SHORT TITLE FOR USE

ON

BINDING

<u>THE USE OF OBJECTIVE TESTS FOR REVIEW IN CHEMISTRY</u>

AN EXPERIMENT IN THE USE OF OBJECTIVE TESTS OF THE MULTIPLE-CHOICE TYPE FOR REVIEW AND MOTIVATION IN THE TEACHING OF HIGH SCHOOL CHEMISTRY

by

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CHAPTER I

OUTLINE OF THE RESEARCH

The high schools of the West Island School Commission are operated on the subject promotion system. In this system the High School Leaving Chemistry course as prescribed by the Quebec Department of Education is offered as a one-year option to students of grades ten and eleven. This experiment made a field study of the learning effect of short, multiple-choice tests given at the end of each chapter of work in first-term chemistry. The first term extended from September 1965 to mid-January 1966 and the end of term examinations in January were used as the criterion measure. These examinations were composed in part of objective questions of the multiple-choice type and in part of descriptive questions requiring essay answers.

This experiment involved two high schools, seven chemistry teachers, twenty-one chemistry classes and five hundred and twenty-four chemistry students. The chemistry classes were assigned at random to experimental and control groups, ten being experimental and eleven control. Each teacher taught at least one experimental and one control class.

The experimental classes were given a short, multiple-choice, review test at the end of each chapter of work in first-term chemistry. Students in these classes corrected their own tests and kept their own test records. The control classes were taught by the teachers' usual methods and did not make use of any of the materials provided to the experimental classes.

High School Leaving Chemistry is a first course in chemistry and therefore no pre-test was used in this experiment. The Permanent Record Cards were consulted for each student involved to obtain age, I.Q. score, Preliminary Scholastic Aptitude Test, Verbal and Mathematical scores and grade nine general science examination results.

In addition to comparing experimental and control groups as a whole, experimental and control students were compared within the four sub-groups, (a) boys, (b) girls, (c) students new to chemistry and (d) students repeating chemistry.

It was hypothesized that in all sub-groups, the experimental students would perform better on the January examinations than the control students. As a result of the experiment, the following conclusions were reached:

1. With the exception of the sub-group of repeating students, in all sub-groups, and on the whole, the experimental students performed better than the control students. The differences were not significant at the .05 level but were consistent in favouring the experimental students.
2. The superior performance of the experimental students in all but one of the sub-groups was evident on both the objective and the descriptive sections of the criterion examinations.
3. In the sub-group of repeating students the control students performed better than the experimental students in all comparisons, one difference being significant at the .05 level.
4. There was neither a significant nor a consistent difference in the effect of the experimental program on the boys and girls sub-groups.

CHAPTER II

REVIEW OF THE LITERATURE

Early Experiments

Interest in the new-type or objective examinations in the early 1930's resulted in several experiments designed to evaluate the effect of these examinations on learning. Kulp[1] gave weekly tests to graduate students. Those students achieving a place in the upper half of the group on a mid-semester examination were excused from the weekly testing program while those in the lower half continued the weekly tests. Kulp found that on the end of semester examination the lower half students did much better in relation to the upper half students than they had at mid-semester. The method of selection of control and experimental groups indicates that regression would account for some, if not all of the relative improvement noted. Kulp attributed all of the improvement to the testing program. His work is

[1]D. H. Kulp, "Weekly Tests for Graduate Students," School and Society, XXXVIII (July 29, 1933), pp. 157-159.

cited without criticism by Keys[2] and by Lee and Symonds[3].

Turney[4] prepared two equivalent forms of an objective examination and gave one of the forms as a pre-test to two sections of students of educational psychology at the first class meetings. Selecting the section with the lower mean score as his experimental group, he gave them weekly tests throughout the semester. The control section did not have the weekly tests. Both sections were given the equivalent form of the pre-test as a final end test. Turney found no significant difference between scores of the sections on the final test and attributed this gain of the experimental group to the weekly testing program. "It can only be said that the experimental group gained the 23 points more than did the control, and that this gain was apparently due to the motivating effect of the short quizzes."[5] In this experiment, as in Kulp's, regression would account for some, if not all, of the relative gain of the

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[2]N. Keys, "The Influence on Learning and Retention of Weekly Tests as Opposed to Monthly Tests," Journal of Educational Psychology, XXV (September 1934), pp.427-36.

[3]J. M. Lee and P. M. Symonds, "New Type or Objective Tests: A summary of Recent Investigations," Journal of Educational Psychology, XXV, pp. 161-84.

[4]A. H. Turney, "The Effect of Frequent Short Objective Tests upon the Achievement of College Students in Educational Psychology," School and Society, XXXIII (June 1931), pp. 760-62.

[5]Ibid., p.762.

experimental group. Turney's work is cited by Ross and Henry[6] and by Keys[7] without comment on the procedure for selection of control and experimental groups.

Although the experiments of Kulp and Turney support the hypothesis that frequent testing will result in efficient learning, both have a weakness in design such that the evidence they present must be discounted.

Experiments presenting valid evidence

Four papers reporting experiments dealing directly with the question of whether or not the testing process itself contributes to learning are to be found in the literature. Two of these papers claim that the testing process does contribute, two claim that it does not.

Jones[8] conducted a number of experiments with university psychology classes to determine the effect of testing on the retention of subject material presented in a lecture. The first series of experiments consisted of completion-type tests given at times ranging from

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[6] C. C. Ross and L. K. Henry, "The Relation between Frequency of Testing and Learning in Psychology," Journal of Educational Psychology, XXX (November 1939), pp.604-11.

[7] Keys, Journal of Educational Psychology, XXV (September 1934), pp. 427-36.

[8] H. E. Jones, "Experimental Studies of College Teaching," Archives of Psychology, X (1923), Paper # 68.

immediately following the lecture to eight weeks afterwards. In this series, Jones was able to determine the curve of forgetting for lecture material. He then proceeded to a series in which he tested immediately following a lecture and retested at intervals ranging from one to seven days. His results indicated that the retention of students not tested immediately following the lecture declined as in his previously established curve of forgetting. The retention of students who were tested immediately following the lecture tended to remain, on retest, at or near the high retention established on immediate testing. He summarized, ". . . the effect of immediate examination, for this type of material, is to maintain the retention measure practically constant, . ."[9]

Working again with psychology lectures, Jones gave a five-minute quiz at the end of lecture A but not at the end of lecture B. He found that the salient points of lecture A were remembered better than those of lecture B at delay intervals ranging from four days to two weeks.

In another experiment, Jones gave five minute

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[9] Ibid., p.38

tests at the end of each lecture and continued for twenty-seven lectures. He determined that when tests were given at delay intervals of from three days to eight weeks, material that was being retested was always retained better than that which had not been included in the test immediately following the lecture.

From the results of his work, Jones drew the conclusion that:

> A test may be valuable in orienting the students toward important points to be studied and reflected upon after class. But its essential efficacy, as demonstrated, lies in the strengthening of recall connections during the actual test period - a strengthening much greater in degree than that which could be accomplished by the same amount of time devoted to mere re-impression.[10]

A weakness in Jones' work is that in retesting he used the same completion items that he had used in the tests immediately following the lectures. Thus the better performance of students on retesting might be due in part to recognition of items that they had seen before.

Ross and Henry[11] also worked with general psychology classes at the university level. Each of the authors taught two sections of psychology, one as an experimental group, the other as a control. Experimental

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[10]Ibid., p.59.

[11]Ross and Henry, Journal of Educational Psychology, XXX (November 1939) pp. 604-11.

and control groups did not differ significantly in results on a pretest covering the whole course given at the first meetings of the classes. The experimental groups had a thirty item objective test weekly, the control groups did not. Experimental and control groups had the same examinations, namely one hour mid-term and two hour at the final stage. The superiority of the experimental groups over the control groups on the final examination was significant at the five per cent level. The experiment was repeated with two classes of educational psychology. There was no significant difference between experimental and control groups on either pretest or final test.

Although not stated specifically by the authors, the implication contained in the paper cited above is that the educational psychology course was a second course in psychology and followed the general course. If this was the case, it may be that if the result of testing is improved learning, it is most likely to be with beginning students in a subject.

Hertzberg, Heilman and Leuenberger[12] report an

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[12] O. E. Hertzberg, J. D. Heilman and Leuenberger, H. W. "The Value of Objective Tests as Teaching Devices in Educational Psychology Classes," Journal of Educational Psychology, XXIII (1932), pp. 371-80.

experiment conducted with educational psychology students at Colorado State Teachers' College. Using the technique of pairing, the authors established experimental and control groups of eighty-six students each. The experimental group was given an objective test at the end of each unit of work and the control group was not. On the final examination, which was not similar to the objective unit tests, there was no significant difference between the two groups. In conclusion, the authors state, "This study would indicate that objective tests used as aids to general study throughout a course have little value for permanency of retention."[13]

In a course in American Government, Selakovich[14] matched nineteen pairs of students using the Cooperative Test in American Government, Form Y. The experimental group was given twelve instructor-made "pop quizzes" (sic - not described, but presumably some form of objective test). During the semester, the control group was given no tests. There was no significant difference between the results of the two groups on the final examination.

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[13]Ibid., p.375

[14]D. Selakovich, "An Experiment Attempting to Determine the Effectiveness of Frequent Testing as an Aid to Learning in Beginning Courses in American Government," Journal of Educational Research, LV (December-January 1962) pp. 178-80.

Related Experiments

In addition to those papers which deal directly with the contribution of testing to learning, there are several reporting related experiments. Jersild[15] used a pre-examination, teaching, criterion-examination technique and found that students who had been given a pre-examination of either multiple choice or essay type did better on the criterion examination than those who had not been given the pre-examination. The criterion examination was, however, the same as the pre-examination, so that the question arises as to whether the students pre-examined actually learned more because of this or whether they scored better because of familiarity with the questions.

Pathael, Fitzpatrick and Bischof[16] found that students did better on those questions on a final examination which had appeared on previous tests than they did on those questions which had not. This effect might account for some of the results of Jones and Jersild cited previously.

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[15] A. T. Jersild, "Examinations as an Aid to Learning," Journal of Educational Psychology, XX (1929), pp. 602-09.

[16] L. I. Pathael Jr., E. D. Fitzpatrick, and L. J. Bischof, "Comparison of the Extent of Retention Accompanying the Use of Three Teaching-Testing Procedures," Journal of Educational Research," XLVII (1953), pp.65-70.

Keys[17] used true-false tests and gave experimental and control groups the same content and amount of testing. The difference in treatment of the groups was that the experimental group was tested in brief, weekly installments while the control group had long, mid-term examinations. There was no significant difference in the results of the two groups on the final examination.

White[18] attempted to determine the motivating effect of complete advance information as to the nature and content of the final examination. Both experimental and control groups were given weekly true-false tests. The experimental group was told that fifty per cent of the course mark would be determined by the weekly test results and the other fifty per cent by a final examination consisting of the same questions as in the weekly tests. The control group was told that the entire course mark would be based on weekly tests and that there would be no final examination, yet both groups were given the final examination. The experimental group scored more than on the weekly tests and the control

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[17] N. Keys, The Influence on Learning and Retention of Weekly Tests as Opposed to Monthly Tests," Journal of Educational Psychology, XXV (September 1934), pp. 427-36.

[18] H. B. White, "Testing as an Aid to Learning," Educational Administration and Supervision, XVIII (January 1932), pp. 41-46.

group scored less. White attributed this difference to a pre-knowledge of the final examination content on the part of the experimental group. This pre-knowledge may not have accounted for all of the difference. The control group students must have felt betrayed when confronted with such an examination. This feeling would not likely have been dissipated completely by the assurance that the examination would not count and the urging to do as well as possible anyway that accompanied its presentation.

Effect on study procedures

Discussing the differences in study procedures used by students preparing for essay and objective examinations, Cook states that:

> In preparing for essay-type examinations, students tend to outline and organize material systematically in large units, emphasizing relationships, trends and personal reactions. In preparing for the broad sampling type of factual objective examinations, students emphasize factual details, names, dates, and results of specific experiments."[19]

The implication is that higher level mental processes are called upon by the student in preparing for

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[19]W. W. Cook, "The Functions of Measurement in the Facilitation of Learning," Educational Measurement, ed. E. F. Lindquist (Washington: American Council on Education, 1951).

essay examinations while objective examinations bring forth only memorization of minutiae. This would seem to be refuted by Vallance's work in high school social science. The second of the three hypotheses in his experiment was, "Apart from any differences in the actual examinations, the methods of preparing for the essay type of examination are superior as learning procedures to those used in preparing for objective examinations, . ."[20] Vallance considered his results to have refuted this hypothesis.

Differences related to I. Q.

With multiple choice test items in a pre-test, teach, re-test situation in high school physics, Cocks[21] found that on retesting the improvement in score was greater for students of high I. Q. than for those of low I. Q. The experimental groups of Ross and Henry[22] had objective tests weekly and showed a gain on the final

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[20]T. R. Vallance, "A Comparison of Essay and Objective Examinations as Learning Experience," Journal of Educational Research, XLI (1947), pp. 279-88.

[21]A. W. Cocks, "The Pedagogical Value of the True-False Examination," (D. Paed. Thesis, University of Toronto.)

[22]Ross and Henry, Journal of Educational Research, XXX (November 1939), pp. 604-11.

examination over the control groups which did not have the weekly tests. The gain was much more marked for the weaker students in the experimental groups. Cook[23] states that weekly tests help low ability pupils at the college level when the final examination is made up of questions of the same type, but that higher ability pupils may be retarded by this process. He offers no experimental evidence to support this statement. The question of the relationship of the learning effect due to testing to I. Q. cannot be considered to have been settled.

Effect of method of correction

Several investigators have studied the relationship between knowledge of quiz results and achievement on an end of course criterion examination. With one exception, the findings favour immediate and full knowledge of results over delayed knowledge, partial knowledge and no knowledge of results.

Angell[24] gave two first semester general chemistry classes the same three mid-term multiple choice quizzes at the same hour on the same days. The

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[23] W. W. Cook, Educational Measurement

[24] G. W. Angell, "The Effect of Immediate Knowledge of Quiz Results on Final Examination Scores in Freshman Chemistry," Journal of Educational Research, XLII (1949), pp. 391-94.

experimental group, using punchboards, gained immediate knowledge of results. The control group, using I. B. M. answer sheets, received no official information concerning quiz results until the next class meeting. At the next class meeting of each group, quiz papers were returned and the full fifty minute period was devoted to a discussion of the quiz. On the one hundred item, multiple choice criterion examination, there was a difference in favour of the experimental group that was significant at the one per cent level. Angell's punchboard technique for quizzes is similar to the early experiments in the field of programmed learning.

Panlasigui and Knight[25] pre-tested to establish 358 matched pairs of fourth grade students. Both experimental and control groups used a series of drill units on fundamentals of arithmetic. Each student in the experimental group kept a progress chart in the form of a graph; those in the control group did not keep any record of progress. The top quarter of the experimental group gained significantly over the top quarter

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[25] I. Panlasigui and F. B. Knight, "The Effect of Awareness of Success or Failure," Chapter Two in the <u>Twenty-ninth Yearbook of the National Society for the Study of Education</u>, (Bloomington, Ill.: Public School Publishing Co., 1930).

of the control group. There was no significant difference between the lowest quarters of the two groups. The authors concluded that, "The beneficial effect of awareness of success, then was substantially in direct proportion to the amount of success available for motivation."[26] Knowledge of lack of success did not affect adversely the lowest quarter of the experimental group. There was no significant sex difference in the gain by the top quarter of the experimental group.

