) gas (b) light (c) sign (d) red

8. TRANSPARENT : TRANSLUCENT :: (a) see : sight (b) clear : cloudy (c) dark : clear (d) light : bright

9. MOON : LIGHT :: ECLIPSE : (a) sun (b) darkness (c) rays (d) speed of light

10. MERCURY : FLUORESCENT :: GAS : (a) neon (b) speed of light (c) black light (d) brilliant

11. NEWSPAPER : OPAQUE :: WAX PAPER : (a) transparent (b) translucent (c) opaque (d) reflecting

12. OPAQUE : REFLECTION :: TRANSPARENT : (a) refraction (b) diffusion (c) equalization (d) translation

13. SPEED OF LIGHT : SPEED OF SOUND :: (a) fastest : much slower (b) 5,280 ft/sec : 1100 ft/sec (c) slow : slower (d) solids : liquids
14. MIRROR : REFLECTION :: LENS : (a) refraction (b) light (c) diffusion (d) optical

15. ROUGH : SCATTER :: SMOOTH : (a) reflect (b) focus (c) sun (d) light

16. MIRROR : PLANE :: PRISM : (a) triangle (b) glass (c) image (d) infra-red

17. MIRROR : REFLECTION :: PRISM : (a) introversion (b) refraction (c) inversion (d) reversion

18. ANGLE OF INCIDENCE : 45 DEGREES :: ANGLE OF REFLECTION : (a) 0 deg. (b) 22 1/2 deg (c) 45 deg. (d) 90 deg.

19. LIGHT : SHADE :: GLARE : (a) dark (b) window (c) sun (d) polarization

20. NEON : INCANDESCENT :: FLUORESCENT : (a) light (b) effervescent (c) electroluminescent (d) luminescent

21. REFLECT : REFRACT :: (a) rebound : bend (b) curve : line (c) real : virtual (d) transparent : translucent

22. \( (I = \frac{1}{d^2}) \) 1 FOOT CANDLE : 1 FOOT :: 9 FOOT CANDLES : (a) 2 feet (b) 3 feet (c) 4.5 feet (d) 9 feet

23. DIVERGE : SPREAD :: CONVERGE : (a) virtual (b) focus (c) reflect (d) transmit

24. SPECTRUM : SPECTACLES :: (a) mirror : image (b) glasses : eyeglasses (c) color : vision (d) sun : light

25. PRISM : SPECTRUM :: LENS : (a) light (b) candle power (c) image (d) color
1. SPECTRUM : PRISM :: RAINBOW : (a) thunderstorm (b) raindrops (c) sun (d) color

2. LENS : CAMERA :: (e) pupil : film (b) light : dark (c) lens : eye (d) telescope : focus

3. IMAGE PLANE MIRROR : IMAGE CONCAVE MIRROR :: (a) real, erect ; virtual, erect (b) virtual, erect ; real, inverted (c) real, inverted ; real, erect (d) real, erect ; virtual, inverted

4. INCIDENT RAY : TOWARD NORMAL :: EMERGENT RAY : (a) toward normal (b) away from normal (c) straight from normal (d) curved toward normal

5. (Object at 2F) VIRTUAL : REAL :: CONVEX MIRROR : (a) plane mirror (b) flat mirror (c) concave mirror (d) one way mirror

6. CONVERGING LENS : DIVERGING LENS :: (a) converge ; diverge (b) transparent ; translucent (c) black ; white (d) refract ; reflect

7. REAL : INVERTED :: VIRTUAL : (a) upright (b) double vision (c) nearsightedness (d) reflection

8. WAVE THEORY : ELECTROMAGNETIC WAVES :: QUANTUM THEORY : (a) polarization (b) photons (c) diffraction (d) incoming

9. ANGLE OF INCIDENCE : ANGLE OF REFLECTION :: NORMAL : (a) curve (b) standard (c) perpendicular (d) smooth

10. CONVERGING LENS : DIVERGING LENS :: (a) thick center ; thin center (b) reflect ; refract (c) enlarge ; magnify (d) focus ; focal point

11. LENS () ← : MIRROR ← : (a) converge ; diverge (b) converge ; converge (c) diverge ; diverge (d) diverge ; converge
12. LENS \( \leftarrow : MIRROR \) \( \leftarrow \) : (a) converge ; diverge 
(b) converge ; converge (c) diverge ; diverge 
(d) diverge ; converge

13. \( (E = mc^2) \) \( \rightarrow \) ENERGY \( \rightarrow \) c : (a) color of light (b) speed of light (c) spectrum of light (d) convergence of light

14. CONCAVE : CONVEX :: (a) flat ; plane (b) glare ; shadow 
(c) nearsightedness ; farsightedness (d) glasses ; lens

15. CONVEX LENS : CONCAVE LENS :: (a) bulge out ; bulge in 
(b) eye ; glasses (c) round ; square (d) see ; color

16. \( (\leftarrow : \rightarrow) \) \( \leftarrow \) : (a) up ; down (b) concave ; convex 
(c) glasses ; telescope (d) light ; color

17. LENS OF CAMERA : LENS OF EYE :: FILM : (a) cornea 
(b) iris (c) optic nerve (d) retina

18. PICTURE PROJECTOR : READING GLASS :: TELESCOPE : 
(a) see (b) virtual image (c) microscope (d) light

19. ALL LIGHT REFLECTED : WHITE :: ALL LIGHT ABSORBED : 
(a) red (b) spectrum (c) black (d) blue

20. SHADE : COLOR :: (a) primary ; secondary (b) beige ; brown (c) white ; black (d) dark ; light

21. INVISIBLE LIGHT : VISIBLE :: ULTRA VIOLET : (a) X-ray 
(b) infrared (c) light (d) cosmic rays

22. X-RAY : ULTRA VIOLET :: ULTRA VIOLET : (a) alpha 
(b) beta (c) gamma (d) infrared

23. MONOCHROMATIC : ONE COLOR :: POLYCHROMATIC : (a) white 
light (b) multi-colored (c) red (d) ultra-violet

24. WHITE LIGHT : LASER :: (a) polychromatic ; monochromatic 
(b) fast ; slow (c) sunlight ; moonlight (d) bright ; dull

25. INCIDENT RAY : INCOMING RAY :: PRINCIPAL FOCUS : (a) lens 
(b) inverted color (c) convergent point (d) straight ray
9th GRADE PHYSICAL SCIENCE (INTRODUCTORY PHYSICS)
UNIT 10. TEMPERATURE, HEAT AND EXPANSION

1. ENGLISH : METRIC :: FAHRENHEIT : (a) heat (b) freeze (c) temperature (d) centigrade

2. 100 DEG. C. : 0 DEG. C. :: 212 DEG. F. : (a) 20 deg. F. (b) 32 deg. F. (c) 68 deg. F. (d) 273 deg. F.

3. FAHRENHEIT : 180 :: CENTIGRADE : (a) 0 (b) 32 (c) 100 (d) 1000

4. TEMPERATURE : AVERAGE KINETIC ENERGY OF SINGLE MOLECULE :: HEAT : (a) degree of hotness (b) total kinetic energy of all molecules (c) mercury height (d) thermometer

5. TEMPERATURE : DEG. C. :: HEAT : (a) deg. F. (b) thermometer (c) calorie (d) sweat

6. 0 DEG. C. : FREEZING POINT :: -273 DEG. C. : (a) melting point (b) vaporization temperature (c) gaseous state (d) absolute zero

7. F. : 9/5C + 32 :: C : (a) 5/9(F - 32) (b) 180 - 32 (c) 9/5(T - 32) (d) 5/9F - 100

8. 100 DEG. C. : 0 DEG. C. :: 373 DEG. K. : (a) 0 deg. F. (b) 100 deg. C. (c) 212 deg. F. (d) 273 deg. C.

9. ONE DEG. C. : ONE DEG. K. :: 1 : (a) 1 (b) 1.8 (c) 32 (d) 273

10. HOT : COLD :: (a) temperature : mercury (b) high energy : low energy (c) gas : liquid (d) 100 deg. C. : 68 deg. C.

11. 20 DEG. C. : 68 DEG. F. :: 37 DEG. C. : (a) 50 deg. F. (b) 70 deg. F. (c) 98 deg. F. (d) 212 deg. F.

12. HOT : COLD :: (a) conduction : convection (b) plastic : wool (c) steam : water (d) temperature : heat

13. HIGH TEMPERATURE : FAST MOLECULAR MOTION :: ABSOLUTE ZERO : (a) slow motion (b) no molecular motion (c) H₂O average motion (d) fastest motion
14. TEMPERATURE : DEGREE OF HOTNESS OR COLDNESS :: HEAT :
   (a) hot (b) energy (c) thermometer (d) molecules

15. CALORIE : B.T.U. :: (a) pound : ounce (b) gram : pound
   (c) kilogram : milligram (d) 0 deg. C. : 32 deg. F.

16. COLD : HOT :: (a) earth : sun (b) night : day
   (c) solid : liquid (d) contract : expand

17. ALCOHOL THERMOMETER : MERCUrial THERMOMETER :: BI-METALLIC
    THERMOMETER : (a) pyrometer (b) water thermometer
    (c) temperature (d) boiling meter

18. WATER HEATED ABOVE 4 DEG. C. : EXPANSION :: WATER COOLED
    BELOW 4 DEG. C. : (a) contraction (b) expansion (c) constant
    (d) refrigeration

19. 1 GM ICE AT 0 DEG. C. TO WATER AT 0 DEG. C. : 80 CAL. ::
    2 GM ICE AT 0 DEG. C. TO WATER AT 2 DEG. C. : (a) 40 cal.
    (b) 160 cal. (c) 273 cal. (d) 320 cal.

20. STEAM TO WATER : 540 CAL/GM :: WATER TO ICE : (a) 100 cal/gm
    (b) 80 cal/gm (c) 32 deg. F. (d) 212 deg. C.

21. \( \frac{V_1}{V_2} = \frac{T_1}{T_2} \) \( V_1 \) IS 10 CC ; \( V_2 \) IS 20 CC :: \( T_1 \) IS
    300 DEG. K. ; (a) \( T_2 \) IS 100 deg. K. (b) \( T_2 \) IS 150 deg. K.
    (c) \( T_2 \) IS 300 deg. K. (d) \( T_2 \) IS 600 deg. K.

22. (FOR LAKE FROZEN OVER) WATER AT TOP OF LAKE : 0 DEG. C. ::
    WATER AT BOTTOM OF LAKE : (a) -5 deg. C. (b) 0 deg. C.
    (c) 4 deg. C. (d) 32 deg. F.

23. RED : BRIGHT RED :: YELLOW : (a) orange (b) green (c) blue
    (d) white

24. BLACK : WHITE :: (a) color : light (b) cold : hot (c) space :
    earth (d) absorption : reflection

25. COEFFICIENT OF LINEAR EXPANSION :: CHANGE IN LENGTH :: SPECIFIC
    HEAT : (a) change in T of 1 deg. C. (b) boiling point of water
    (c) change in ice to water (d) 540 cal/gm
9th GRADE PHYSICAL SCIENCE (INTRODUCTORY PHYSICS)
UNIT 11. HEAT, TEMPERATURE, TRANSFER OF HEAT AND CHANGE OF STATE

1. CONDUCTION : MOLECULES :: CONVECTION : (a) cooling (b) fluids (c) solids (d) heat

2. CONVECTION : CENTRAL HEATING :: RADIATION : (a) water cooler (b) thermos bottle (c) hot water heater (d) sun

3. WARM AIR : COLD AIR :: (a) vapor : gas (b) central heating : convection (c) heat : heating (d) rise : sink

4. CONDUCTION : MOLECULES :: RADIATION : (a) convection (b) rising air (c) electromagnetic waves (d) molecular motion

5. (TELEPHONE WIRES) SAG : TIGHT :: (a) shrink : contract (b) heat : expand (c) radiation : convection (d) summer : winter

6. (WITH HEATING) SOLIDS : EXPAND :: LIQUIDS : (a) expand (b) expand then contract (c) contract (d) remain the same

7. CONVECTION : AIR :: RADIATION : (a) man (b) space (c) car (d) water

8. SOLID : GAS :: (a) slowest moving molecules : fastest moving molecules (b) ice : ice water (c) heat : motion (d) absolute zero : zero deg. C.

9. SOLID : LIQUID :: (a) cold : hot (b) solid T. : liquid T. (c) freezing : ice (d) molecules close together : molecules farther apart

10. ICE : WATER :: DRY ICE : (a) frozen water vapor (b) ice crystals (c) carbon dioxide (d) frozen air

11. HIGH HUMIDITY : LOW HUMIDITY :: (a) summer : winter (b) dry : wet (c) water : steam (d) clouds : rain

12. SILVER : ASBESTOS :: IRON : (a) copper (b) wool (c) metal (d) steel

13. STEAM : CONDENSATION :: WATER : (a) evaporation (b) coagulation (c) vaporization (d) solidification
14. HEAT : EVAPORATION :: COLD : (a) ice (b) refrigeration (c) icy (d) condensation

15. HEAT : STEAM :: COLD : (a) dry (b) ice (c) wet (d) winter

16. HEATING : COOLING : (a) expanding ; contracting (b) winter ; freezing (c) 212 deg. F. 100 deg. (d) ice ; snow

17. CONDENSATION : VAPOR TO LIQUID :: SUBLIMATION : (a) solid to gas (b) vapor to gas (c) liquid to solid (d) cold to hot

18. HEAT OF FUSION : HEAT OF VAPORIZATION :: (a) 0 deg. C. : 32 deg. F. (b) 32 deg. F. : 100 deg. F. (c) 0 deg. C. : 100 deg. F. (d) 100 deg. F. : 101 deg. F.