The results of Brown's[27] work agreed with those of Panlasigui and Knight in that knowledge of progress resulted in a greater degree of success on the criterion test. They differed in that Brown found a sex difference; the difference between groups with knowledge of progress and those with no knowledge was significantly greater among boys than among girls. He also found that the difference was less among younger children than among older children.

Ross[28] disagreed with those who found some teaching value in a knowledge of the results. Working

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[26] Ibid., p.615

[27] F. J. Brown, "Knowledge of Results as an Incentive in Schoolroom Practice," Journal of Educational Psychology, XXIII (October 1932), pp.532-52.

[28] C. C. Ross, "The Influence Upon Achievement of a Knowledge of Progress," Journal of Educational Psychology, XXIV (November 1933), pp.609-19.

with a total of 296 students in five university classes, Ross did two series of experiments in which he allowed students to have varying degrees of knowledge of results. One group was not given any results of tests, a second group was given vague results - fair, good, et cetera, a third group was given only scores, and the fourth group had scored papers returned for discussion. Ross states that, ". . . nowhere is there a statistically significant difference among the four groups."[29] and goes on to say that, ". . . the knowledge of progress is equally impotent in influencing the achievement of students making high scores and those making low scores."[30]

Over a four year period, Curtis and Woods[31] studied four methods of correcting objective examinations. They used pupils of grade levels from seven to eleven. The method in which pupils corrected their own papers in the class period following the examination proved superior in teaching value to three different methods of teacher correction.

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[29]Ibid., p.613.

[30]Ibid., p.618.

[31]F. D. Curtis and G. G. Woods, "A Study of the Relative Teaching Values of Four Common Practices in Correcting Examination Papers," School Review, XXXVII (1929), pp. 615-623.

Cocks[32] also found that pupils who corrected their own tests had an advantage over those who did not and that they maintained this advantage on a delayed retest given three weeks later.

Lingren[33] set up an experiment to evaluate four methods of correcting objective tests in chemistry. Criteria were retests without warning at three day and six week delay intervals. He found that a method in which students checked their own papers as the teacher read out the correct responses proved to be the best from a teaching standpoint. It gave to those students with whom it was used an advantage on both delay tests.

Citing Panlasigui and Knight[34], Cook concludes that, "Logic and experimental evidence indicate that in the test situation the more immediate and direct the student's knowledge of when and why he is correct and when and why he is incorrect, the greater the tendency to fixate the correct responses."[35]

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[32] Cocks, (D. Paed. Thesis, University of Toronto.)

[33] V. C. Lingren, "The Relative Instructional Values of Four Methods of Correcting Objective Tests in High School Chemistry," Science Education, XIX (October 1935) pp. 123-27.

[34] Panlasigui and Knight, Twenty-ninth Yearbook of the National Society for the Study of Education.

[35] Cook, Educational Measurement, p.42.

Rationale

Without providing corroborative experimental evidence, several authors claim learning values for objective testing and offer a rationale. Jersild holds that such tests require rehearsal and recapitulation of previous learning and put pressure on the student to participate more actively in the learning situation. He states that the multiple choice question, ". . . comes rather as a challenge to the individual's attention and as an instigator of doubt and perplexity."[36] According to Wrightstone, "the test exercises, properly constructed help to clarify and to refine the objectives for teacher and pupil."[37]

Flook[38] reports that the dogmatic nature of the objective question led to good results when used as a take-off point for subsequent discussion. Michel[39]

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[36]Jersild, Journal of Educational Psychology, XX (1929), p. 609.

[37]J. W. Wrightstone, "The Relation of Testing Programs to Teaching and Learning," Chapter Three in the Sixty-second Yearbook of the National Society for the Study of Education, (Chicago: the Society, 1963).

[38]A. J. M. Flook, "Note on the Use of New-Type Tests for Improving the Quality of Discussion in Discussion Groups," British Journal of Educational Psychology, XXIX (1959), pp. 261-63.

[39]E. Michel, "Teaching Values in New-Type History Tests (New York: World Book Co., 1930).

found value in the objective test as a means of cutting through the wall of verbiage thrown up by students on essay examinations.

The strongest statement in support of the idea that there are teaching values in testing is provided by Cook who states that:

> When test items approximate the situations in life in which learning will function, each item is not only an excellent test item, but a good teaching question as well. Such an examination becomes an effective learning device because it requires thought and problem-solving effort, and not mere recall or recognition of previous learning. Because of the additional motivation resulting from the test situation, it is probable that more learning takes place during the examination period than during any other equal period of learning time."[40]

Of these authors claiming learning values for testing, only Jersild provides experimental data. No tests of statistical significance are offered nor is the information supplied which would be required to perform them.

Chemistry teaching experiments not involving testing

Anderson, Montgomery and Moore[41] used a total of thirty-three high school chemistry classes in an

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[40]Cook, Educational Measurement, p. 42

[41]K. E. Anderson, F. S. Montgomery and S. F. Moore, "An Evaluation of the Introductory Chemistry Course on Film," Science Education, XLV (April 1961), pp. 254-69.

experiment to evaluate the effectiveness of an introductory chemistry course on film. They found that the conventionally taught classes were superior to the film-taught classes in measured achievement. Reports of students' reactions seemed to indicate that a full year's course on film was just too much film - boredom set in after the novelty had worn off. The course used was the 160 color film Encyclopaedia Britannica course.

Mallinson[42] cites research by Krause which determined that high school students who did not keep science notebooks performed as well as those who did keep notebooks on tests measuring factual knowledge, the development of scientific attitudes and the ability to apply principle.

Nelson[43] taught a high school chemistry unit on Sulphur to an experimental group using appropriate

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[42]G. G. Mallinson, "The Implications of Recent Research in the Teaching of Science at the Secondary School Level," Journal of Educational Research, XLIII (January 1950), pp.321-342, citing P. E. Krause, "Evaluation of the Pupil-Made Notebook in Relation to Certain Measurable Outcomes in the Teaching of General Science," (Ph.D. Thesis, New York University).

[43]C. M. Nelson, "Effectiveness of Sound Motion Pictures in Teaching a Unit on Sulfur in High School Chemistry", School Science and Mathematics, LII (January 1952), pp. 8-10.

movies along with classroom presentation. The control group did not see the movies. He found a significant difference in favour of the experimental group on a test given at the conclusion of the unit and also on a retest given without warning five weeks later.

Clark[44] compared three different methods of teaching high school chemistry, a workbook method with little teacher amplification, the regular lecture-recitation method and the method credited to H. C. Morrison of the University of Chicago. This last method was an elaborate one involving: (1) a pre-test to determine the student's orientation to the topic to be presented, (2) lecture teaching and review of the topic in one class period and testing on it in the next, (3) reteaching and retesting students achieving less than eighty-five per cent on the first test, this process continuing until the entire class had been brought up to the eighty-five per cent level. According to Clark, Morrison had claimed that his technique would

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[44]R. V. Clark, "A Comparative Study of Classroom Methods in the Teaching of Chemistry," (M. A. Thesis, University of Alberta).

result in more permanent learning. Clark's comparison of the results of classes taught by the different methods on June [end of course] and September [with two months' delay] examinations did not support this claim. Clark presented no statistical tests of significance of any kind and provided no bibliography.

Shampo[45] compared group use of a game called Chemo with individual study of the same chemistry facts presented on mimeographed sheets. There was no significant difference between the groups when tested on the material.

Colyer and Anderson[46] compared two methods of teaching the writing of molecular formulas. The control groups were taught to match radicals and the experimental groups were taught a sequence method involving diagramming of the empirical formulas. Analysis of covariance showed a difference in favour of the experimental group that was significant at the five per cent level.

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[45]M. A. Shampo, "A Comparative Study of Two Teaching Methods in High School General Chemistry," (Ph.D. Thesis, University of Wisconsin).

[46]L. M. Colyer and K. E. Anderson, "A Comparison of Two Methods of Teaching Formula Writing in High School Chemistry," School Science and Mathematics, LII (January 1952) pp. 50-59.

With a random selection of classes for experimental and control groups, Boeck[47] compared the use of an inductive-deductive approach with a deductive-descriptive approach. Comparisons were made on four objectives: (1) knowledge of facts and principles of chemistry, (2) applications of chemical principles to new situations, (3) knowledge of and ability to use the scientific method with accompanying scientific attitude, (4) ability to perform in the laboratory. The experimental groups, taught by the inductive-deductive approach, had a significant advantage on measures (3) and (4).

In the field of research on the teaching of high school chemistry there seems to have been more studies of the single topic of a comparison between Lecture Demonstration and Individual Laboratory Method than on all other aspects combined. While laboratory and demonstration work is not within the scope of this thesis, it is interesting to note that Cunningham[48]

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[47] C. H. Boeck,"Teaching Chemistry for Scientific Method and Attitude Development," Science Education, XXVII (March 1953) pp. 81-84.

[48] H. A. Cunningham, "Lecture Demonstration Versus Individual Laboratory Method in Science Teaching - A Summary," Science Education, XXX (1946) pp. 70-82.

was able to cite thirty-seven different investigations on this single topic. Smith and Anderson[49] have commented on this unusual fascination of so many researchers with such a small corner of the entire field. It would be fair as a general summary to say that the two methods, lecture demonstration and individual laboratory, were found to be equally effective in producing learning of the informational type but that the individual laboratory method was more effective in producing learning of manipulatory skills.

Summary

It is evident that research to date has produced no consensus with regard to the contribution of testing to learning. The early experiments lack design validity and of the four more recent experiments that appear to present statistically valid results, two contend that testing does contribute to learning and two contend that testing does not contribute to learning. A related question also appears to remain inadequately answered. One study supports the hypothesis that study techniques used in preparing for essay examinations are superior to those used in preparing for objective examinations and another

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[49] H. A. Smith and K. E. Anderson, "Science", Encyclopedia of Educational Research, Third Edition.

study refutes this same hypothesis.

The only study examining the relative effectiveness of a few long tests versus many short tests, total testing time being equal, concludes that there is no significant difference in learning effect. Both long and short tests were of the true-false type so that no comparison of the effects of objective versus descriptive tests was made. In two studies of improvement of scores on retesting there is also disagreement. One concludes that high I. Q. pupils show greater improvement than low I.Q. pupils while the other concludes just the opposite.

When one considers the amount of time spent in schools by pupils in writing tests and teachers in correcting them and takes into account the fact that most class tests are given on the assumption, implied or stated, that without them pupils will not learn as well as with them, it is surprising to note the lack of evidence in the literature for the efficacy of testing in producing learning. Surely an activity which consumes such a large part of the time at our disposal for educating children should be examined more closely to determine whether or not it produces results sufficient to justify the time expended on it.

CHAPTER III

BACKGROUND OF THE EXPERIMENT AND STATEMENT OF THE PROBLEM

The Department of Education of the Province of Quebec announced in the 1964-65 school year that the High School Leaving Examinations in all subjects might contain objective questions up to a maximum of thirty per cent of the value of the paper. Most of the examinations of June 1965 did have an objective section and in at least one, the Chemistry examination, this comprised forty per cent of the value of the paper. Objective questions had appeared on High School Leaving Examination papers before, but not in such quantity, nor on as many papers and certainly not as the result of a policy statement by the Department of Education.

The influence of examinations on curriculum and teaching methods is well known and need not be discussed here. Suffice it to say that the announced policy of the Department of Education stimulated considerable discussion among teachers of High School Leaving Examination subjects. Is there a practice effect? Should class tests and term examinations be, at least in part, objective so that students will be used to this type of question? If class tests were objective only, would the students suffer on the descriptive section of a subsequent examination? The whole question of how many and what kind of tests are necessary for efficient learning was reexamined in many a staff room discussion.

It was in this climate that the writer decided to examine the learning effects of objective testing in Chemistry. The basic question to be answered was, "Would students given frequent, short, objective tests [the experimental group] perform better on a criterion examination than students who were not given such tests [the control group]." Secondary questions were:

1. If the criterion examination were part objective and part descriptive, would there be any difference between the experimental and control groups on either part?
2. Would there be any difference in the effect of the testing program between boys and girls or between students new to chemistry and those repeating the course?

In order that the testing program fit the course of study as closely as possible and that the tests be of the type that any experienced teacher might make for his own use, the writer constructed the tests instead of making use of commercial tests designed for other chemistry programs. To simplify the testing program, only multiple-choice items with four possible answers were used. Participating teachers pointed out ambiguities and errors in several of the items and these will require correction if the program is to receive further use.

The purpose of this study was to determine whether or not frequent testing had a review or motivating effect that would improve learning as measured by a criterion examination. No attempt was made to measure the effectiveness of the tests themselves as instruments of evaluation. An item analysis of the tests in a subsequent study would be required to provide this information.

General Conditions Under Which the Program was Carried Out

This experiment was carried out in the course of the normal program of two high schools and as such was not subject to the same strict controls that might have been feasible in a laboratory experiment. Each teacher involved in the study maintained his own individual approach to the teaching of chemistry with both experimental and control classes. Each teacher proceeded at his own rate through the work of the first term although it was generally agreed at the start that, given the content of the course and the length of the school year, the material of the first thirteen or fourteen chapters of the text-book would probably have to be taught before the January end-of-term examinations.

As might be expected, each teacher had an individual opinion concerning the learning effect of thirteen or fourteen short, end-of-chapter objective tests versus the two or three more traditional full-period class tests. The most common concern was that because each of the tests covered only a single chapter and was to be given immediately following the teaching of that material, the marks would tend to be higher than on the traditional tests and that therefore the students would coast and do poorly on the end-of-term examination. The fact that the tests were designed so that each student corrected his own test immediately after completion was also a cause for concern. It was felt that some students would inflate their marks and keep a record that would delude them as to their true standing in the course. Some teachers felt that the testing program would prove to be a help to the student and to the teacher through relief from correcting. It would be fair to say that at the beginning of the program the participating teachers had mixed feelings with regard to the possible effects on the teaching-learning process. Even those who felt that it might be beneficial wanted assurance that it would be carried on during the first term only.

CHAPTER IV

DESIGN OF THE EXPERIMENT

The purpose of this study was to evaluate the effect of a short, multiple-choice, review test given at the end of each chapter of work in first-term chemistry. The tests were designed to review the text material required by the Quebec Department of Education syllabus for the High School Leaving Chemistry course.[1] This course is completed in one year in the schools of the West Island School Commission. Tests were prepared on the first fourteen chapters of the work, the maximum that any of the participating teachers felt could be taught during the first term, September to mid-January.

The West Island School Commission operates three high schools and permission was obtained from Mr. C. W. Dickson, Director of Studies, to approach the principals and heads of science departments for their cooperation. This cooperation was readily

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1. Department of Education, Quebec, Syllabus to accompany Elements of Chemistry, (Revised in June 1965).

obtained and a brief outline of the intent of the experiment [Appendix A] and instructions for administering the tests [Appendix B] were provided for each participating teacher. A supply of Test Record Sheets [Appendix C] sufficient for all pupils in each experimental class was provided. The tests themselves [Appendix D] were prepared in sufficient quantity so that each teacher received a file folder containing thirty-five copies of a test and the answer key for that test. The first six test folders were provided at the start of the experiment and the others at intervals during the first term so that the teachers would have them on hand as required. Answer Slips [Appendix E] were provided in quantity.

The program was designed to minimize the possibility of it being inconvenient or onerous for a participating teacher to administer. In the experimental classes, teachers were asked to announce to pupils ahead of time when the review test on a particular chapter was to be given. In the designated class period, the teacher had only to hand out the tests and answer slips, allow the pupils ten minutes for completion, place the answer key on the blackboard, and see that the pupils calculated their scores as percentages and entered them on the Test Record Sheet that each experimental pupil kept in his notebook. Tests and Answer Slips were then collected by the teacher. The entire procedure could be completed in fifteen to eighteen minutes leaving a half-hour of the class period for other work.