19. HEAT OF FUSION : HEAT OF VAPORIZATION :: (a) ice : water (b) liquid : gas (c) cool : cold (d) molecules : atoms

20. HEAT OF VAPORIZATION : 540 cal/gm :: HEAT OF FUSION : (a) 1 cal/gm (b) 32 cal/gm (c) 80 cal/gm (d) 100 cal/gm

21. RELEASE OF HEAT : EXOTHERMIC :: ABSORPTION OF HEAT : (a) adiabatic (b) isothermic (c) endothermic (d) kinetic energy

22. C. TO F. : 9/5C + 32 :: C. TO K. : (a) 5/9F + 32 (b) C. + 273 (c) F. - C. (d) 100 - 32

23. BOILING WATER AT GALVESTON, TEXAS : 100 deg C. :: BOILING WATER AT DENVER, COLORADO : (a) 32 deg F. (b) 68 deg. C. (c) 95 deg. C. (d) 273 deg C.

24. STEAM : 100 deg. C. :: ICE : (a) 0 deg. C. (b) 20 deg. C. (c) 32 deg. F. (d) 68 deg. C.

25. WATER : STEAM :: (a) cold : warm (b) liquid : gas (c) solid : gas (d) heat : temperature
1. SOLID : LIQUID :: DEFINITE SIZE AND SHAPE : (a) indefinite volume and shape (b) definite volume, indefinite shape (c) indefinite volume, definite shape (d) definite size

2. \( P = \frac{F}{A} \) \( P \) : PRESSURE :: (a) absolute (b) area (c) acceleration (d) adhesion

3. FORCE : PRESSURE :: GRAMS : (a) weight (b) grams/cm² (c) volume (d) pounds

4. AIR : BALLOON :: WATER : (a) cork (b) stone (c) sea (d) fly

5. BOOK LYING FLAT :: 1 PSI :: SAME BOOK SET ON END : (a) 0.1 psi (b) 0.5 psi (c) 1 psi (d) 2 psi

6. \( P = H \times D \) \( H \) : HEIGHT :: (a) depth (b) drag (c) density (d) difference

7. \( P = \frac{F}{A} \) \( P = H \times D \) : (a) pressure : force (b) solid : liquid (c) area : depth (d) force : height

8. \( \square \) \( \square \) \( \triangle \) \( \bigcirc \) (All containers full. Refer to pressure at bottom of container.)

| A | B | C | D |

PRESURE A : PRESSURE B :: PRESSURE C : (a) 1/2 pressure A (b) pressure A (c) twice pressure A (d) 1 1/2 times pressure A

9. PRESSURE D : PRESSURE C :: PRESSURE A : (a) pressure B (b) pressure A + pressure B (c) pressure D - pressure C (d) \( L \times W \times H \)

10. PRESSURE DEPENDENT : H AND D :: PRESSURE INDEPENDENT : (a) variable (b) area (c) difference (d) size and shape

11. PASCAL : ARCHIMEDES :: (a) force : weight (b) ship : boat (c) fluid pressure : buoyant force (d) height : density

12. ARCHIMEDES : UPWARD :: PASCAL : (a) North (b) same direction (c) equally all directions (d) downward
13. HYDRAULIC BRAKES : BARBER CHAIR :: SERVICE STATION LIFT ; (a) oil (b) mechanic (c) power steering 
(d) typewriter

14. AREA OF EFFORT PISTON : AREA OF RESISTANCE PISTON :: 
DISTANCE EFFORT PISTON MOVES ; (a) resistance piston 
squared (b) diameter of effort piston (c) radius of resistance piston (d) distance resistance piston moves

15. WEIGHT OF WATER DISPLACED : WEIGHT OF AIR DISPLACED :: 
(a) rain : wind (b) water force : air pressure (c) boat; dirigible (d) depth : height

16. SUBMARINE : ARCHIMEDES :: BALLOON ; (a) Pascal 
(b) Galileo (c) Toricelli (d) Archimedes

17. FRESH WATER : WOOD FLOATS HALF ABOVE WATER :: SALT WATER ; (a) same wood floats 1/4th above water (b) same wood floats 1/2 above water (c) same wood floats 3/4ths above water (d) same wood sinks

18. WOOD : WATER :: STEEL BOLT ; (a) nut (b) air (c) oil 
(d) mercury

19. LIKE MOLECULES : UNLIKE MOLECULES :: (a) force : pressure 
(b) cohesion : adhesion (c) fusion : diffusion (d) centi-grade : fahrenheit

20. WATER IN GLASS TUBING : MERCURY IN GLASS TUBING :: 
(a) thermometer ; temperature (b) cohesion : adhesion 
(c) boiling : freezing (d) liquid : gas

21. GRAVITY : BUOYANCY ; (a) earth ; ocean (b) 32 ft/sec^2 ; 
62.4 pounds/ cubic foot (c) downward : upward (d) space; vacuum

22. BALLOON ; ELASTICITY :: SOAP BUBBLE ; (a) soap and water 
(b) air (c) density (d) surface tension

23. SURFACE TENSION : COHESION :: CAPILLARITY ; (a) water 
(b) temperature of liquid (c) adhesion (d) mercury

24. 1 GRAM/CC : 1 :: (a) weight : volume (b) float : sink 
(c) density : S.G. (d) height of liquid : depth of liquid

25. WEIGHT OF OBJECT DRY - 20 GRAMS : WEIGHT OF DISPLACED LIQUID - 22 GRAMS :: BUOYANT FORCE ; (a) 2 grams upward 
(b) 2 grams downward (c) 21 grams downward (d) 42 grams upward
1. **LIQUID** : DEFINITE VOLUME AND INDEFINITE SHAPE  ; **GAS** : (a) indefinite volume and indefinite shape (b) definite volume and definite shape (c) indefinite volume and definite shape (d) definite volume and indefinite shape

2. **HYDRAULIC** : **NEUMATIC** : (a) air  ; kite (b) weight  ; mass (c) liquid  ; air (d) airplane  ; airship

3. 76 CM : 29.92 INCHES : 14.7 LBS/IN² : (a) 32 ft/sec² (b) 1013.2 millibars (c) 1000 cc. (d) 1 ton

4. 64 ft/sec² : TWICE ACCELERATION OF GRAVITY  ; 147 LBS/IN² : (a) twice density of air (b) specific gravity of air (c) 2 gms/cc (d) 10 atmospheres

5. **BAROGRAPH** : **MERCURIAL BAROMETER** ; **ANEROID BAROMETER** : (a) balloon (b) altimeter (c) air flow (d) wind

6. **MEDICINE DROPPER** : **SODA STRAW** ; **VACUUM CLEANER** : (a) fan (b) dirt (c) house (d) suction cup

7. **AIRPLANE** : **WING** ; **DIRIGIBLE** : (a) oxygen (b) helium (c) wind (d) cloud

8. **AIRCRAFT ELEVATOR** ; **VERTICAL MOTION** ; **AILERON** : (a) pitch (b) control column (c) throttle (d) bank

9. **RESPIRATION** ; **PHOTOSYNTHESIS** : **OXYGEN** : (a) H₂O (b) air (c) carbon dioxide (d) hydrogen

10. **AIRPLANE** ; **PAINT SPRAYER** ; **CURVING BASEBALL** : (a) spin (b) relative velocity of air (c) atomizer (d) air conditioner

11. **DIRIGIBLE** ; **ARCHIMEDES** ; **AIRPLANE** : (a) Torricelli (b) Galileo (c) Bernoulli (d) Pascal

12. (Temperature constant) **FIRST VOLUME** ; **LAST VOLUME** : **FIRST PRESSURE** ; (a) first volume  ; last volume (b) last pressure (c) density of gas (d) first pressure  ; last pressure \( \frac{P_o V_o}{T_o} = \frac{P_1 V_1}{T_1} \)

13. (Volume constant) **FIRST PRESSURE** ; **LAST PRESSURE** ; **FIRST TEMPERATURE** : (a) last temperature (b) density of gas (c) Bernoulli's Law (d) \( T_o - T_1 \)
14. (Temperature constant) \( P_0 = 10 \text{ GMS/cm}^2 \) : \( V_0 = 10 \text{ cc} \) ;
\( P_1 = 20 \text{ GMS/cm}^2 \):
(a) \( V_1 = 5 \text{ cc} \)  (b) \( V_1 = 20 \text{ cc} \)  (c) \( V_1 = 100 \text{ cc} \)
(d) \( V_1 = 200 \text{ cc} \)

15. (Volume constant) \( P = 20 \text{ GMS/cm}^2 \) : \( T = 10 \text{ DEG. C.} \) ;
\( P_1 = 40 \text{ GMS/cm}^2 \):
(a) \( T_1 = 5 \text{ deg. C.} \)  (b) \( T_1 = 20 \text{ deg. C.} \)
(c) \( T_1 = 40 \text{ deg. C.} \)  (d) \( T_1 = 80 \text{ deg. C.} \)

16. VOLUME OF AIR ENTERING AT A; VOLUME OF AIR LEAVING AT C ::
VOLUME OF AIR PASSING THROUGH B ;
(a) volume of air entering at A (b) volume of air at A \times\ volume of air at C
(c) volume of air at A + volume of air at C (d) (volume of air at A)\(^2\)

17. VELOCITY OF AIR AT A :: VELOCITY OF AIR AT B :: VELOCITY
OF AIR AT C ;
(a) velocity of air at A (b) velocity of air at B (c) velocity of air at A \sim\ velocity of air at B
(d) (velocity of air at B)\(^2\)

18. BERNOULLI :: VENTURI :: GREATER VELOCITY-LESS PRESSURE :
(a) less velocity-less pressure (b) greater pressure-greater density (c) smaller opening-greater velocity
(d) greater volume-less velocity

19. BERNOULLI :: AIRPLANE :: VENTURI:
(a) electric fan (b) car (c) pressure gauge (d) carburetor

20. MOLECULES :: CONDUCTION :: AIR ;
(a) radiation (b) wind (c) advection (d) heat

21. (Constant P) VOLUME OF SOLID CUBE : \( L \times W \times H \) ::
VOLUME OF GAS ;
(a) temperature (b) \( \pi r^2 h \) (c) \( 4/3 \pi r^3 \) (d) weight

22. LOW TEMPERATURE OF GAS :: HIGH TEMPERATURE OF GAS ;
(a) low average kinetic velocity \sim\ high average kinetic velocity (b) \( V_0 P_0 \); \( V_1 P_1 \)
(c) low velocity ; high pressure (d) small volume ; greater volume

23. COMPRESSION :: RAREFACTION ;
(a) tightly packed molecules : loosely packed molecules (b) great volume ; small volume
(c) vacuum : gas (d) \( V_0 : V_1 \)
24. AIR : GAS :: HYDROGEN : (a) nitrogen (b) oxygen (c) gas (d) liquid

25. WEIGHT OF GAS : GRAMS :: PRESSURE OF GAS : (a) grams/cm² (b) grams/cm³ (c) grams/sec² (d) 32 feet/sec²
1. **CAUSE OF MOTION** :: **FORCE** ;; **RESISTANCE TO MOTION** :
   (a) energy (b) static (c) power (d) inertia

2. (Feather and a coin falling for 1 second in a vacuum)
   FEATHER : 16 ft. ;; COIN : (a) 16 ft. (b) 32 ft.
   (c) 64 ft. (d) 144 ft.

3. (Acceleration of gravity) **ENGLISH** : 32 ft/sec/sec :: **METRIC** :
   (a) 100 mph (b) 960 cm/sec/sec (c) 16 gms/sec
   (d) 2 km/hr

4. **SPEED** : **DISTANCE/TIME** :: **VELOCITY** : (a) displacement/time
   (b) fastness/time (c) rocket (d) travel time

5. **WEIGHT** :: **VARIATES WITH DISTANCE FROM CENTER OF EARTH** :: **MASS** :
   (a) varies with heaviness (b) variable at N. Pole
   (c) weight/volume (d) constant

6. **AT EARTH'S SURFACE** : **WEIGHT OF 144 LBS** :: **4000 MILES**
   ABOVE EARTH'S SURFACE : (a) 522 lbs. (b) 144 lbs.
   (c) 36 lbs (d) 0 lbs.

7. **WEIGHT** :: **MEASURE OF GRAVITATIONAL PULL** :: **MASS** :
   (a) energy (b) inertia (c) volume (d) speed

8. **SUN** :: **EARTH** :: **EARTH** : (a) moon (b) stars (c) water
   (d) gravity

9. **WEIGHT OF OBJECT ON EARTH** : 36 LBS. :: **WEIGHT OF SAME OBJECT ON MOON** :
   (a) 6 lbs (b) 2 lbs (c) 4 lbs (d) 56 lbs

10. \( D = 16t^2 \) for free falling object
    1 SEC. : 16 FT. :: 2 SEC. : (a) 16 ft (b) 32 ft (c) 64 ft (d) 96 ft

11. \( M = mV \) \( M \) : **MOMENTUM** :: \( m \) : (a) minute (b) mass
    (c) measurement (d) mile