In control classes, the teachers were asked to continue with their normal teaching techniques and not to use any of the materials designed for the experimental classes. As far as the writer has been able to determine, none of the teachers did otherwise.

Shortly after the beginning of the experiment, the science department in one of the schools, for reasons not connected with the experiment, decided on an approach to the chemistry course that precluded the use of a sufficient number of the review tests. In the two schools that carried the program to completion, all chemistry teachers, four in one school and three in the other, participated. These seven teachers taught a total of twenty-one chemistry classes including five hundred and twenty-four pupils. All of these classes and pupils were included in this study.

Experimental and control classes were selected at random. The designating numbers or letters (usage varies from school to school) of the classes of a teacher were placed on slips of paper and drawn lottery fashion. For teachers with two chemistry classes, one was drawn as experimental, the remaining being the control. Those teachers with four chemistry classes provided two experimental and two control classes. In the case of teachers with three chemistry classes, the toss of a coin determined whether a given teacher would provide one or two experimental classes. These classes were then drawn lottery fashion as they were with teachers of two or four classes. As it turned out, of the three teachers having three classes each, two provided one experimental class and one provided two experimental classes. In all, ten experimental and eleven control classes were selected by this method.

TABLE I

EXPERIMENTAL AND CONTROL DISTRIBUTION OF CLASSES AND PUPILS

School	No. of Participating Teachers	No. of Classes		No. of Pupils	
		Exper.	Control	Exper.	Control
J.R.H.S.	3	5	6	127	110
B.H.S.	4	5	5	134	153
Totals	7	10	11	261	263
		21		524	

The experimental program was begun in September 1965 and carried on throughout the first term. The end-of-term examination given in each school in mid-January 1966 (Appendix F) was used as the criterion examination. As each school prepared and administered its own end-of-term examination, the data from each school were treated separately.

The chemistry course on which this study was based is a first course in chemistry and therefore it was not considered feasible to attempt to construct a pre-test and to measure differences in pre-test - post-test gain. Campbell and Stanley state that, "While the pretest is a concept deeply embedded in the thinking of research workers in education and psychology, it is not actually essential to true experimental designs."[2] These authors then go on to point out that ". . . in educational research . . ., we must frequently experiment with methods for the introduction of entirely new subject matter, for which pretests in the ordinary sense are impossible, . . ."[3]

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[2]D. T. Campbell and J. C. Stanley, "Experimental and Quasi-Experimental Designs for Research on Teaching," Chapter Five in Gage, N. L., Handbook of Research on Teaching, Chicago, Rand McNally, 1963. p. 195.

[3]Ibid.

Without a pre-test, it was considered necessary to obtain some background information in order to establish the equality of the experimental and control groups at the beginning of the experiment. Once the classes were selected at random as described previously, the Permanent Record Card of each pupil involved was examined and the following information extracted:

1. Age in completed months as of January 15, 1966.
2. I.Q as measured by the Otis test[4] for John Rennie students and the Dominion test[5] for Beaconsfield students. In both schools, pupils are tested in Grade Eight and pupils entering the school above the Grade Eight level are tested shortly after registration. The testing programs are conducted by the respective Guidance Departments.
3. Preliminary Scholastic Aptitude Test scores, both

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[4]Otis Quick-Scoring Mental Ability Tests: New Edition. Gamma Test: Forms EM and FM. Harcourt, Brace and World, New York, 1954.

[5]The Dominion Tests: Quick-Scoring Group Test of Learning Capacity. Intermediate - Grades 7, 8, 9. Department of Educational Research, Ontario College of Education, Toronto, 1958.

Verbal and Mathematical.[6] These tests are prepared and scored by the College Entrance Examination Board, administered by school staff members and written voluntarily by most Grade Ten students in West Island Schools.

4. Grade Nine General Science examination results. These are based on a paper of total value one hundred marks prepared and scored by the science teachers of each school and written in June at the end of the General Science course. Most students take General Science the year before proceeding to the senior sciences, Chemistry, Physics and Biology.

Using analysis of variance, the experimental and control groups in each of the schools were compared on each of the above measures. The results of these comparisons are presented in Chapter Five along with a comparison of the end-of-term examination results in Chemistry.

In addition to comparing the whole experimental

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[6]Preliminary Scholastic Aptitude Test, College Entrance Examination Board, New York, published annually.

group in a school with the whole control group, each of these groups was subdivided and experimental sub-groups were compared with their corresponding control sub-groups. The four sub-groupings used were: (a) boys, (b) girls, (c) pupils new to chemistry and (d) pupils repeating chemistry.

CHAPTER V

EXPERIMENTAL DATA

The Population Sample

This study was conducted in two of the three high schools of the West Island School Commission whose jurisdiction in Protestant education includes a large part of the western end of the island of Montreal. John Rennie High School is located in the City of Pointe Claire at 501 St. John's Road and Beaconsfield High School is located in the Town of Beaconsfield at 84 Beaconsfield Court. The third high school of the West Island School Commission, located in the City of Pointe Claire, was not included in this study.

The two schools included in the study offer grades eight to eleven on the subject promotion system and have enrollments distributed as shown in Table II.

TABLE II

PUPIL ENROLLMENT BY GRADE APRIL 1966

	8	9	10	11	TOTALS
Beaconsfield	394	320	259	246	1219
John Rennie	239	237	257	277	1010

The chemistry course as prescribed by the Quebec Department of Education syllabus is taught in one year in these schools. One class period of approximately forty-five minutes duration is devoted to chemistry each day. Theoretically the course is optional and may be elected at either the grade ten or the grade eleven level. In practice, all but a very few students take chemistry. A variety of factors contribute to this, the main one being the limited number of other courses from which to choose in order to complete the requirements for a High School Leaving Certificate or for university entrance.

The two schools draw upon similar, but not identical, populations. The Town of Beaconsfield and the City of Pointe Claire are adjacent suburbs of the City of Montreal. Most of the wage earners of both communities commute daily to Montreal by train or by automobile although Pointe Claire does have a growing Industrial Park. The differences between the communities are reflected in Table III.

TABLE III

COMMUNITY CHARACTERISTICS

	Beacons-field	Pointe Claire	Prov. of Que.
Population[1]	10,064	22,709	-
Type of Housing by number of dwellings:[2]			
Single Detached	2,269	4,547	-
Single Attached	105	362	-
Apartments or flats	None	648	-
Total	2,403	5,557	-
Median Value - Single detached[3]	20,865	18,115	10,004
Average earnings male wage earners[4]	8,179	7,089	3,367

It is apparent that neither of the communities are typical of the towns and cities of the Province of Quebec. They are probably very similar to the single-dwelling suburbs that have developed around many of the

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[1]Dominion Bureau of Statistics, 1961 Census of Canada, Bulletin 1.1-6, Table 9.

[2]Ibid., Bulletin 2.2-1, Table 7.

[3]Ibid., Bulletin 2.2-6, Table 61 and Table 62.

[4]Ibid., Bulletin 3.3-2, Table 9 and Table 13.

larger cities of Canada. This must be taken into account in any attempt to generalize from the results of this experiment.

Background Data

Background data on each of the pupils involved in the study were collected as outlined in Chapter IV. The availability of these data is summarized in Table IV.

TABLE IV

AVAILABILITY OF BACKGROUND DATA

School	Whole Sample	Scores Available							
		I. Q.		P.S.A.T.		SCI. 9		JAN. EXAM.	
	n	n	%	n	%	n	%	n	%
JRHS:									
Exp.	127	114	89.8	95	74.8	113	89.0	126	99.2
Cont.	110	104	94.6	78	70.9	103	93.6	110	100.0
Total	237	218	92.0	173	73.0	216	91.1	236	99.6
BHS:									
Exp.	134	111	82.8	94	70.2	113	84.3	129	96.3
Cont.	153	133	86.9	100	65.4	140	91.5	149	97.4
Total	287	244	85.0	194	67.6	253	88.2	278	96.9
Totals Both Schools	524	462	88.2	367	70.0	469	89.5	514	98.1

Age was recorded for every student and therefore it is not included in the table. Most of the students without recorded I.Q. scores had entered the schools above the grade eight level, and had not been tested. The Preliminary Scholastic Aptitude Test is taken by grade ten students on a voluntary basis. The few students for whom January examination results were not available were absent due to illness at the time the examination in chemistry was written. The assumption was made that the missing data would not have altered significantly the mean scores of experimental or control groups on any of the measures.

Sub-Groups

As indicated in Chapter IV, four sub-groupings were used in comparing experimental and control groups. The distribution of students according to these sub-groups is shown in Table V.

TABLE V

DISTRIBUTION OF STUDENTS BY SUB-GROUP

School	Whole Sample	Boys		Girls		New to Chemistry		Repeating Chemistry	
	n	n	%	n	%	n	%	n	%
JRHS:									
Exp.	127	81	63.8	46	36.2	100	78.7	27	21.3
Cont.	110	64	58.2	46	41.8	82	74.5	28	25.5
Total	237	145	61.2	92	38.8	182	76.9	55	23.1
BHS:									
Exp.	134	76	56.7	58	43.3	117	87.3	17	12.7
Cont.	153	78	51.0	75	49.0	120	78.5	33	21.5
Total	287	154	53.7	133	46.3	237	82.6	50	17.4
Totals Both Schools	524	299	57.0	225	43.0	419	80.0	105	20.0

Experimental Results

The results of this experiment are summarized in the tables that follow. In each case where means are compared, the degree of significance of the difference is indicated: N.S. Not significant at the .05 level

* Significant at the .05 level.

** Significant at the .01 level.

TABLE VI

COMPARISON OF EXPERIMENTAL AND CONTROL MEANS

Beaconsfield High School - All Students

Measure	Means		Mean Exp. Minus Mean Control	Significance
	Exp.	Control		
Age	195.84	200.39	- 4.55	**
I.Q.	114.19	115.61	- 1.42	N.S.
P.S.A.T.-V.	41.54	43.24	- 1.70	N.S.
P.S.A.T.-M.	46.80	48.20	- 1.40	N.S.
Science 9	76.99	75.33	+ 1.66	N.S.
Jan. Exam. - M.C.	27.61	27.09	+ 0.52	N.S.
Jan. Exam. - D.	31.73	31.21	+ 0.52	N.S.

TABLE VII

ANALYSIS OF VARIANCE FOR BEACONSFIELD HIGH SCHOOL - ALL STUDENTS - AGE

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	1,484	1,484	9.13
Within Groups	285	46,312	162.5	-
Total	286	47,796	-	-

TABLE VIII

ANALYSIS OF VARIANCE FOR BEACONSFIELD HIGH SCHOOL - ALL STUDENTS - I.Q

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	122	122	0.98
Within Groups	242	30,034	124.11	-
Total	243	30,156	-	-

TABLE IX

ANALYSIS OF VARIANCE FOR BEACONSFIELD HIGH SCHOOL - ALL STUDENTS - P.S.A.T. - V.

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	140	140	1.865
Within Groups	192	14,411	75.06	-
Total	193	14,551	-	-

TABLE X

ANALYSIS OF VARIANCE FOR BEACONSFIELD HIGH SCHOOL - ALL STUDENTS - P.S.A.T. - M.

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	95	95	1.078
Within Groups	192	16,927	88.16	-
Total	193	17,022	-	-

TABLE XI

ANALYSIS OF VARIANCE FOR BEACONSFIELD
HIGH SCHOOL - ALL STUDENTS - GRADE 9 SCIENCE

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	173	173	1.32
Within Groups	251	32,933	131	-
Total	252	33,106	-	-

TABLE XII

ANALYSIS OF VARIANCE FOR BEACONSFIELD
HIGH SCHOOL - ALL STUDENTS - JANUARY EXAMINATION
MULTIPLE-CHOICE SECTION

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	18	18	.464
Within Groups	276	10,710	38.80	-
Total	277	10,728	-	-

TABLE XIII

ANALYSIS OF VARIANCE FOR BEACONSFIELD
HIGH SCHOOL - ALL STUDENTS - JANUARY EXAMINATION
DESCRIPTIVE SECTION

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	18	18	.130
Within Groups	276	38,291	138.7	-
Total	277	38,309	-	-

TABLE XIV

COMPARISON OF EXPERIMENTAL AND CONTROL MEANS

Beaconsfield High School - Boys

Measure	Means		Mean Exp. Minus Mean Control	Significance
	Exp.	Control		
Age	196.21	201.23	-5.02	*
I.Q.	116.03	116.91	-0.88	N.S.
P.S.A.T.-V.	42.45	44.29	-1.84	N.S.
P.S.A.T.-M	51.15	51.16	-0.01	N.S.
Science 9	77.63	76.01	+1.62	N.S.
Jan. Exam. - M.C.	28.59	27.87	+0.72	N.S.
Jan. Exam. - D.	30.86	31.54	-0.68	N.S.

TABLE XV

ANALYSIS OF VARIANCE FOR BEACONSFIELD HIGH SCHOOL - BOYS - AGE

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	971	971	4.90
Within Groups	152	30,070	198	-
Total	153	31,041	-	-

TABLE XVI

ANALYSIS OF VARIANCE FOR BEACONSFIELD
HIGH SCHOOL - BOYS - I.Q.

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	25	25	0.15
Within Groups	125	20,534	164.27	-
Total	126	20,559	-	-

TABLE XVII

ANALYSIS OF VARIANCE FOR BEACONSFIELD
HIGH SCHOOL - BOYS - P.S.A.T.-V.

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	83	83	1.082
Within Groups	96	7,363	76.70	-
Total	97	7,446	-	-

TABLE XVIII

ANALYSIS OF VARIANCE FOR BEACONSFIELD
HIGH SCHOOL - BOYS - P.S.A.T.-M.

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	0	0	0
Within Groups	96	7,747	80.70	-
Total	97	7,747	-	-

TABLE XIX

ANALYSIS OF VARIANCE FOR BEACONSFIELD
HIGH SCHOOL - BOYS - GRADE 9 SCIENCE.

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	164	164	1.399
Within Groups	132	15,471	117.20	-
Total	133	15,635	-	-

TABLE XX

ANALYSIS OF VARIANCE FOR BEACONSFIELD
HIGH SCHOOL - BOYS - JANUARY EXAMINATION
MULTIPLE CHOICE SECTION

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	19	19	.503
Within Groups	147	5,555	37.79	-
Total	148	5,574	-	-

TABLE XXI

ANALYSIS OF VARIANCE FOR BEACONSFIELD
HIGH SCHOOL - BOYS - JANUARY EXAMINATION
DESCRIPTIVE SECTION

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	17	17	.105
Within Groups	147	23,698	161.2	-
Total	148	23,715	-	-

TABLE XXII

COMPARISON OF EXPERIMENTAL AND CONTROL MEANS

Beaconsfield High School - Girls

Measure	Means		Mean Exp. Minus Mean Control	Significance
	Exp.	Control		
Age	195.34	199.52	- 4.18	*
I.Q.	111.86	114.37	- 2.51	N.S.
P.S.A.T.-V	40.64	42.14	- 1.50	N.S.
P.S.A.T.-M.	42.44	45.12	- 2.68	N.S.
Science 9	76.13	74.66	+ 1.47	N.S.
Jan. Exam. - M.C.	26.34	26.29	+ 0.05	N.S.
Jan. Exam. - D.	32.86	30.88	+ 1.98	N.S.