12. **VELOCITY** : **CM/SEC.** :: **ACCELERATION** : (a) m/cm (b) gms/cm
    (c) cm/sec/sec (d) miles/hr
13. \[(F = ma) \quad F : \text{FORCE} :: a : (a) \text{acting} \quad (b) \text{acceleration} \quad (c) \text{constant} \quad (d) \text{addition}\]

14. \[(F = ma) \quad F : ma :: a : (a) Fm \quad (b) am \quad (c) F/m \quad (d) m/F\]

15. VELOCITY : DISPLACEMENT AND TIME :: ACCELERATION :
(a) speed and distance \quad (b) motion and distance \quad (c) time and inertia \quad (d) velocities and time

16. SCALAR : MAGNITUDE :: VECTOR : (a) arrow \quad (b) measure \quad (c) quantity \quad (d) magnitude and direction

17. SCALAR : VECTOR :: AREA : (a) force \quad (b) speed \quad (c) time \quad (d) volume

18. VECTOR : SCALAR :: (a) velocity \quad (b) force \quad (c) cold \quad (d) light \quad (e) cold \quad temperature \quad (d) light \quad dark

19. AREA : ENERGY :: DISPLACEMENT : (a) temperature \quad (b) time \quad (c) velocity \quad (d) quantity

20. FORCE : CONCURRENT FORCES :: (a) push \quad (b) existing forces \quad present forces \quad (c) weak force \quad moving force \quad (d) independently \quad simultaneously

21. BALL : PLATE LYING FLAT :: (a) stability \quad (b) neutral \quad stable \quad (c) stable \quad (d) stable \quad unstable

22. LOW CENTER OF GRAVITY : HIGH CENTER OF GRAVITY ::
(a) neutral \quad unstable \quad (b) stable \quad more unstable \quad (c) thin \quad wide \quad (d) unstable \quad instability

23. WHEEL : WATER :: (a) car \quad (b) rolling friction \quad fluid friction \quad (c) smooth \quad choppy \quad (d) slide \quad liquid

24. BOAT : FLUID FRICTION :: AIRPLANE : (a) sliding friction \quad (b) rolling friction \quad (c) fluid friction \quad (d) neutral friction

25. SLIDING FRICTION : ROUGHNESS OF SURFACE :: FLUID FRICTION : (a) water \quad (b) speed of air \quad (c) liquid pressure \quad (d) density of fluid
UNIT 15. FORCE, MOTION AND NEWTON'S LAWS OF MOTION

1. NEWTON'S FIRST : NEWTON'S SECOND : (a) earth : gravity (b) speed : motion (c) inertia : acceleration (d) space : orbit

2. BALANCED FORCES : UNIFORM MOTION : UNBALANCED FORCES : (a) inertia (b) acceleration (c) destruction (d) speed

3. RESULTANT : VECTOR SUM : EQUILIBRIUM : (a) force of motion (b) weight minus gravity (c) equal and opposite of vector sum (d) scalar sum

4. (Two concurrent forces) SAME DIRECTION : ADD : OPPOSITE DIRECTIONS : (a) square root (b) add (c) subtract (d) divide

5. RATE OF MOTION : SPEED : RATE OF DISPLACEMENT : (a) accelerate (b) average speed (c) velocity (d) momentum

6. LUBRICATE : SMOOTH SURFACE : DECREASE WEIGHT : (a) use rollers (b) speed up (c) raise center of gravity (d) increase gravitational force

7. INERTIA : RESISTANCE TO CHANGE IN MOTION : FRICTION : (a) curvilinear (b) rolling (c) centrifugal (d) resistance to motion

8. BRAKE : WHEEL : (a) road : surface (b) car : wagon (c) match cover : match (d) stop : start

9. FORCE RESULTING IN CIRCULAR MOTION : CENTRIFETAL : FORCE OPPOSING THIS MOTION : (a) acceleration (b) speed (c) momentum (d) centrifugal

10. FORCE : DISPLACEMENT : VELOCITY : (a) acceleration (b) time (c) area (d) temperature

11. ACCELERATE : DECELERATE : (a) speedy : fast (b) motion : force (c) speed up : slow down (d) velocity : speed

12. \( t = \sqrt{\frac{D}{4}} \). For free falling body 64 FT. : 2 SEC : 400 FT. : (a) 3 sec (b) 4 sec (c) 5 sec (d) 10 sec
13. (Free fall acceleration) 1 SEC : 32 FT/SEC/SEC :: 3 SEC : (a) 32 ft/sec/sec (b) 64 ft/sec/sec (c) 96 ft/sec/sec (d) 144 ft/sec/sec

14. ROCKET ; KICK OF GUN :: WALKING ; (a) gravity (b) space (c) rotary lawn sprinkler (d) acceleration

15. (Two bullets at same height, one fired horizontally; one dropped vertically at same time) TIME FOR HORIZONTAL BULLET TO STRIKE GROUND : 1 SEC :: TIME FOR VERTICAL BULLET TO STRIKE GROUND : (a) 0.5 sec (b) 1 sec (c) 2 sec (d) 4 sec

16. \( CF = \frac{mV^2}{r} \) CF : CENTRIFUGAL FORCE :: r : (a) rate (b) ratio (c) radius (d) repulsion

17. \( F = ma \) and \( m = \frac{w}{g} \) ma : mg :: FORCE : (a) acceleration (b) momentum (c) weight (d) velocity

18. OUTWARD : INWARD :: (a) centrifuge : centrifugal (b) centrifugal : centripetal (c) center of gravity : center of curve (d) away : from

19. STRAIGHT : CURVED :: RECTILINEAR : (a) space (b) time (c) centrifugal (d) corner

20. (Two concurrent forces) ACTING AT RIGHT ANGLES TO EACH OTHER : PARALLELOGRAM :: ACTING AT ACUTE ANGLE TO EACH OTHER : (a) square (b) subtract (c) divide (d) parallelogram

21. (Ten grams to E. and 5 grams to E., concurrently) RESULTANT : 15 GRAMS TO E. :: EQUILIBRANT : (a) 5 grams to E. (b) 7.5 grams to E. (c) 15 grams to W (d) 1/2 gram

22. (Ten grams to S. and 2 gram to N., concurrently) RESULTANT : 8 GRAMS TO S. :: EQUILIBRANT : (a) 5 grams to N. (b) 8 grams to N. (c) 12 grams to E. (d) 1/5th gram

23. IMPULSE ; FORCE AND TIME :: MOMENTUM : (a) acceleration and time (b) mass and velocity (c) velocity and time (d) distance and time

24. \( \text{Period} = 2\pi\sqrt{\frac{L}{g}} \) (Short pendulum is 25 cm long and longer pendulum is 100 cm long) PERIOD OF SHORT PENDULUM : PERIOD OF LONG PENDULUM :: 1 : (a) 1 (b) 2 (c) 3 (d) 4