TABLE XXIII

ANALYSIS OF VARIANCE FOR BEACONSFIELD HIGH SCHOOL - GIRLS - AGE

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	570	570	4.636
Within Groups	131	16,106	122.95	-
Total	132	16,676	-	-

TABLE XXIV

ANALYSIS OF VARIANCE FOR BEACONSFIELD
HIGH SCHOOL - GIRLS - I.Q.

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	179	179	2.34
Within Groups	115	8,808	76.59	-
Total	116	8,987	-	-

TABLE XXV

ANALYSIS OF VARIANCE FOR BEACONSFIELD
HIGH SCHOOL - GIRLS - P.S.A.T.-V.

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	54	54	.740
Within Groups	94	6,857	72.95	-
Total	95	6,911	-	-

TABLE XXVI

ANALYSIS OF VARIANCE FOR BEACONSFIELD
HIGH SCHOOL - GIRLS - P.S.A.T.-V.

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	172	172	2.491
Within Groups	94	6,491	69.05	-
Total	95	6,663	-	-

TABLE XXVII

ANALYSIS OF VARIANCE FOR BEACONSFIELD
HIGH SCHOOL - GIRLS - GRADE 9 SCIENCE

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	61	61	.412
Within Groups	117	17,335	148.16	-
Total	118	17,396	-	-

TABLE XXVIII

ANALYSIS OF VARIANCE FOR BEACONSFIELD
HIGH SCHOOL - GIRLS - JANUARY EXAMINATION
MULTIPLE CHOICE SECTION

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	0	0	0
Within Groups	127	4,902	38.60	-
Total	128	4,902	-	-

TABLE XXIX

ANALYSIS OF VARIANCE FOR BEACONSFIELD
HIGH SCHOOL - GIRLS - JANUARY EXAMINATION
DESCRIPTIVE SECTION

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	124	124	1.090
Within Groups	127	14,451	113.8	-
Total	128	14,575	-	-

TABLE XXX

COMPARISON OF EXPERIMENTAL AND CONTROL MEANS

Beaconsfield High School - Students New to Chemistry

Measure	Means Exp.	Means Control	Mean Exp. Minus Mean Control	Significance
Age	193.32	197.43	- 4.11	**
I.Q.	114.70	117.01	- 2.31	N.S.
P.S.A.T.-V.	41.60	45.32	- 3.72	*
P.S.A.T.-M.	47.12	49.63	- 2.51	N.S.
Science 9	77.56	77.05	+ 0.51	N.S.
Jan. Exam. - M.C.	27.68	27.08	+ 0.60	N.S.
Jan. Exam. - D.	31.73	29.97	+ 1.76	N.S.

TABLE XXXI

ANALYSIS OF VARIANCE FOR BEACONSFIELD HIGH SCHOOL - STUDENTS NEW TO CHEMISTRY - AGE

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	1,000	1,000	7.96
Within Groups	235	29,516	125.60	-
Total	236	30,516	-	-

TABLE XXXII

ANALYSIS OF VARIANCE FOR BEACONSFIELD HIGH SCHOOL - STUDENTS NEW TO CHEMISTRY - I.Q.

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	268	268	2.43
Within Groups	199	21,940	110.25	-
Total	200	22,208	-	-

TABLE XXXIII

ANALYSIS OF VARIANCE FOR BEACONSFIELD HIGH SCHOOL - STUDENTS NEW TO CHEMISTRY - P.S.A.T.-V.

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	561	561	7.344
Within Groups	160	12,221	76.38	-
Total	161	12,782	-	-

TABLE XXXIV

ANALYSIS OF VARIANCE FOR BEACONSFIELD HIGH SCHOOL - STUDENTS NEW TO CHEMISTRY - P.S.A.T.-M.

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	255	255	2.944
Within Groups	160	13,857	86.61	-
Total	161	14,112	-	-

TABLE XXXV

ANALYSIS OF VARIANCE FOR BEACONSFIELD
HIGH SCHOOL - STUDENTS NEW TO
CHEMISTRY - GRADE 9 SCIENCE

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	13	13	.101
Within Groups	212	27,170	128.16	-
Total	213	27,183	-	-

TABLE XXXVI

ANALYSIS OF VARIANCE FOR BEACONSFIELD
HIGH SCHOOL - STUDENTS NEW TO CHEMISTRY -
JANUARY EXAMINATION MULTIPLE CHOICE SECTION

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	21	21	.518
Within Groups	230	9,321	40.53	-
Total	231	9,342	-	-

TABLE XXXVII

ANALYSIS OF VARIANCE FOR BEACONSFIELD
HIGH SCHOOL - STUDENTS NEW TO CHEMISTRY -
JANUARY EXAMINATION DESCRIPTIVE SECTION

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	179	179	1.21
Within Groups	230	34,307	149.16	-
Total	231	34,486	-	-

TABLE XXXVIII

COMPARISON OF EXPERIMENTAL AND CONTROL MEANS.

Beaconsfield High School -
Students Repeating Chemistry

Measure	Means		Mean Exp. Minus Mean Control	Significance
	Exp.	Control		
Age	213.12	211.15	+ 1.97	N.S.
I.Q.	110.93	110.36	+ 0.57	N.S.
P.S.A.T.-V.	41.10	35.86	+ 5.24	**
P.S.A.T.-M.	44.10	43.14	+ 0.96	N.S.
Science 9	71.73	68.43	+ 3.30	N.S.
Jan. Exam. - M.C.	27.13	27.16	- 0.03	N.S.
Jan. Exam. - D.	31.73	35.97	- 4.24	N.S.

TABLE XXXIX

ANALYSIS OF VARIANCE FOR BEACONSFIELD HIGH SCHOOL - STUDENTS REPEATING CHEMISTRY - AGE

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	43	43	.338
Within Groups	48	6,111	127.31	-
Total	49	6,154	-	-

TABLE XL

ANALYSIS OF VARIANCE FOR BEACONSFIELD HIGH SCHOOL - STUDENTS REPEATING CHEMISTRY - I.Q.

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	4	4	0.02
Within Groups	41	6,931	169.05	-
Total	42	6,935	-	-

TABLE XLI

ANALYSIS OF VARIANCE FOR BEACONSFIELD HIGH SCHOOL - STUDENTS REPEATING CHEMISTRY - P.S.A.T.-V.

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	188	188	8.624
Within Groups	30	654	21.80	-
Total	31	842	-	-

TABLE XLII

ANALYSIS OF VARIANCE FOR BEACONSFIELD HIGH SCHOOL - STUDENTS REPEATING CHEMISTRY - P.S.A.T.-M.

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	6	6	.079
Within Groups	30	2,266	75.53	-
Total	31	2,272	-	-

TABLE XLIII

ANALYSIS OF VARIANCE FOR BEACONSFIELD HIGH SCHOOL - STUDENTS REPEATING CHEMISTRY - GRADE 9 SCIENCE

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	86	86	.847
Within Groups	37	3,759	101.59	-
Total	38	3,845	-	-

TABLE XLIV

ANALYSIS OF VARIANCE FOR BEACONSFIELD HIGH SCHOOL - STUDENTS REPEATING CHEMISTRY - JANUARY EXAMINATION MULTIPLE CHOICE SECTION

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	0	0	0
Within Groups	44	1,384	31.45	-
Total	45	1,384	-	-

TABLE XLV

ANALYSIS OF VARIANCE FOR BEACONSFIELD HIGH SCHOOL - STUDENTS REPEATING CHEMISTRY - JANUARY EXAMINATION DESCRIPTIVE SECTION

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	181	181	2.57
Within Groups	44	3,100	70.45	-
Total	45	3,281	-	-

TABLE XLVI

COMPARISON OF EXPERIMENTAL AND CONTROL MEANS

John Rennie High School - All Students

Measure	Means		Mean Exp. Minus Mean Control	Significance
	Exp.	Control		
Age	198.54	198.18	+ 0.36	N.S.
I.Q.	116.26	114.70	+ 1.56	N.S.
P.S.A.T.-V	44.31	43.42	+ 0.89	N.S.
P.S.A.T.-M	48.67	47.63	+ 1.04	N.S.
Science 9	72.90	71.77	+ 1.13	N.S.
Jan. Exam. - M.C.	24.94	24.10	+ 0.84	N.S.
Jan. Exam. - D.	35.61	34.13	+ 1.48	N.S.

TABLE XLVII

ANALYSIS OF VARIANCE FOR JOHN RENNIE
HIGH SCHOOL - ALL STUDENTS -
AGE

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	8	8	.042
Within Groups	235	45,277	192.67	-
Total	236	45,285	-	-

TABLE XLVIII

ANALYSIS OF VARIANCE FOR JOHN RENNIE HIGH SCHOOL - ALL STUDENTS - I.Q.

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	132	132	1.47
Within Groups	216	19,342	89.55	-
Total	217	19,474	-	-

TABLE XLIX

ANALYSIS OF VARIANCE FOR JOHN RENNIE HIGH SCHOOL - ALL STUDENTS - P.S.A.T.-V.

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	34	34	.387
Within Groups	171	15,019	87.83	-
Total	172	15,053	-	-

TABLE L

ANALYSIS OF VARIANCE FOR JOHN RENNIE HIGH SCHOOL - ALL STUDENTS - P.S.A.T.-M.

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	47	47	.669
Within Groups	171	12,007	70.22	-
Total	172	12,054	-	-

TABLE LI

ANALYSIS OF VARIANCE FOR JOHN RENNIE
HIGH SCHOOL - ALL STUDENTS - GRADE 9 SCIENCE

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	70	70	.471
Within Groups	214	31,824	148.71	-
Total	215	31,894	-	-

TABLE LII

ANALYSIS OF VARIANCE FOR JOHN RENNIE
HIGH SCHOOL - ALL STUDENTS
JANUARY EXAMINATION MULTIPLE CHOICE SECTION

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	41	41	1.246
Within Groups	234	7,701	32.91	-
Total	235	7,742	-	-

TABLE LIII

ANALYSIS OF VARIANCE FOR JOHN RENNIE
HIGH SCHOOL - ALL STUDENTS -
JANUARY EXAMINATION DESCRIPTIVE SECTION

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	129	129	.662
Within Groups	234	45,614	194.9	-
Total	235	45,743	-	-

TABLE LIV

COMPARISON OF EXPERIMENTAL AND CONTROL MEANS

John Rennie High School - Boys

Measure	Means		Mean Exp. Minus Mean Control	Significance
	Exp.	Control		
Age	201.27	198.91	+ 2.36	N.S.
I.Q.	115.05	114.31	+ 0.74	N.S.
P.S.A.T.-V.	44.58	43.51	+ 1.07	N.S.
P.S.A.T.-M.	50.70	48.84	+ 1.86	N.S.
Science 9	69.93	69.62	+ 0.31	N.S.
Jan. Exam. - M.C.	24.78	24.67	+ 0.11	N.S.
Jan. Exam. - D.	34.03	33.20	+ 0.83	N.S.

TABLE LV

ANALYSIS OF VARIANCE FOR JOHN RENNIE HIGH SCHOOL - BOYS - AGE

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	200	200	.895
Within Groups	143	31,942	223.37	-
Total	144	32,142	-	-

TABLE LVI

ANALYSIS OF VARIANCE FOR JOHN RENNIE
HIGH SCHOOL - BOYS - I.Q.

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	18	18	0.19
Within Groups	132	12,608	95.52	-
Total	133	12,626	-	-

TABLE LVII

ANALYSIS OF VARIANCE FOR JOHN RENNIE
HIGH SCHOOL - BOYS - P.S.A.T.-V

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	28	28	.293
Within Groups	98	8,379	95.70	-
Total	99	8,407	-	-

TABLE LVIII

ANALYSIS OF VARIANCE FOR JOHN RENNIE
HIGH SCHOOL - BOYS - P.S.A.T.-M

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	85	85	1.179
Within Groups	98	7,066	72.10	-
Total	99	7,151	-	-

TABLE LIX

ANALYSIS OF VARIANCE FOR JOHN RENNIE
HIGH SCHOOL - BOYS - GRADE 9 SCIENCE

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	3	3	.022
Within Groups	128	17,307	135.21	-
Total	129	17,310	-	-

TABLE LX

ANALYSIS OF VARIANCE FOR JOHN RENNIE
HIGH SCHOOL - BOYS - JANUARY EXAMINATION
MULTIPLE CHOICE SECTION

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	0	0	0
Within Groups	142	4,752	33.46	-
Total	143	4,752	-	-

TABLE LXI

ANALYSIS OF VARIANCE FOR JOHN RENNIE
HIGH SCHOOL - BOYS - JANUARY EXAMINATION
DESCRIPTIVE SECTION

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	24	24	.124
Within Groups	142	27,456	193.4	-
Total	143	27,480	-	-

TABLE LXII

COMPARISON OF EXPERIMENTAL AND CONTROL MEANS

John Rennie High School - Girls

Measure	Means		Mean Exp. Minus Mean Control	Significance
	Exp.	Control		
Age	193.74	197.17	- 3.43	N.S.
I.Q.	118.41	115.26	+ 3.15	N.S.
P.S.A.T.-V.	43.89	43.31	+ 0.58	N.S.
P.S.A.T.-M.	45.63	46.14	- 0.51	N.S.
Science 9	77.74	74.77	+ 2.97	N.S.
Jan. Exam. - M.C.	25.22	23.30	+ 1.92	N.S.
Jan. Exam. - D.	38.37	35.41	+ 2.96	N.S.

TABLE LXIII

ANALYSIS OF VARIANCE FOR JOHN RENNIE HIGH SCHOOL - GIRLS - AGE

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	271	271	2.104
Within Groups	90	11,590	128.78	-
Total	91	11,861	-	-

TABLE LXIV

ANALYSIS OF VARIANCE FOR JOHN RENNIE
HIGH SCHOOL - GIRLS - I.Q.

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	210	210	2.68
Within Groups	82	6,415	78.23	-
Total	83	6,625	-	-

TABLE LXV

ANALYSIS OF VARIANCE FOR JOHN RENNIE
HIGH SCHOOL - GIRLS - P.S.A.T.-V

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	5	5	.054
Within Groups	71	6,630	93.38	-
Total	72	6,635	-	-

TABLE LXVI

ANALYSIS OF VARIANCE FOR JOHN RENNIE
HIGH SCHOOL - GIRLS - P.S.A.T.-M

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	5	5	.084
Within Groups	71	4,215	59.37	-
Total	72	4,220	-	-

TABLE LXVII

ANALYSIS OF VARIANCE FOR JOHN RENNIE
HIGH SCHOOL - GIRLS - GRADE 9 SCIENCE

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	190	190	1.305
Within Groups	84	12,226	145.55	-
Total	85	12,416	-	-

TABLE LXVIII

ANALYSIS OF VARIANCE FOR JOHN RENNIE
HIGH SCHOOL - GIRLS - JANUARY EXAMINATION
MULTIPLE CHOICE SECTION

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	84	84	2.612
Within Groups	90	2,894	32.16	-
Total	91	2,978	-	-

TABLE LXIX

ANALYSIS OF VARIANCE FOR JOHN RENNIE
HIGH SCHOOL - GIRLS - JANUARY EXAMINATION
DESCRIPTIVE SECTION

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	201	201	1.035
Within Groups	90	17,476	194.18	-
Total	91	17,677	-	-

TABLE LXX

COMPARISON OF EXPERIMENTAL AND CONTROL MEANS

John Rennie High School - Students New to Chemistry.

Measure	Means		Mean Exp. Minus Mean Control	Significance
	Exp.	Control		
Age	194.31	193.44	+ 0.87	N.S.
I.Q.	117.70	116.19	+ 1.51	N.S.
P.S.A.T.-V.	45.19	44.78	+ 0.41	N.S.
P.S.A.T.-M.	50.20	49.42	+ 0.78	N.S.
Science 9	74.44	73.09	+ 1.35	N.S.
Jan. Exam. - M.C.	25.45	24.11	+ 1.34	N.S.
Jan. Exam. - D.	36.61	33.88	+ 2.73	N.S.

TABLE LXXI

ANALYSIS OF VARIANCE FOR JOHN RENNIE HIGH SCHOOL - STUDENTS NEW TO CHEMISTRY - AGE

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	35	35	.295
Within Groups	180	21,352	118.62	-
Total	181	21,387	-	-

TABLE LXXII

ANALYSIS OF VARIANCE FOR JOHN RENNIE HIGH SCHOOL - STUDENTS NEW TO CHEMISTRY - I.Q.

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	96	96	1.08
Within Groups	168	14,930	88.87	-
Total	169	15,026	-	-

TABLE LXXIII

ANALYSIS OF VARIANCE FOR JOHN RENNIE HIGH SCHOOL - STUDENTS NEW TO CHEMISTRY - P.S.A.T.-V.

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	6	6	.066
Within Groups	139	12,694	91.36	-
Total	140	12,700	-	-

TABLE LXXIV

ANALYSIS OF VARIANCE FOR JOHN RENNIE HIGH SCHOOL - STUDENTS NEW TO CHEMISTRY - P.S.A.T.-M.

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	20	20	.308
Within Groups	139	9,016	64.86	-
Total	140	9,036	-	-

TABLE LXXV

ANALYSIS OF VARIANCE FOR JOHN RENNIE HIGH SCHOOL - STUDENTS NEW TO CHEMISTRY - GRADE 9 SCIENCE

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	76	76	.497
Within Groups	167	25,547	152.98	-
Total	168	25,623	-	-

TABLE LXXVI

ANALYSIS OF VARIANCE FOR JOHN RENNIE HIGH SCHOOL - STUDENTS NEW TO CHEMISTRY - JANUARY EXAMINATION MULTIPLE CHOICE SECTION

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	81	81	2.266
Within Groups	179	6,397	35.74	-
Total	180	6,478	-	-

TABLE LXXVII

ANALYSIS OF VARIANCE FOR JOHN RENNIE HIGH SCHOOL - STUDENTS NEW TO CHEMISTRY - JANUARY EXAMINATION DESCRIPTIVE SECTION

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	333	333	1.594
Within Groups	179	37,403	208.96	-
Total	180	37,736	-	-

TABLE LXXVIII

COMPARISON OF EXPERIMENTAL AND CONTROL MEANS

John Rennie High School
Students Repeating Chemistry

Measure	Means Exp.	Means Control	Mean Exp. Minus Mean Control	Significance
Age	214.22	212.07	+ 2.15	N.S.
I.Q.	110.27	110.23	+ 0.04	N.S.
P.S.A.T.-V.	39.21	38.89	+ 0.32	N.S.
P.S.A.T.-M.	39.86	41.67	- 1.81	**
Science 9	66.54	67.64	- 1.10	N.S.
Jan. Exam. - M.C.	23.04	24.07	- 1.03	N.S.
Jan. Exam. - D.	31.96	34.86	- 2.90	*

TABLE LXXIX

ANALYSIS OF VARIANCE FOR JOHN RENNIE HIGH SCHOOL - STUDENTS REPEATING CHEMISTRY - AGE

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	63	63	.405
Within Groups	53	8,249	155.64	-
Total	54	8,312	-	-

TABLE LXXX

ANALYSIS OF VARIANCE FOR JOHN RENNIE HIGH SCHOOL - STUDENTS REPEATING CHEMISTRY - I.Q.

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	0	0	0
Within Groups	46	2,740	59.57	-
Total	47	2,740	-	-

TABLE LXXXI

ANALYSIS OF VARIANCE FOR JOHN RENNIE HIGH SCHOOL - STUDENTS REPEATING CHEMISTRY - P.S.A.T.-V.

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	1	1	.021
Within Groups	30	1,418	47.27	-
Total	31	1,419	-	-

TABLE LXXXII

ANALYSIS OF VARIANCE FOR JOHN RENNIE HIGH SCHOOL - STUDENTS REPEATING CHEMISTRY - P.S.A.T.-M.

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	188	188	7.824
Within Groups	30	721	24.03	-
Total	31	909	-	-

TABLE LXXXIII

ANALYSIS OF VARIANCE FOR JOHN RENNIE HIGH SCHOOL - STUDENTS REPEATING CHEMISTRY - GRADE 9 SCIENCE

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	14	14	.137
Within Groups	45	4,611	102.46	-
Total	46	4,625	-	-

TABLE LXXXIV

ANALYSIS OF VARIANCE FOR JOHN RENNIE HIGH SCHOOL - STUDENTS REPEATING CHEMISTRY - JANUARY EXAMINATION MULTIPLE CHOICE SECTION

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	15	15	.673
Within Groups	53	1,181	22.28	-
Total	54	1,196	-	-

TABLE LXXXV

ANALYSIS OF VARIANCE FOR JOHN RENNIE HIGH SCHOOL - STUDENTS REPEATING CHEMISTRY - JANUARY EXAMINATION DESCRIPTIVE SECTION

Source of Variance	d.f.	S.S.	Mean Square	F
Between Groups	1	1,018	1018	7.079
Within Groups	53	7,634	143.8	-
Total	54	8,652	-	-

CHAPTER VI

DISCUSSION OF RESULTS

Six significant differences occur in the data from Beaconsfield High School and all of these are in what has been termed background data. Of the six, four are in age data, in the figures for all students and in those for three of the four sub-groups, boys, girls and students new to chemistry. In each case of a significant difference in mean age, that of the control group was higher. The chemistry course may be taken in either grade ten or eleven but most students elect chemistry in grade ten. At Beaconsfield High School, most of the grade eleven students of chemistry were in two classes and, by chance, both of these classes were included in the control group. If maturity is a factor in success in chemistry, these differences should have worked to the advantage of the control groups.

The two significant differences other than age both occurred in the Preliminary Scholastic Aptitude Test Verbal scores. Among the students new to chemistry, the control group mean was higher while among those repeating chemistry the experimental group mean was higher. These differences should have worked to the advantage of the control group in the first instance and the experimental group in the second.

In the data from John Rennie High School there were only two significant differences. Both of these occurred in the sub-group of students repeating chemistry. The mean of the control group on the Preliminary Scholastic Aptitude Test Mathematics score was higher than that of the experimental group. The control group mean was also higher on the descriptive section of the January examination.

To summarize, in comparing experimental and control groups with respect to background data on five measures with five student groupings in each of the two schools, a total of fifty differences in means were computed. Of the fifty differences, thirty favoured the experimental groups and twenty favoured the control groups. With the seven exceptions noted above, these differences were not significant.

The picture is somewhat different when the experimental and control groups are compared with respect to the January examination results which were used as the end of experiment criteria. Here twenty differences in means, only one of which was significant, were computed. These are summarized from Tables VI to LXXXV for comparison in Table LXXXVI.

TABLE LXXXVI

JANUARY EXAMINATION RESULTS

EXPERIMENTAL MEAN MINUS CONTROL MEAN.

Group	Beaconsfield H.S.		John Rennie H.S.	
	Multiple Choice	Descriptive	Multiple Choice	Descriptive
All Students	+ 0.52	+ 0.52	+ 0.84	+ 1.48
Boys	+ 0.72	- 0.68	+ 0.11	+ 0.83
Girls	+ 0.05	+ 1.98	+ 1.92 ✓	+ 2.96
Students New to Chemistry	+ 0.60	+ 1.76	+ 1.34 ✓	+ 2.73 ✓
Students Repeating Chemistry	- 0.03	- 4.24 ✓	- 1.03	- 2.90 *

Considering together all students in a school, the Beaconsfield experimental students performed better on both the multiple-choice and the descriptive sections of the Beaconsfield January examination than the Beaconsfield control students. The same is true of the John Rennie students with respect to the John Rennie examination. Although the superiority of the experimental students is not significant, it is consistent.

In the boys' sub-groups at the two schools, the Beaconsfield experimental boys performed better than the control boys on the multiple-choice section of the January examination but not as well on the descriptive section. The John Rennie experimental boys performed better than their control counterparts on both sections of the January examination.

In the girls' sub-groups, both Beaconsfield and John Rennie experimental girls performed better on both sections of their respective examinations than did the control girls.

In the new to chemistry sub-groups, both Beaconsfield and John Rennie experimental students performed better on both sections of their respective January examinations than did the control students.

In the repeating sub-groups, both Beaconsfield and John Rennie control students performed better than the experimental students on both multiple-choice and descriptive sections of the January examinations. The superior performance of the John Rennie control students on the descriptive section of the examination was significant at the .05 level.

An examination of the last two rows of Table LXXXVI shows that when the students were divided into repeating and new to chemistry sub-groups the results of comparing experimental and control groups are diametrically opposed. In the repeating sub-group the control groups exceed the performance of the experimental groups in all four comparisons while among students new to chemistry the experimental groups are superior in all four comparisons.

According to Winer, "The frequent use of the .05 and the .01 levels of significance is a matter of convention having little scientific or logical basis."[1] In amplification of this Winer says that, under certain circumstances, "the .30 and .20 levels of significance may be more appropriate than the .05 and .01 levels."[2]

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[1]B. J. Winer, Statistical Principles in Experimental Design, McGraw-Hill, New York, 1962. p.13

[2]Ibid.

Re-examined at the .25 level of significance the differences between experimental and control groups in the repeating and new to chemistry sub-groups show significance in four of the eight comparisons. One of these was found to be significant at the .05 level, the three additional ones have been indicated with a √ in Table LXXXVI.

The use of a program of multiple-choice review tests in this experiment did produce differences between experimental and control groups on the criterion examinations. In all cases, these differences favoured the experimental students new to chemistry and were to the disadvantage of experimental students repeating chemistry. It is this consistency that bears examination in spite of the fact that in only one of the eight comparisons did the difference reach the usually accepted level of significance.

Why should this consistent difference exist between the repeating and new to chemistry sub-groups? A tentative explanation may be advanced. Participating teachers had been asked to introduce the testing program to the experimental classes as part of their normal teaching routine and without mentioning "experiment". There is little reason to believe that students new to the subject would not accept the testing program as simply being part of chemistry. They accept other routines new to them, demonstration and laboratory work for example, on this basis. If this is so, then the slight superiority of the experimental groups is encouraging. It shows significance only when considered at the .25 level, but it is consistent.

It is not likely that the repeating students would have accepted the testing program simply as being part of chemistry. This would be difficult to substantiate, but many teachers have experienced the attitude of repeating students who say, "May I use last year's notes?", "Is that on the course, we didn't do that last year?" and "Mr. X didn't ask us to do this last year." The repeating student does seem to be rather hostile to new approaches in teaching a subject. When reminded that he is repeating the subject because "last year" didn't work out, he will grudgingly accept a new approach. It may be that because this experimental testing program was new and different from what the repeating student expected in chemistry that it met with a negative attitude.

The tentative explanation advanced is purely subjective. In this exploratory experiment, the discovery of a difference in the effect of the testing program on repeaters and students new to chemistry was not anticipated and therefore no provision was made in the experimental design for obtaining objective evidence of its cause.

When the students were divided into the sub-groups boys and girls, there was no consistent difference in the effect of the testing program on experimental and control groups. With one exception in the boys' sub-group, the experimental groups did better than the control groups in all comparisons. The effect of the program, however small, seemed to be about equal for boys and girls.

CHAPTER VII

SUMMARY AND CONCLUSIONS

Summary

1. This experiment was a field study of the effect of a program of multiple-choice chapter review tests on learning in high school chemistry.
2. The experiment was performed in two of the high schools of the West Island School Commission (the jurisdiction of this Commission includes several towns and cities in the western suburbs of Montreal) in which the chemistry course prescribed by the Quebec Department of Education is taught in one year on the subject promotion system.
3. The experiment involved all chemistry teachers and all chemistry students in the two schools.
4. The pupils were drawn from grades ten and eleven with most of them being from grade ten.
5. The writer teaches in one of the schools and visited the other frequently and thus was able to discuss the program with all of the participating teachers.

6. The background information desired, age, I.Q. scores, Preliminary Scholastic Aptitude Verbal and Mathematical Test Scores, grade nine general science scores, was available from the Permanent Record Cards for most students.

7. From the 21 classes involved, 10 were selected at random as experimental classes, the remaining 11 being control classes. Each teacher involved taught at least one experimental and one control class.

8. At the end of each chapter of work, the experimental classes used a multiple-choice review test prepared by the writer. The tests were self-corrected by the students using a key provided for each teacher. The students kept a record of their results, test by test, on a graph sheet prepared for the purpose. The control classes followed the normal classroom routine of their teacher without using any of the material prepared for this program.

9. In each school comparisons were made between all experimental students and all control students, experimental boys and control boys, experimental girls and control girls, experimental repeating students and control repeating students, and

experimental students new to chemistry and control students new to chemistry.

10. The chemistry course involved is a first course in chemistry and therefore no pretest was used for comparison of experimental and control groups. The experimental and control groups were compared, using analysis of variance, on the five items of background information detailed in point six of this summary. Due to the sub-groupings detailed in point nine, fifty separate comparisons were made. Seven significant differences were found, six of them favouring control groups.

11. The criterion measure used in each school was the January end of term examination prepared and marked by the chemistry teachers of the school. In both schools, the examination was in two sections, the first consisting of multiple-choice questions and the second consisting of questions requiring written answers.

12. Omitting for the moment the repeating students sub-group, sixteen comparisons were made of experimental and control students in the various sub-groups on both the multiple-choice and descriptive sections of the criterion examinations. Of these sixteen

comparisons, fifteen favoured the experimental students and one favoured control students. None of these differences were significant at the .05 level.

13. In the sub-group of repeating students four comparisons were made of experimental and control students. All four comparisons favoured control students and one of the differences was significant at the .05 level.

Conclusions

Within the limitations of a preliminary field study, the following conclusions can be drawn from this experiment:

1. The pupils taught with the use of regular, self-corrected, multiple-choice review tests did better on the January examinations than the pupils who did not have the benefit of this program. An exception to this was the sub-group of repeating students and this exception should be kept in mind in considering the following conclusions. The results supporting the conclusions are, with one exception, not significant

at the .05 level but they are consistent.

2. The fear of participating teachers that students whose regular testing was of the multiple-choice objective type would do poorly on the descriptive section at the end of term examination was not substantiated. The experimental students did in fact do better on the descriptive section than the control students. The experimental students also did better on the multiple-choice section of the criterion examination. The differences were consistent, but not significant.

3. Another fear of participating teachers was that because the review tests covered only a small amount of material, students would achieve higher than normal results and thus tend to coast rather than prepare diligently for the end of term examination. The experimental students did have higher scores on the chapter review tests than they would have been expected to achieve on the more traditional full period class tests. But in spite of, or perhaps even in part because of, this they still out-performed the control students on the January examination.

4. In comparing the effect of the program of review

tests on boys and girls, no consistent difference was observed.

5. In comparing the effect of the program of review tests on repeating students and those new to chemistry a consistent and in one case significant difference was observed. It appeared that repeating students had responded negatively to the introduction of a new testing routine. They performed better on the January examination when their class testing had been of the traditional, full period, descriptive test type.