25. PROJECTILE ; TRAJECTORY :: SATELLITE : (a) planet (b) space (c) orbit (d) rocket
9th GRADE PHYSICAL SCIENCE (INTRODUCTORY PHYSICS)
UNIT 16. SIMPLE MACHINES, WORK AND MECHANICS

1. FORCE : PUSH OR PULL :: WORK : (a) time (b) distance
   (c) machine (d) speed

2. FT-LB : WORK :: FT-LB : (a) energy (b) horsepower
   (c) force (d) power

3. \( W = F \times D \) : FORCE :: D : (a) diameter (b) density
   (c) difference (d) distance

4. FT-LB : WORK :: GM-CM : (a) speed (b) force (c) m/sec
   (d) work

5. FRICTION : OIL :: EFFORT : (a) machine (b) power
   (c) energy (d) speed

6. INPUT FORCE : EFFORT :: OUTPUT FORCE : (a) friction
   (b) speed (c) resistance (d) movement

7. (For inclined plane) WORK INPUT : LENGTH :: WORK OUTPUT :
   (a) effort (b) height (c) push (d) time

8. FORCE x DISTANCE : WORK :: WORK OUTPUT/WORK INPUT :
   (a) power (b) speed (c) friction (d) efficiency

9. (Work input is 4 ft-lb, work output is 3 ft-lb) 75% :
   EFFICIENCY :: 25% : (a) net gain in force (b) work lost
   through friction (c) speed decrease (d) force

10. FRICTION IN JACKSCREW : FRICTION IN LEVER :: (a) rolling
    sliding (b) high : low (c) efficient : inefficient
     (d) force : effort

11. FORCE, DISTANCE : WORK :: RESISTANCE, EFFORT : (a) power
    (b) speed increase (c) mechanical advantage (d) energy
     lost in friction

12. EFFORT : FORCE :: RESISTANCE : (a) inclined plane
    (b) motion (c) load (d) smooth surface
13. CAR TRAVELING ON LEVEL ROAD : FRICTION :: CAR TRAVELING UP HILL : (a) work (b) speed (c) gravity (d) distance

14. ABILITY TO DO WORK : RATE WORK IS DONE :: (a) energy : power (b) friction : oil (c) effort : force (d) length : resistance

15. FT-LB/SEC : POWER :: GM-CM/SEC : (a) mechanical advantage (b) friction (c) efficiency (d) power

16. WORK : FORCE AND DISTANCE :: POWER : (a) force and energy (b) force and horsepower (c) work and distance (d) work and time

17. POTENTIAL ENERGY : HEIGHT :: KINETIC ENERGY : (a) work (b) velocity (c) distance (d) horsepower

18. \( \text{MA} = \frac{L}{H} \) : LENGTH :: H : (a) heat of friction (b) height (c) horsepower (d) hardness

19. (For frictionless inclined plane) \( R/E : \text{MA} \) :: (a) input x output (b) friction (c) force (d) \( \frac{L}{H} : \text{MA} \)

20. (\( \text{MA} = \frac{R}{E} \)) R : RESISTANCE :: E : (a) energy (b) effort (c) efficiency (d) elasticity

21. FORCE : POWER :: DISTANCE : (a) efficiency (b) time (c) mechanical advantage (d) friction

22. (1100 lbs lifted 1 ft in 1 sec) WORK : HP :: (a) 1 ft-lb : 1 HP (b) 550 ft-lb : 1 HP (c) 1100 ft-lb : 2 HP (d) 2 ft-lbs : 1 HP

23. 1 LB, LIFTED 1 FT : WORK :: 1 LB, LIFTED 1 FT, IN 1 SEC : (a) lifting efficiency (b) 550 ft-lbs (c) power (d) 1 HP

24. (A 1 lb book is held 5 ft above floor for 10 sec) WORK IN LIFTING BOOK TO 5 FT :: 5 FT-LB :: WORK DONE IN HOLDING BOOK FOR 10 SEC : (a) 0 ft-lb (b) 5 ft-lb (c) 15 ft-lb (d) 50 ft-lb

25. 550 FT-LB/SEC : 33000 FT-LB/SEC :: (a) 1 HP : 1 HP (b) 1 HP : 2 HP (c) 1 HP : 6 HP (d) 1 HP : 60 HP
1. **Multiply force**: Change direction of force
   - Transform energy: (a) multiply work, (b) make energy, (c) multiply speed, (d) decrease friction

2. **Inclined plane**: Lever :: Wheel and axle: (a) car, (b) typewriter, (c) pulley, (d) screw driver

3. **Simple machine**: Complex machine :: (a) nail, screw, (b) wheel and axle: automobile, (c) lever, pulley, (d) wedge: axe

4. **Actual mechanical advantage**: Ideal mechanical advantage :: Work output: (a) efficiency, (b) work used in overcoming friction, (c) work input, (d) ideal effort

5. **AMA**: IMA: (a) friction: no friction, (b) speed: work, (c) force: effort, (d) efficiency: resistance

6. **Weight of object on inclined plane**: Force tending to pull object down plane :: Height of plane: (a) base of plane, (b) length of plane, (c) friction of plane, (d) material of which plane is constructed

7. **Wheel**: Axle: (a) horizontal, vertical, (b) track: parallel, (c) man: invention, (d) lever: fulcrum

8. **Inclined plane**: Stairs :: Lever: (a) step ladder, (b) fan, (c) key, (d) broom

9. **Saw**: Crow bar :: Pliers: (a) bolt, (b) scissors, (c) fan, (d) nail

10. \((R \times D_r = E \times D_e)\) :: Distance from fulcrum to resistance: (a) drag on effort, (b) distance between effort and resistance, (c) distance from fulcrum to effort, (d) decrease of effort
11. (For AMA) DISTANCE FROM FULCRUM TO EFFORT :: DISTANCE FROM FULCRUM TO RESISTANCE :: RESISTANCE:  
(a) fulcrum (b) lever (c) effort (d) torque  

12. GRAVITY :: VERTICAL MOTION :: TORQUE: (a) pull (b) horizontal force (c) slide (d) rotation  

13. (For no torque) 5 GM :: 4 CM TO RIGHT OF FULCRUM ::  
2 GM :: (a) 8 cm to right of fulcrum (b) 10 cm to left of fulcrum (c) 15 cm to left of fulcrum (d) 20 cm to right of fulcrum  

14. MORE WEIGHT ON RIGHT SIDE OF FULCRUM :: MORE WEIGHT ON LEFT SIDE OF FULCRUM :: (a) clockwise torque: counterclockwise torque (b) push: pull (c) AMA: IMA (d) anti-torque: no torque  

15. (For equilibrium) \( R \times D_e = E \times D_e \) :: 50 CM D_e ::  
20 CM D_e :: 100 GM E :: (a) 5 gm R (b) 100 gm E (c) 250 gm R (d) 500 gm R  