6. The fact that experimental students were not subjected to the usual routine of full period, teacher corrected, class tests did not adversely affect their performance on the January examinations. They corrected their own multiple-choice review tests throughout the first term and performed better on the January examinations than did the control students. It would seem reasonable to question the value of using a considerable amount of class time in having students write descriptive tests and using even more of the teachers' time in correcting them if students can perform as well or better using short,

self-corrected, objective tests. Whether or not these short tests gave the teachers as accurate an assessment of the students' standing at a given time as the usual descriptive tests is a question that was not examined in this study.

7. The differential effects of the program on repeating students and those new to chemistry would lend weight to what might be suggested on general educational grounds that consideration should be given to using different teaching techniques with each group. It might be advantageous to have repeating students in classes separate from students new to chemistry so that attempts can be made to develop the optimum teaching method for each group. This would have been administratively feasible in the schools participating in this study; each school had enough repeating students to form two full classes.

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APPENDIX A

A BRIEF SUMMARY OF THE EXPERIMENT

(As given to participating teachers)

The object of this experiment is to evaluate the effect on learning of a short, multiple-choice test given at the end of each chapter of work in first-term Chemistry. These tests are designed to review the text material required by the Department of Education in each chapter. Each test has twenty items, a time limit of ten minutes and should not require more than fifteen minutes total time to administer. Experimental classes will use the multiple-choice testing program throughout the first term, control classes will not.

The tests are designed to replace a class exercise of fifteen minutes duration and should not interfere with any other testing that the teacher may wish to conduct during the first term.

The testing program is set up to minimize the possibility of it being an extra load on the cooperating teacher. Tests are self-scored by students and each student keeps a continuous record of his standing on the

Chemistry Test Record. Hopefully this will provide additional motivation to do well on the part of the student. Emphasis, then, is on the student being responsible for his own self-evaluation by means of the test and for initiating any extra study required to raise his graphical record to an acceptable standard.

In order to compare the Experimental and Control groups, I.Q.'s, Grade 9 Science scores and similar data will be collected from Permanent Record Cards for all students in both groups. This must be done in order to ensure that, as far as can be determined, the two groups are equal in ability and previous preparation. If they prove not to be equal, (highly unlikely with approximately four hundred students in each group) the data collected will enable statistical adjustments to be made. Cooperating teachers <u>will not be asked</u> to collect any of the required data. The assistance they render in this program by administering the tests, seeing that the students keep their Chemistry Test Records up to date and retaining the Answer slips for collection is much appreciated and <u>no further imposition will be made</u>.

As soon as possible after the first-term examinations, January 10-18, the performance of the Experimental and Control groups will be compared statistically and the results of this analysis made available to all cooperating teachers. It may also be possible to obtain computer analysis of the tests themselves in order that those items which prove to be most valid may be identified. If the necessary cooperation can be obtained from McGill University, this analysis will be carried out and a list of the "best" items provided to cooperating teachers to use as they see fit in future testing.

APPENDIX B

TESTING PROCEDURE

(As given to Participating Teachers)

1. Assign a code number to each student in the experimental classes. See that the student records this number on his Chemistry Test Record and that this Record becomes a permanent part of the student's notebook.

   Code numbers: John Rennie 100 - 399

   Beaconsfield 400 - 699

2. In administering a test:
   1. Announce ahead of time that a Chapter Review Test will be given.
   2. In the appointed class period:
      (a) Distribute copies of the Review Test and the Answer slip to each student.
      (b) Have the students record their names and code numbers on the answer slips
      (c) Give the students exactly ten minutes to complete the test
      (d) Write the answer key on the blackboard. Students are to mark each wrong answer and each omitted answer with an X
      (e) Each student calculates his own score,

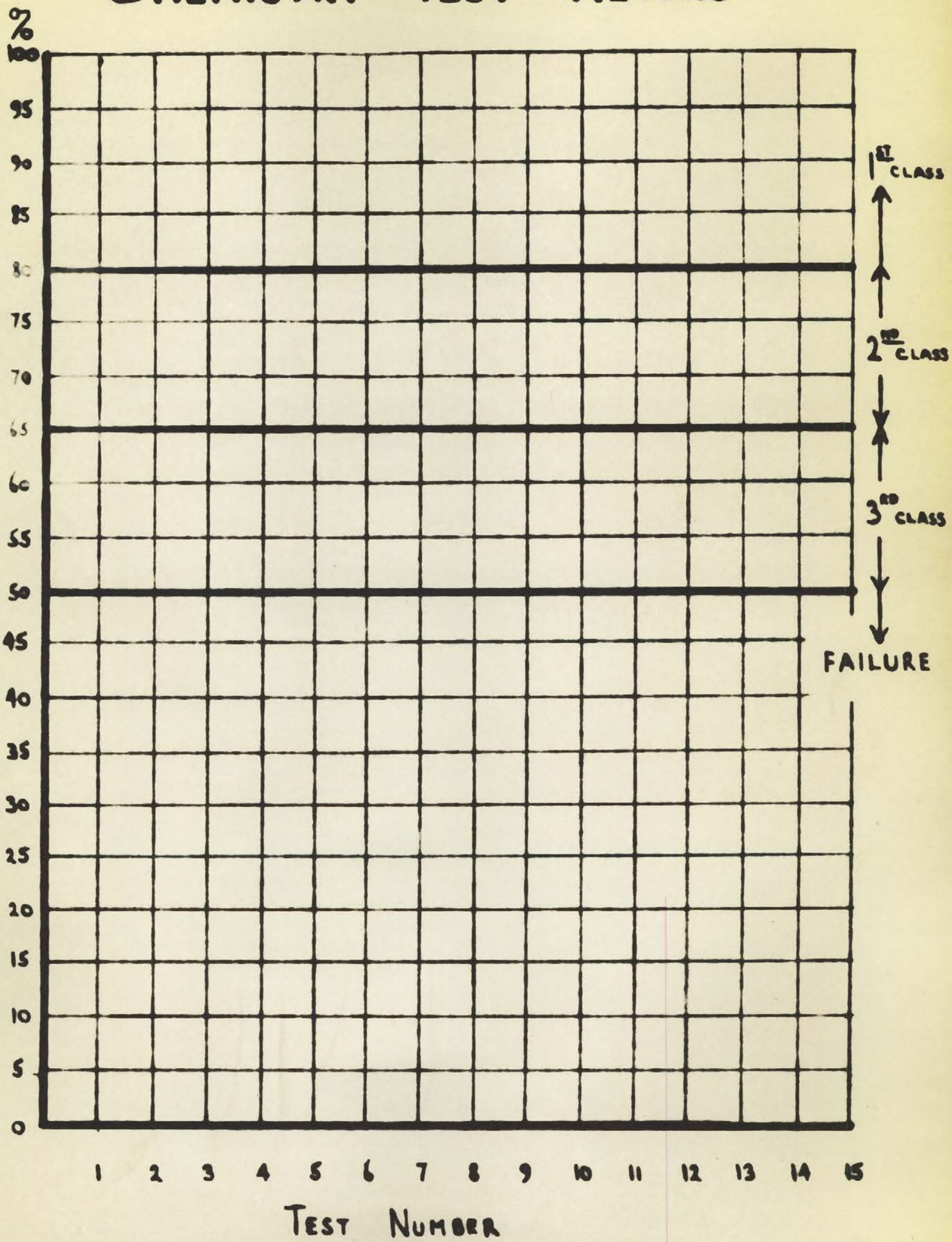
$\frac{\text{NUMBER CORRECT}}{20}$, and converts this score to a per cent. The score expressed as a per cent is to be recorded by the student as a point in a line graph on the Chemistry Test Record.

(f) Collect the answer slips, fasten with an elastic band and pass them on to the Department Head who will retain them for collection.

3. PLEASE do not use these tests or record sheets with your control classes. With these classes carry on the teaching and testing program that you would normally use. This point is essential if the statistical analysis of this program is to have any validity at all.

APPENDIX C

CHEMISTRY TEST RECORD



APPENDIX D

CHEMISTRY REVIEW TEST - CHAPTER ONE

For each question select the best answer from among the four choices provided. Record your choice as directed by your teacher.

PLEASE DO NOT WRITE ON OR MARK THIS QUESTION PAPER IN ANY WAY.

1. For practical purposes, the liter is approximately the same as
   (1) 1000 cubic centimeters
   (2) 1000 cubic meters
   (3) 100 kilometers
   (4) 10 cubic centimeters

2. Only a physical change is involved when
   (1) steel wool burns in pure oxygen
   (2) ice melts to form water
   (3) water is decomposed by an electric current
   (4) iron rusts

3. The equation $E = mc^2$ expresses the relationship between
   (1) electrical energy and chemical energy
   (2) endothermic and exothermic reactions
   (3) English and metric systems of measurement
   (4) matter and energy

4. When a chemical reaction gives off heat energy, it is
   (1) absorbing energy
   (2) exothermic
   (3) gaining inertia
   (4) endothermic

5. At the instant an archer releases the string of his bow, there is a change of energy from
   (1) potential to kinetic
   (2) chemical to kinetic
   (3) kinetic to potential
   (4) kinetic to chemical

6. The energy of a coiled watch spring is
   (1) chemical energy
   (2) heat energy
   (3) kinetic energy
   (4) potential energy

7. At 4°C, one gram of pure water will occupy
   (1) 10 cubic centimeters
   (2) 1 milliliter
   (3) 1 liter
   (4) 100 milliliters

8. The fundamental quantities to which all measurement can be reduced are mass, time and
   (1) volume
   (2) length
   (3) pressure
   (4) temperature

9. In science, general statements summarizing a number of related facts are called scientific
   (1) laws
   (2) theories
   (3) arguments
   (4) hypotheses

10. Which of the following is a measure of the inertia of a body
   (1) weight
   (2) volume
   (3) density
   (4) mass

11. Which of the following properties of matter depends on the force of gravity for its existence?
   (1) weight
   (2) occupies space
   (3) inertia
   (4) none of these

12. The state of matter having no definite shape and no definite volume is
   (1) liquid
   (2) fluid
   (3) solid
   (4) gas

13. Which of the following is a statement of a chemical property?
   (1) Substance X reacts rapidly with oxygen
   (2) Substance X has a density of 327 lbs/cu. ft.
   (3) Substance X has a melting point of 575°C
   (4) Substance X forms cubic crystals

14. A temperature of 30°C is equivalent to a temperature of
(1) 49°F
(2) -15°
(3) 27°F
(4) 86°F

15. In powers-of-ten notation, the number 0.000007 would be written as
(1) 7×10^{-5}
(2) 7×10^{-6}
(3) 7×10^{6}
(4) 7×10^{5}

16. The metric prefix meaning "one thousand" is
(1) milli
(2) mega
(3) kilo
(4) micro

17. In powers-of-ten notation, the number 50,000 would be written as
(1) 5×10^{4}
(2) 5×10^{5}
(3) 5×10^{-4}
(4) 5×10^{3}

18. A temperature of 50°F is equivalent to a temperature of
(1) -4°C
(2) 122°C
(3) 10°C
(4) 32°C

19. In an endothermic reaction
(1) heat energy is given off
(2) kinetic energy changes to potential energy
(3) heat energy is absorbed
(4) there is no energy exchange

20. A rectangular box has a length of 3.1 cm., a width of 2.4 cm. and a depth of 1.2 cm. The volume of the box is correctly recorded as
(1) 8.928 cu. cm.
(2) 89.3 cu. cm.
(3) 8.93 cu. cm.
(4) 8.9 cu. cm.

CHEMISTRY REVIEW TEST - CHAPTER TWO

For each question select the best answer from among the four choices provided. Record your choice as directed by your teacher.

PLEASE DO NOT WRITE ON OR MARK THIS QUESTION PAPER IN ANY WAY.

1. Of the 103 elements known at present, 92 are called natural elements because
   (1) they occur in the earth's crust, oceans or atmosphere.
   (2) they have more normal boiling points than the other 11.
   (3) they had all been discovered by Lavoisier's time.
   (4) they are easier to produce by chemical combination.

2. A compound differs from a mixture in that it
   (1) may be solid, liquid or gas.
   (2) has a definite composition by weight.
   (3) can only be produced if the constituent substances are heated.
   (4) can not be dissolved.

3. A substance that can be hammered into thin sheets is said to be
   (1) brittle
   (2) ductile
   (3) crystalline
   (4) malleable

4. The formation of a new substance with new properties is involved whenever we make a
   (1) compound
   (2) mixture
   (3) solution
   (4) homogeneous mixture

5. The state of matter having definite volume but no definite shape is the
   (1) fluid state
   (2) solid state
   (3) liquid state
   (4) gaseous state

6. The metalloids are
   (1) Alloys of two or more metals
   (2) elements with properties intermediate between those of metals and non-metals
   (3) compounds containing both a metal and a non-metal
   (4) man-made elements

7. A substance that can be drawn out into a thin wire is said to be
   (1) ductile
   (2) malleable
   (3) lustrous
   (4) brittle

8. Which of the following is a statement of a physical property?
   (1) substance X will burn in oxygen
   (2) the reaction between substances X and Y is exothermic
   (3) on decomposition, substance X releases oxygen and chlorine
   (4) substance X is very malleable

9. A chemical reaction which gives off heat energy is said to be
   (1) absorbing energy
   (2) exothermic
   (3) gaining inertia
   (4) endothermic

10. The fundamental unit of length in the metric system is the
    (1)centimeter
    (2) kilometer
    (3) liter
    (4) meter

11. In the language of chemistry, a Christmas pudding would be said to be
    (1) an element
    (2) homogeneous material
    (3) heterogeneous material
    (4) a compound

12. Matter that has similar properties thoughout is said to be
    (1) heterogeneous
    (2) elemental
    (3) homogeneous
    (4) extensive

13. A solution can be considered to be a mixture that
    (1) does not vary in composition
    (2) is difficult to separate
    (3) will change the individual properties of the components
    (4) is homogeneous

14. Definite composition by weight is a characteristic of
    (1) solutions
    (2) homogeneous mixtures
    (3) compounds
    (4) alloys

15. Substance X, a black powder, is heated gently; a gas is released and a white residue remains in the test tube. Substance X must be
    (1) an element
    (2) a compound
    (3) a non-metal
    (4) a metal

16. Elements are simple substances
    (1) produced by chemical combination
    (2) with a crystalline structure
    (3) which cannot be separated by ordinary chemical means
    (4) which are malleable and ductile

17. Three properties that, in general, common to metals are
    (1) low density, good electrical conductivity, and ductility
    (2) high density, ductility, and malleability
    (3) malleability, good electrical conductivity and brittleness
    (4) brittleness, malleability and ductility

18. On the Fahrenheit scale, the number of degrees between the freezing and boiling points of water is
    (1) 100
    (2) 212
    (3) 180
    (4) 32

19. The three most abundant elements in the earth's crust are oxygen, silicon and
    (1) iron
    (2) sodium
    (3) calcium
    (4) aluminum

20. If samples of sand and common salt are mixed together,
(1) there is a change in the properties of the individual substances
(2) an energy change is observed
(3) they can be separated by simple mechanical means
(4) the parts of the mixture cannot be varied in amount

CHEMISTRY REVIEW TEST - CHAPTER THREE

For each question select the best answer from among the four choices provided. Record your choice as directed by your teacher.

Please do not write on or mark this question paper in any way.

1. Molecules formed by the union of two atoms are called
   (1) atomic
   (2) triatomic
   (3) monatomic
   (4) diatomic

2. The formula H_2S represents a molecule of hydrogen sulfide containing
   (1) two hydrogen atoms and two sulphur atoms
   (2) two hydrogen atoms and one sulphur atom
   (3) one hydrogen atom and two sulphur atoms
   (4) one hydrogen atom and one sulphur atom

3. When a gas is heated, its molecules will
   (1) continue to move at the same rate
   (2) move faster
   (3) move more slowly
   (4) stop moving

4. The escape of molecules from the surface of a liquid is called
   (1) vapor pressure
   (2) Brownian movement
   (3) evaporation
   (4) elasticity

5. The number of molecules in a cup of air would approximate
   (1) 1×10^3
   (2) 1×10^{21}
   (3) 1×10^{-15}
   (4) 1×10^5

6. The smallest particle of a substance which has the properties of that substance is the
   (1) electron
   (2) crystal
   (3) molecule
   (4) milligram

7. In the expression $3H_2SO_4$ the coefficient is
(1) 4
(2) 1 (understood)
(3) 2
(4) 3

8. One atomic mass unit (amu) has a value of
(1) 1.660×10^{24} gram
(2) 1.660 kilogram
(3) 1.660×10^{-24} gram
(4) 1.660 gram

9. The symbol Cl stands for
(1) One atom of chlorine and the weight of one atom
(2) One molecule of chlorine
(3) One molecule of chlorine and the weight of one molecule
(4) One liter of chlorine gas.

10. A substance made up of the same kind of atoms is called
(1) a compound
(2) an element
(3) a mixture
(4) a solution

11. The diameter of an ordinary gas molecule is approximately
(1) 3 cm.
(2) 3×10^{-8} cm.
(3) 0.03 cm.
(4) 3×10^{8} cm.

12. Atoms of the same element that have different masses are called
(1) isobars
(2) atomic mass units
(3) relative atoms
(4) isotopes

13. The atomic weight of oxygen is 16 amu and that of nitrogen is 14 amu. The expression $2N_2O$ stands for a total weight of
(1) 72 amu.
(2) 60 amu.
(3) 88 amu.
(4) 92 amu.

14. Particles resulting from the union of two or more atoms, called complex atoms by Dalton, are now known as
(1) molecules
(2) isotopes
(3) electrons
(4) protons

15. The force of attraction between molecules is least in
    (1) gases
    (2) liquids
    (3) solids
    (4) metals

16. A molecule of a compound is formed by the union of
    (1) two atoms of the same element
    (2) crystals of different elements
    (3) atoms of different elements
    (4) more than two atoms of the same element.

17. Noting crystals growing during an experiment that had never before produced crystals, a chemist ventured an explanation. Scientists would call this explanation a
    (1) theory
    (2) law
    (3) definition
    (4) hypothesis

18. According to Dalton, atoms of all substances are alike in that they
    (1) do not divide in chemical reactions
    (2) have the same weight
    (3) are easily divisible into simpler particles
    (4) have similar chemical properties

19. At a given temperature, the rate of molecular motion would be
    (1) the same in solids, liquids and gases
    (2) greatest in solids
    (3) greatest in liquids
    (4) greatest in gases

20. The term that best describes the spread of an odor throughout a room is
    (1) diffusion
    (2) Brownian movement
    (3) condensation
    (4) expansion

CHEMISTRY REVIEW TEST - CHAPTER FOUR

For each question select the best answer from among the four choices provided. Record your choice as directed by your teacher.

PLEASE DO NOT WRITE ON OR MARK THIS QUESTION PAPER IN ANY WAY.

1. A charged particle with a mass of 55×10^{-5} amu is the
   (1) electron
   (2) proton
   (3) neutron
   (4) atom

2. An atom with 5 protons and 6 neutrons in its nucleus will have in its outermost shell
   (1) 1 electron
   (2) 11 electrons
   (3) 5 electrons
   (4) 3 electrons

3. The symbol n^o represents one
   (1) nitrogen atom
   (2) neutron
   (3) nickel atom
   (4) nitrogen molecule

4. Of the following particles, the one with the least mass is the
   (1) atom
   (2) electron
   (3) neutron
   (4) proton

5. Isotopes of a given element will all have equal
   (1) atomic masses (A numbers)
   (2) numbers of neutrons in the atomic nucleus
   (3) atomic numbers (Z numbers)
   (4) numbers of particles in the nucleus

6. An atom has 4 protons, 5 neutrons and 4 electrons. Its mass number, A, will be
   (1) 13
   (2) 4
   (3) 9
   (4) 5

7. The Bohr atom is visualized as having
(1) a positive nucleus with electrons in orbit about it
(2) a negative nucleus with protons in orbit about it
(3) positive and negative charges mixed at random.
(4) positive and negative charges orbiting together about a point in space

8. Protium, deuterium and tritium are isotopes of hydrogen. This means that they will have
(1) equal numbers of protons and neutrons
(2) equal numbers of protons but different numbers of neutrons
(3) different numbers of protons and neutrons
(4) equal numbers of electrons but different numbers of protons

9. The neutron was first described by
(1) Albert Einstein
(2) Ernest Rutherford
(3) James Chadwick
(4) J. J. Thompson

10. The maximum number of electrons contained in any shell may be found by the formula
(1) $2n^3$
(2) $3n^2$
(3) $2n^2$
(4) $2n$

11. The lithium atom has 3 protons, 4 neutrons and 3 electrons. Its atomic number (Z number) is
(1) 3
(2) 4
(3) 6
(4) 7

12. The chemical activity of an atom is determined by the
(1) number of neutrons in its nucleus
(2) number of its outermost electrons
(3) mass of the atom as a whole
(4) total mass of the neutrons in the atom

13. A particle with a positive charge and a mass almost equal to that of the neutron is the
(1) electron
(2) molecule
(3) atom
(4) proton

14. Bohr's model of the atom differs from Dalton's model in that it
(1) will never have to be changed
(2) is not considered to be indivisible
(3) cannot take part in chemical reactions
(4) does not include phlogiston

15. The positron, predicted by Dirac and discovered by Anderson, has
(1) the same mass as an electron and a positive charge.
(2) a mass and charge equal to that of the proton
(3) the same mass as a proton and a negative charge
(4) neither mass nor charge

16. Atom X has 7 electrons in its outermost shell and atom Y has 5.
(1) Atom X will likely be more active chamically than Y
(2) Atoms X and Y will both be inert
(3) Atom X will likely be less active chemically than Y
(4) Atoms X and Y will be equally active

17. The isotopes of an element are similar in
(1) nuclear properties
(2) atomic mass
(3) radioactivity
(4) chemical properties

18. The maximum number of electrons in the third shell is
(1) 6
(2) 8
(3) 16
(4) 18

19. An element with eight electrons in its outermost shell is
(1) helium
(2) oxygen
(3) neon
(4) fluorine

20. The smallest part of an element which can take part in a chemical reaction is the
(1) atom
(2) molecule
(3) proton
(4) electron

CHEMISTRY REVIEW TEST - CHAPTER FIVE

For each question select the best answer from among the four choices provided. Record your choice as directed by your teacher.

PLEASE DO NOT WRITE ON OR MARK THIS QUESTION PAPER IN ANY WAY.

1. In the modern periodic table, the successive series of elements are placed in horizontal rows called
   (1) periods
   (2) groups
   (3) octets
   (4) shells

2. The chemical properties of an element are determined by
   (1) the total weight of protons and neutrons in the nucleus
   (2) the number of electrons in the outermost shell
   (3) the number of neutrons in the nucleus
   (4) the name of the element

3. In the modern periodic table, period 7
   (1) contains 8 elements
   (2) contains more elements than any other period
   (3) is incomplete
   (4) is known as a short period

4. In the modern periodic table, the elements of one of Dobereiner's Triads would be
   (1) consecutive elements in the same Group
   (2) non-consecutive elements in the same Group
   (3) consecutive elements in the same Period
   (4) non-consecutive elements in the same Period

5. The rare earth elements (lanthanide series) have almost identical chemical properties because in most cases they
   (1) occur in period six
   (2) have the same number of electrons in the outermost shell
   (3) are radioactive
   (4) have unstable nucleii

6. Mendeleyev's statement, "Elements arranged in order of their increasing atomic weights show a periodic repetition of properties" became known as the
   (1) periodic law
   (2) law of atomic weights
   (3) repetitive law
   (4) law of the elements

7. The atomic number of an element depends on
   (1) the total number of particles in the atom
   (2) the number of neutrons in the nucleus
   (3) the number of protons in the nucleus
   (4) the number of electrons in the outermost shell

8. The arrangement of elements known as Newlands' Octaves depended for its characteristics on
   (1) its similarity to the musical scale
   (2) the average atom c weight of each group of eight elements
   (3) a periodic recurrence of certain properties of elements with increasing atomic weight
   (4) the correct placement of the inert gases in each octave

9. In the modern periodic table, period 3 contains
   (1) 2 elements
   (2) 8 elements
   (3) 18 elements
   (4) 32 elements

10. X-rays are
    (1) streams of high energy electrons
    (2) radiation similar to light but of higher frequency
    (3) less penetrating than visible light
    (4) radiation of lower frequency than visible light

11. Less active metals, often with variable valence, found in the centre of the periodic table are called
    (1) transition elements
    (2) metalloids
    (3) alloys
    (4) alkali metals

12. Moseley showed conclusively that the square root of the frequency of the X-rays emitted by the elements was
    (1) inversely proportional to the atomic weight of the element
    (2) directly proportional to the atomic weight of the element
    (3) inversely proportional to the atomic number of the element
    (4) directly proportional to the atomic number of the element

13. As had others before him, Mendeleyev arranged the elements in order of increasing atomic weight with the important difference that
    (1) he knew the atomic weights of all the natural elements

(2) he took into account the ratio of protons to neutrons in each atom
(3) he understood the nature of radioactivity
(4) he left spaces in his table for elements yet to be discovered

14. Except for the inert gases at the extreme right, moving from left to right within any period there is a progressive change from
(1) strongly metallic to strongly non-metallic elements
(2) elements with one electron shell to elements with many
(3) strongly non-metallic to strongly metallic elements
(4) gaseous to liquid to solid elements

15. The restatement of the periodic law on the basis of atomic numbers instead of atomic weights was due to the work of
(1) Moseley
(2) Mendeleyev
(3) Newlands
(4) Dobereiner

16. The Eka-aluminum predicted by Mendeleyev in 1871 had properties strikingly similar to the metallic element
(1) germanium
(2) gallium
(3) indium
(4) cadmium

17. Compared to the smaller atoms in any main group, the larger atoms of that group will
(1) have a greater tendency to lose valence electrons
(2) be more non-metallic in properties
(3) have a greater tendency to attract electrons to the valence shell
(4) be more active chemically

18. Moseley discovered that elements subjected to streams of electrons in high voltage vacuum tubes would
(1) emit X-rays of the same frequency regardless of the element used as a target
(2) emit X-rays that could not be photographed because they were invisible
(3) emit X-rays of energy and frequency characteristic of the target element
(4) absorb the electrons with no emission of radiation

19. The modern periodic table gives atomic weights based on the relative weight of the element compared to
    (1) the average weight of the naturally occurring isotopes of carbon set at 12
    (2) the weight of the most common isotope of oxygen set at 16.
    (3) the average weight of the naturally occurring isotopes of oxygen set at 16
    (4) the weight of the most common isotope of carbon set at 12.

20. Generally, elements in each group are similar in that they
    (1) have the same number of electron shells
    (2) have the same number of electrons
    (3) have the same number of protons
    (4) have the same number of electrons in the outermost shell

CHEMISTRY REVIEW TEST - CHAPTER SIX

For each question select the best answer from among the four choices provided. Record your answer as directed by your teacher.

Please do not write on or mark this question paper in any way.

1. Electrovalent bonding is another term for
   (1) ionic bonding
   (2) covalent bonding
   (3) metallic bonding
   (3) electrolysis

2. Covalent bonding may take place
   (1) only between like atoms (atoms of the same element)
   (2) between like or unlike atoms
   (3) only between unlike atoms
   (4) between like or unlike ions

3. Coordinate covalent bonding differs from covalent bonding in that
   (1) only one pair of electrons can be shared
   (2) there must be sharing of more than one pair of electrons
   (3) both electrons of a shared pair come from the same atom
   (4) electrons are shared singly and not in pairs

4. The maximum valence possible is
   (1) 8
   (2) 2
   (3) 7
   (4) 10

5. In general, the non-metals of Group VII will be
   (1) likely to lose electrons in chemical reactions
   (2) solids at room temperature
   (3) more active than the non-metals of Group VI
   (4) likely to form compounds less stable than those formed by the elements of Group VI

6. The charged particles formed when one atom loses an electron to another in chemical bonding are called
   (1) positrons
   (2) ions
   (3) protons
   (4) nucleii

7. The sharing of electrons between atoms results in what is called
(1) covalent bonding
(2) formation of ions
(3) metallic bonding
(4) ionic bonding

8. The formula ZnS represents the compound
(1) zinc sulfate
(2) zinc sulfide
(3) zinc sulfite
(4) zinc bisulfate

9. The correct formula for ferric chloride is
(1) FeCl
(2) $FeCl_2$
(3) $FeCl_3$
(4) Fe_2Cl

10. The compound containing the most oxygen is
(1) sodium hypochlorite
(2) sodium chlorite
(3) sodium chlorate
(4) sodium perchlorate

11. Ionic bonding is a type of chemical bond typified by
(1) sharing of electrons in pairs
(2) loosely held valence electrons which are free to move about
(3) an exchange of protons between atoms
(4) gain and loss of electrons

12. The only common radical with a positive valence is the
(1) sulfate radical
(2) hydroxide radical
(3) carbonate radical
(4) ammonium radical

13. Ions are held together by
(1) Van der Wall's forces
(2) sharing electrons
(3) the force of electrical attraction
(4) inter-molecular attraction

14. Dipole molecules are electrically unbalanced because
(1) they have fewer protons than electrons
(2) the numbers of positive and negative ions are not balanced
(3) they have fewer electrons than protons
(4) the shared electrons are nearer to one atom than the other.

15. In chemical reactions, elements in Groups I and II of the periodic table tend to
    (1) exhibit non-metallic properties
    (2) lose electrons
    (3) gain electrons
    (4) behave as metalloids

16. A crystal of common table salt is made up of
    (1) molecules of sodium chloride
    (2) sodium atoms mixed, but not united, with chlorine atoms
    (3) sodium and chlorine atoms in an orderly crystal lattice
    (4) sodium ions and chloride ions

17. A group of atoms with a characteristic group valence and a tendency to behave as a single atom in chemical reactions is called
    (1) a radical
    (2) a molecule
    (3) monatomic
    (4) trivalent

18. An atom that is chemically inert is likely to have
    (1) a completely filled outer shell
    (2) eight electron shells
    (3) a position in the middle of a period on the periodic table
    (4) a valence of -1

19. The number of electrons gained, lost or shared when an atom joins another atom is called the
    (1) atomic number
    (2) valence
    (3) Z number
    (4) A number

20. Polar compounds are made up of
    (1) dipole molecules
    (2) atoms which have lost or gained electrons
    (3) molecules formed by ionic bonding
    (4) molecules arranged in an orderly crystal lattice

CHEMISTRY REVIEW TEST - CHAPTER SEVEN

For each question select the best answer from among the four choices provided. Record your answer as directed by your teacher.

PLEASE DO NOT WRITE ON OR MARK THIS QUESTION PAPER IN ANY WAY.