16. 1ST CLASS LEVER :: FULCRUM BETWEEN E AND R :: 2ND CLASS LEVER: (a) E at one end, R at other end (b) fulcrum and E at one end (c) fulcrum at one end, E at other end (d) E adjacent to fulcrum  

17. 1ST CLASS LEVER :: 2ND CLASS LEVER :: (a) scissors: pliers (b) see saw: wheel barrow (c) screw: nail (d) E : R  

18. 1ST CLASS LEVER :: MULTIPLY FORCE :: 3RD CLASS LEVER: (a) decrease friction (b) overcome IMA (c) increase energy (d) increase speed  

19. FULCRUM BETWEEN E AND R :: 1ST CLASS LEVER :: FULCRUM AT END, AND ADJACENT TO E: (a) 2nd class lever (b) 3rd class lever (c) wheel and axle (d) pulley  

20. SHOVEL :: BROOM :: FOREARM: (a) fishing pole (b) wrench (c) pulley (d) see saw  

21. 1ST CLASS LEVER :: E AND R OPPOSITE DIRECTION :: 3RD class lever: (a) E and R same direction (b) E and R opposite direction (c) multiply effort (d) increase work
22. **1ST CLASS LEVER**: CHANGE DIRECTION OF $E$ :: SINGLE FIXED PULLEY : (a) multiply effort (b) increase speed (c) increase inertia (d) change direction of $E$

23. **EFFORT** :: **FORCE** :: **RESISTANCE** : (a) load (b) overcome (c) IMA (d) energy

24. **LOSS IN SPEED** :: **GAIN IN FORCE** :: **LOSS IN DISTANCE** : (a) gain in work (b) gain in speed (c) gain in energy (d) gain in force

25. (For single fixed pulley) **EFFORT** :: **RESISTANCE** :: (a) fast : slow (b) gain in effort : gain in speed (c) AMA : IMA (d) down : up
9th GRADE PHYSICAL SCIENCE (INTRODUCTORY PHYSICS)
UNIT 18. SIMPLE MACHINES, PULLEYS, WHEEL AND AXLE
AND GEARS

1. SINGLE FIXED PULLEY : SINGLE MOVABLE PULLEY :
   (a) IMA 1 : IMA 2 (b) stationary R : Moving R
   (c) lever : wheel and axle (d) long rope : short rope

2. 1ST CLASS LEVER : PULLEY : SPIRAL INCLINED PLANE :
   (a) 3rd class lever (b) wedge (c) screw (d) axe

3. (For single fixed pulley) IMA : 1 ; AMA : (a) 0
   (b) 1 (c) less than 1, but not 0 (d) 2

4. LADDER : STAIRS : ELEVATOR : (a) heights (b) IMA
   (c) escalator (d) wheel and axle

5. BLOCK AND TACKLE : PULLEYS : WEDGE : (a) razor blade
   (b) double inclined plane (c) screw and screw driver
   (d) lever

6. TWO ROPES SUPPORTING R : IMA 2 ; THREE ROPES SUPPORTING
   R : (a) AMA 3 (b) IMA 3 (c) IMA 1/3 (d) AMA 2/3

7. (IMA of wheel and axle) WHEEL CIRCUMFERENCE : AXLE
   CIRCUMFERENCE :: WHEEL RADIUS : AXLE RADIUS :
   (a) wheel diameter (b) 2 x AMA (c) number of wheels (d) axle radius

8. DOOR KNOB : WHEEL AND AXLE : KEY : (a) lever (b) pulley
   (c) fulcrum (d) wheel and axle

9. (IMA of wheel and axle) R : E :: RADIUS OF WHEEL :
   (a) radius of axle (b) IMA : AMA (c) length of axle
   (d) diameter of wheel

10. KNIFE : NAIL : RAZOR BLADE : (a) screw (b) hammer
    (c) lever (d) pin

11. STEERING WHEEL : DOOR KNOB : SCREW DRIVER : (a) pliers
    (b) hammer (c) bicycle pedal and sprocket (d) spoon

12. 1ST CLASS LEVER : CHANGE DIRECTION OF EFFORT, MULTIPLY
    EFFORT :: 2ND CLASS LEVER : (a) change direction of
    effort (b) multiply effort (c) increase energy
    (d) increase speed
13. (For 3rd class lever) IMA : 3/4 :: AMA : (a) 7
   (b) 2 (c) 1 (d) 1/2

14. SINGLE FIXED PULLEY : 1ST CLASS LEVER :: SINGLE
   MOVABLE PULLEY : (a) 2nd class lever (b) 3rd class
   lever. (c) wedge (d) 1st class lever

15. JACKSCREW : CORKSCREW :: LID ON FRUIT JAR : (a) key
   (b) base of light bulb (c) tire (d) knife

16. DRIVEN WHEEL : RESISTANCE :: DRIVING WHEEL : (a) belt
   (b) effort (c) pulley (d) friction

17. BICYCLE CHAIN : SPROCKET :: BELT : (a) rope (b) effort
   (c) pulley (d) force

18. MOTOR, DRIVING WHEEL : BELT :: DRIVEN WHEEL : (a) fan
   (b) engine (c) power (d) effort

19. BUFFER JACK : CAR :: JACKSCREW : (a) cork (b) house
   (c) twist (d) effort

20. (For gears) GAIN EFFORT : LOSE SPEED :: LOSE SPEED :
    (a) gain effort (b) multiply work (c) increase friction
    (d) increase energy

21. 1ST GEAR : LOWEST SPEED, GREATEST EFFORT :: 3RD GEAR :
    (a) lowest speed, lowest effort (b) greatest speed,
    least effort (c) hydromatric (d) least speed, greatest
    effort

22. DRIVEN GEAR : CLOCKWISE :: DRIVING GEAR : (a) clockwise
    (b) counterclockwise (c) down (d) up

23. (With idler gear) DRIVEN GEAR : CLOCKWISE :: DRIVING
    GEAR : (a) clockwise (b) counterclockwise (c) down
    (d) up

24. KNIFE : WEDGE AND LEVER :: SISSORS : (a) wheel and axle
    (b) wedge and lever (c) rope and pulley (d) plier

25. (For IMA) RADIUS OF DRIVING WHEEL IS 20 CM : RADIUS
    OF DRIVEN WHEEL IS 10 CM :: RESISTANCE IS 100 GM :
    (a) effort is 10 gm (b) effort is 20 gm (c) effort is
    50 gm (d) effort is 100 gm
APPENDIX B

ANALOGY ITEM VALIDATORS
ANALOGY ITEM VALIDATORS

1. Escue, Richard B., Ph.D., Professor of Chemistry at North Texas State University, Denton, Texas, member, Texas Education Agency committee on physical science education in public schools.

2. Harris, Jesse, B.S. Chemistry, M.Ed. School Administration, science consultant for Dallas, Texas, ISD for twelve years, twenty-four years in science education.

3. Little, R. N., Ph.D., Professor of Physics and Education at University of Texas at Austin, Texas, member, Texas Education Agency committee on physical science education in public schools.

4. Terrell, Glen, Ph.D., Assistant Professor of Physics at University of Texas at Arlington, Texas, science consultant for Education Department, also teacher of physical science laboratory methodology for public school teachers.
APPENDIX C

CRITERIA FOR VALIDATING ANALOGY ITEMS
Criteria Used by Panel in Validating Analogy Items

For Validity:

1. The content must be appropriate for 9th grade level.
2. The items must be stated in correct scientific terms.
3. There must be a relationship established in each item and the relationship may be one of several types, such as:
   a. purpose
   b. cause and effect
   c. part vs. whole
   d. part vs. part
   e. action to object
   f. object to action
   g. synonym
   h. antonym
   i. person or place
   j. degree
   k. characteristic
   l. sequence
   m. numerical
   n. association

4. The items must be of a TYPE I, II or III analogy format, such as:
   TYPE I. X : Y :: Z : (a), (b), (c), (d).
   (Read "X is to Y, as Z is to ".)
   TYPE II. X : Y :: (a):__, (b):__, (c):__, (d):__;
   TYPE III. X : Y :: (a), (b), (c), (d) : Z.

5. Approval by three of the four experts constitutes validation of an item.

Will you please make a notation by each item which in your opinion is not valid for the purpose at hand?
APPENDIX D

GUIDE FOR WORKING WITH ANALOGY-STRUCTURED TEACHING
PLAN FOR WORKING WITH TEACHERS

1. The Science Consultant and the researcher will select six teachers from the volunteers. Three will serve the control groups, while the other three serve the experimental groups. The experimental teachers will be determined from expressed interest and willingness to try analogies. Each of the six teachers will select one of his classes, which he considers to be representative. From results of the pre-test, control group students in the upper third will be administratively grouped as the high ability group, the middle third will be the middle ability group and the lower third will be the low ability group. The experimental groups will follow the same procedure.

2. Each of the six teachers must have a minimum of two years experience in physical science within the present school district. In addition, they must be full time physical science teachers. It will be emphasized to the these six teachers that the results of the study will, in no manner, be used as an evaluation of teacher effectiveness.

3. Other than being informed of the nature of the experiment, and conducting a pre-test and a post-test, the three control group teachers will instruct their classes in the usual manner.

4. At the beginning of school in-service training, the researcher will spend approximately two hours discussing procedures with the experimental groups teachers. This orientation will consist of the following:

   I. DISCUSSION

   A. Present dilemma in teaching science
      1. Analogies as a possible solution
   B. Theory of Analogies
      1. Thorndike, James and others
      2. Miller Analogy test, and other tests
C. Analogy format and types of analogies  
D. Experimental set-up and procedures  
   1. Materials provided by researcher  
   2. Grading of items by researcher  
E. Hypotheses  
F. Analogy item development and validation  
G. Achievement tests  

II. PRACTICE  
A. Heading on answer sheets  
B. Teachers respond to a set of analogies  
C. Review responses and demonstrate teacher's role in leading discussion  
D. Stress importance of relationships  

III. OTHER DISCUSSION  
A. Regard analogies as another teaching tool  
B. Importance of minimizing "Hawthorne Effect"  
C. Student grades on analogy items  

5. The pre-test for all groups will be on Friday of the first school week.  

GUIDE TO ANALOGY-STRUCTURED-TEACHING  

1. Analogy items will be based on the following curriculum outline:  

<table>
<thead>
<tr>
<th>Semester</th>
<th>Topic</th>
<th>Weeks</th>
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<tr>
<td>Fall</td>
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<td>Matter and Energy</td>
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<td>Molecular Theory, Structure of Atoms</td>
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2. Each week students will be given twenty-five analogy questions and an answer sheet. The heading on the answer sheet will be completely filled in by each student. The answers will be marked on the question sheet, as well as on the answer sheet. The answer sheet will be collected for grading by the researcher. The question sheet with answers marked on it will be kept by the students for class discussion and study. The student will get an idea of his grade by checking his answers during the class discussion.

3. Approximately one class hour per week will be devoted to analogies. Half the period will be used for responding to the analogy items and the other half for teacher lead discussion of relationships involved. After students have turned in the answer sheet, the instructor should discuss each analogy item by pointing out the relationship between the first two words, then by considering each possible answer to determine if a similar relationship can be found. Possibly the best way to establish the correct answer is to state the word or phrase which shows the relationship between the first two words. Example: OZONE : O :: DIAMOND :
(a) glass (b) jewel (c) ruby (d) carbon. Ozone is a form of the element oxygen. "Diamond is a form of the element ..."
(a) Certainly, diamonds are not made from glass.
(b) A diamond is a jewel, but an element in jewels is not specified which will make a diamond.
(c) Ruby is a precious stone like diamond, but again, there is no element specified which will make a diamond.
(d) The answer has to be carbon, because diamond is a form of the element carbon.

Example: PROJECTILE : TRAJECTORY :: SATELLITE : (a) planet (b) space (c) orbit (d) rocket. A projectile has a trajectory (path). "A satellite has a ..."
(a) A planet can have a satellite, but the inverse is not true.
(b) One thinks of outer space in association with a satellite, but this has nothing to do with the relationship we're seeking.
(c) A satellite does have an orbit, or path, so this is the correct answer since it has the same relationship as the first two key words.
(d) 'A satellite has a rocket' does not fit the relationship.
4. Every two weeks the researcher will contact each experimental teacher. At this time the researcher will collect the answer sheets for grading. The answer sheets will be retained by the researcher, but the grades of all the students for each analogy set will be submitted to the teacher for use at his discretion.

5. The researcher will maintain a log on his bi-weekly contacts with the experimental teachers. Dates will be entered as well as comments to pertinent questions and discussions on analogies.

6. Results of the experiment will be provided to each participating teacher.
APPENDIX E

TABLES FOR UNADJUSTED MEANS AND STANDARD DEVIATIONS
TABLES FOR UNADJUSTED MEANS AND STANDARD DEVIATIONS

TABLE A
UNADJUSTED MEANS AND STANDARD DEVIATIONS
(3 x 2 An of Cov) FOR CHEMISTRY CONTENT
OF PHYSICAL SCIENCE

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TABLE B
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TABLE C
UNADJUSTED MEANS AND STANDARD DEVIATIONS
(3 x 2 An of Cov) FOR OVERALL
PHYSICAL SCIENCE

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TABLE D

UNADJUSTED MEANS AND STANDARD DEVIATIONS WITH
ONE-WAY ANALYSIS OF COVARIANCE FOR STUDENTS
IN CHEMISTRY CONTENT

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TABLE F

UNADJUSTED MEANS AND STANDARD DEVIATIONS WITH
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