1. The reaction between acetylene and oxygen
   (1) is endothermic
   (2) requires a catalyst
   (3) is electrolytic
   (4) is exothermic

2. Commercial quantities of oxygen are prepared by
   (1) fractional distillation of liquid air
   (2) heating potassium chlorate with manganese dioxide
   (3) heating mercuric oxide
   (4) dropping water on sodium peroxide

3. Oxides may be
   (1) solids, liquids or gases
   (2) solids or liquids
   (3) liquids or gases
   (4) solids or gases

4. In the Bunsen flame, the part known as the 'reducing flame' is
   (1) within the inner cone
   (2) just above the inner cone
   (3) at the extreme tip of the outer cone
   (4) around the outside edges of the outer cone

5. CO_2, SO_2, Fe_3O_4 and H_2O are similar in that they are all
   (1) formed by ionic bonding
   (2) either gases or liquids at room temperature
   (3) oxides
   (4) triatomic molecules

6. The two atoms in the diatomic oxygen molecule are held together by a (an)
   (1) metallic bond
   (2) covalent bond
   (3) coordinate covalent bond
   (4) ionic bond

7. If the equation $KClO_3 \longrightarrow KCl + O_2$ were to be balanced, the coefficient for KCl would be
   (1) 1
   (2) 2
   (3) 3
   (4) 4

8. When one gram of wood is burned, the products formed will weigh
(1) one gram
(2) more than one gram
(3) less than one gram
(4) not more than one-half gram

9. Of the following, which is not a property of oxygen
(1) supports combustion
(2) is magnetic in the liquid state
(3) burns readily
(4) can be solidified at low temperatures

10. The temperature range between the solidification point of oxygen and its boiling point is approximately
(1) 35 Centigrade degrees
(2) 183 Centigrade degrees
(3) 218 Centigrade degrees
(4) 100 Centigrade degrees

11. Finely divided combustibles are serious fire hazards because
(1) reduction in particle size results in a reduction in kindling temperature
(2) Of the greatly increased surface area exposed to the air
(3) the rate of oxidation is low
(4) once burning, they cannot be extinguished

12. In the laboratory preparation of oxygen, manganese dioxide is used as a catalyst in order to
(1) raise the temperature of the reaction
(2) slow down the reaction for safety
(3) speed up the reaction at a lower temperature
(4) make the oxygen in the dioxide available as a product

13. In the electrolysis of water, hydrogen and oxygen are obtained in a ratio by weight of approximately
(1) 2:1
(2) 1:2
(3) 1:9
(4) 1:5

14. The boiling point of oxygen is
(1) $-40^{o}C$
(2) $100^{o}C$
(3) $-183^{o}C$
(4) $32^{o}F$

15. The three natural isotopes of oxygen have
(1) the same A number and different Z numbers
(2) equal numbers of neutrons in their nucleii
(3) different numbers of protons in their nucleii
(4) the same Z number and different A numbers

16. The oxidation of metals and non-metals to form oxides would proceed most rapidly at
(1) low temperature and high oxygen concentration
(2) high temperature and high oxygen concentration
(3) low temperature and low oxygen concentration
(4) high temperature and low oxygen concentration

17. If four different substances are heated together in an open container, the first one to burst into flame will be the one with the
(1) highest kindling temperature
(2) highest boiling point
(3) lowest kindling temperature
(4) position closest to oxygen in the periodic table

18. Credit for the discovery of oxygen is given to
(1) Priestley
(2) Lavoisier
(3) Scheele
(4) Dalton

19. (A) Rusting of iron, (B) burning of wood and (C) the explosion of hydrogen are all examples of oxidation. The reaction is exothermic in
(1) B only
(2) B and C only
(3) A, B and C
(4) A and C only

20. The hottest part of a properly adjusted Bunsen flame has a temperature of approximately
(1) 3600°C.
(2) 600°C.
(3) 2600°C.
(4) 1600°C.

CHEMISTRY REVIEW TEST - CHAPTER EIGHT

For each question select the best answer from among the four choices provided. Record your answer as directed by your teacher.

PLEASE DO NOT WRITE ON OR MARK THIS QUESTION SHEET IN ANY WAY.

1. Hydrogen gas molecules are
   (1) monatomic
   (2) diatomic
   (3) triatomic
   (4) divalent

2. A metal that may not be used in place of zinc in the usual laboratory preparation of hydrogen from an acid is
   (1) magnesium
   (2) iron
   (3) aluminum
   (4) copper

3. In the reaction with heated copper oxide, $H_2 + CuO \longrightarrow H_2O + Cu$, the hydrogen is acting as a (an)
   (1) dehydrating agent
   (2) reducing agent
   (3) catalyst
   (4) oxidizing agent

4. Compounds formed by the combination of hydrogen with a metal are called
   (1) hydrides
   (2) acids
   (3) metalloids
   (4) hydrogenated

5. An active metal which will react with cold water to release hydrogen is
   (1) sodium
   (2) magnesium
   (3) zinc
   (4) iron

6. Hydrogen burned in air produces
   (1) H_2O
   (2) H_2O and CO_2
   (3) H_2O and NO_2
   (4) HCl

7. The most common isotope of hydrogen contains
   (1) 1 neutron
   (2) no neutron
   (3) 2 neutrons
   (4) 3 neutrons

8. The change of corn oil into solid fat is accomplished by
   (1) hydration
   (2) dehydration
   (3) hydrogenation
   (4) condensation

9. In the usual laboratory preparation of hydrogen by the action of zinc on an acid, the first bubbles of gas collected will be
   (1) pure hydrogen
   (2) a mixture of hydrogen and hydrogen sulfide
   (3) pure methane
   (4) a mixture of hydrogen and air

10. The boiling point of hydrogen is
   (1) $0^{o}C.$
   (2) $-137^{o}C.$
   (3) $-253^{o}C.$
   (4) $-40^{o}C.$

11. Of the following metals, all of which will release hydrogen from cold water, the most violent reaction will take place with
   (1) potassium
   (2) sodium
   (3) lithium
   (4) calcium

12. Nitric acid is <u>not</u> used to produce hydrogen in the usual laboratory preparation by displacement with zinc because
   (1) zinc will not react with nitric acid
   (2) nitric acid does not contain hydrogen
   (3) nitric acid will oxidize the hydrogen released to form water
   (4) nitric acid cannot safely be used with glass flasks

13. Water gas is formed commercially by
   (1) electrolysis of water
   (2) passing steam through hot coke
   (3) electrolysis of brine
   (4) mixing pure hydrogen and pure carbon monoxide

14. Hot iron reacts with steam thus Fe + $H_2O \longrightarrow Fe_3O_4$ + H_2. If this equation were to be balanced, the coefficient required for the H_2O would be
(1) 1
(2) 2
(3) 3
(4)

15. The density of hydrogen is approximately
(1) 90 gm/l
(2) 9 gm/l
(3) 0.9 gm/l
(4) 0.09 gm/l

16. Water gas is a mixture of
(1) hydrogen and air
(2) oxygen and carbon dioxide
(3) carbon monoxide and hydrogen
(4) hydrogen and ammonia

17. The metal most closely resembling potassium in its reaction with water is
(1) aluminum
(2) lithium
(3) magnesium
(4) zinc

18. Tritium, the heaviest isotope of hydrogen, has
(1) 1 neutron
(2) 2 neutrons
(3) 3 neutrons
(4) 4 neutrons

19. Salts of sulfuric acid are known as
(1) sulfides
(2) sulfites
(3) sulfates
(4) bisulfites

20. The oxyhydrogen torch and the atomic hydrogen torch differ in that
(1) the oxyhydrogen torch produces higher temperatures
(2) only the oxyhydrogen torch involves combustion of hydrogen
(3) the atomic hydrogen torch will operate without the presence of oxygen
(4) in the atomic hydrogen torch recombination of hydrogen atoms to form molecules produces part of the heat

CHEMISTRY REVIEW TEST - CHAPTER NINE

For each question select the best answer from among the four provided. Record your answer as directed by your teacher.

PLEASE DO NOT WRITE ON OR MARK THIS QUESTION PAPER IN ANY WAY.

1. Ice, water and steam are three states of one compound. The state in which the molecules are practically independent of each other is:
(1) crystalline
(2) solid
(3) liquid
(4) gaseous

2. The process of evaporation followed by condensation of the vapors in a separate vessel is:
(1) distillation
(2) analysis
(3) synthesis
(4) dehydration

3. As liquid water is heated from room temperature (20°C) toward its boiling point, its density:
(1) increases steadily
(2) decreases steadily
(3) remains unchanged
(4) increases then decreases

4. As ice melts and the water thus formed is heated, its density:
(1) increases steadily
(2) decreases steadily
(3) increases to 4°C and then decreases
(4) decreases to 4°C and then increases

5. The composition of water may be determined by:
(1) boiling the water
(2) synthesising water from its elements
(3) freezing the water
(4) determining the density at various temperatures

6. Analysis of water reveals that the ratio of the volume of oxygen to that of the hydrogen is:
(1) 1:1
(2) 2:1
(3) 1:2
(4) 8:1

7. The reaction between hydrogen and oxygen is $2H_2 + O_2 \longrightarrow 2H_2O$. The weight of oxygen required to completely convert 4 grams of hydrogen to water is
(1) 8 grams
(2) 2 grams
(3) 32 grams
(4) 16 grams

8. A mixture consisting of 10 ml. of hydrogen and 10 ml. of oxygen is placed in a eudiometer over mercury. After an electric spark is passed through the mixture the volume of gas remaining is:
(1) 0 ml.
(2) 5 ml.
(3) 9 ml.
(4) 15 ml.

9. A metal which reacts readily with cold water is
(1) potassium
(2) magnesium
(3) iron
(4) zinc

10. Water reacts with the oxides of several non-metals to form:
(1) a basic solution
(2) an acid solution
(3) an anhydride
(4) a hydride

11. The metal calcium may be burned in air and the resulting compound dissolved in water. The formula for the final compound formed is
(1) H_2CaO_3
(2) CaH_2
(3) CaOH
(4) $Ca(OH)_2$

12. The oxides of very active metals are
(1) basic anhydrides
(2) acidic anhydrides
(3) hydrates
(4) peroxides

13. Chemically pure water can best be prepared by
(1) filtration
(2) chlorination
(3) boiling
(4) distillation

14. What volume of oxygen will combine with 11.2 ml. of hydrogen to form water, both gases being measured at the same temp. and press.
    (1) 5.6 ml.
    (2) 11.2 ml.
    (3) 22.4 ml.
    (4) 44.8 ml.

15. Sea water could be made salt free by
    (1) filtration through beds of sand
    (2) chlorination
    (3) boiling
    (4) distillation

16. After a mixture of 60 ml. of oxygen and 50 ml. of hydrogen has been exploded in a eudiometer, how many ml. of residual gas will remain unexploded?
    (1) 10 ml.
    (2) 20 ml.
    (3) 25 ml.
    (4) 35 ml.

17. Which is not a method of purifying water?
    (1) sand filtration
    (2) distillation
    (3) electrolysis
    (4) sedimentation

18. Which is not a characteristic of water at 4 degrees Celsius?
    (1) It expands upon cooling
    (2) It expands upon warming
    (3) It has maximum density
    (4) It has minimum density

19. Which of the following is a characteristic of water?
    (1) Water has a greater density at 5°C than at 4°C.
    (2) Water boils below 100°C when the pressure is 770 mm. of Hg.
    (3) The specific heat of water is 1 calorie per gram per degree C.
    (4) Water is a mixture of hydrogen and oxygen.

20. Water may be decomposed into hydrogen and oxygen by the process of
    (1) electrolysis
    (2) hydrolysis
    (3) osmosis
    (4) synthesis

CHEMISTRY REVIEW TEST - CHAPTER TEN

**** Unlike the other tests in this series, this problem test will require a full class period for completion. Read each problem carefully, do the necessary calculations on a separate sheet of paper and select the correct answer from among the four provided. Record your answer as directed by your teacher.

PLEASE DO NOT WRITE ON OR MARK THIS QUESTION SHEET IN ANY WAY.

Atomic weights: Carbon 12, Hydrogen 1, Oxygen 16, Sodium 23, Silicon 28, Calcium 40 Chlorine 35.5, Sulfur 32, Silver 108 Nitrogen 14.

1. The percentage composition of silicon dioxide SiO_2 is
   (1) Si 41.3%, O 58.7%
   (2) Si 57.2%, O 42.8%
   (3) Si 46.7%, O 53.3%
   (4) Si 55.5%, O 44.5%

2. The formula for baking soda is $NaHCO_3$. The formula weight is
   (1) 95
   (2) 84
   (3) 73
   (4) 87

3. A gas having a molecular weight of 30 is composed of 39.95% carbon, 6.69% hydrogen and 53.36% oxygen. The molecular formula is
   (1) CH_2O
   (2) C_2HO
   (3) CH_2O_2
   (4) $C_2H_2O_2$

4. The weight of sodium in 100 grams of sodium hydroxide, NaOH, is
   (1) 23.0 gms.
   (2) 32.5 gms.
   (3) 65.3 gms.
   (4) 57.5 gms.

5. A compound contains 70.13% silver, 9.09% nitrogen and 20.77% oxygen. The empirical formula is
(1) $AgNO_3$
(2) Ag_2NO_2
(3) $AgNO_2$
(4) AgN_2O

6. Chloride of lime has the formula $CaOCl_2$. The percentage composition is
(1) Ca 45.3%, O 8.7%, Cl 46.0%
(2) Ca 42.1%, O 10.3%, Cl 47.6%
(3) Ca 31.5%, O 12.6%, Cl 55.9%
(4) Ca 37.8%, O 9.6%, Cl 52.6%

7. The formula for glycerine is $C_3H_5(OH)_3$. The formula weight is
(1) 92
(2) 82
(3) 105
(4) 53

8. A gas contains 75% carbon and 25% hydrogen. The molecular weight is 16. The molecular formula is
(1) C_2H_8
(2) CH_3
(3) C_3H
(4) CH_4

9. A compound contains 29.41% calcium, 23.52% sulfur and 47.05% oxygen. The empirical formula is
(1) $CaSO_3$
(2) $CaSO_2$
(3) CaS_2O_3
(4) Ca_2SO_2

10. The weight of carbon in 10 lb. of table sugar (sucrose), $C_{12}H_{22}O_{11}$, is

(1) 4.2 lb.
(2) 0.7 lb.
(3) 2.6 lb.
(4) 6.8 lb.

CHAPTER REVIEW TEST - CHAPTER ELEVEN

For each question select the best answer from among the four choices provided. Record your answer as directed by your teacher.

PLEASE DO NOT WRITE ON OR MARK THIS QUESTION SHEET IN ANY WAY

For atomic weights see end of test.

1. In the balanced equation for the decomposition of calcium carbonate to produce carbon dioxide and calcium oxide, the coefficient for the calcium oxide will be:
   (1) 1 (understood)
   (2) 2
   (3) 3
   (4) 4

2. Of the following equations, the one representing double replacement is:
   (1) $Fe + CuSO_4 \longrightarrow FeSO_4 + Cu$
   (2) $2KClO_3 \longrightarrow 2KCl + 3O_2$
   (3) $CaO + H_2O \longrightarrow Ca(OH)_2$
   (4) $NaOH + HCl \longrightarrow NaCl + H_2O$

3. What weight of oxygen could be produced from 100 gm. of potassium chlorate?
   (1) 19.6 gm.
   (2) 39.2 gm.
   (3) 13.1 gm.
   (4) 96.0 gm.

4. Which of the following equations is correctly balanced?
   (1) $4FeS_2 + 11O_2 \longrightarrow 2Fe_2O_3 + 8SO_2$
   (2) $2KNO_3 \longrightarrow 2KNO_2 + O_2$
   (3) $H_2 + O_2 \longrightarrow H_2O$
   (4) $MnO_2 + 4HCl \longrightarrow MnCl_2 + H_2O + Cl_2$

5. 0.2 grams of hydrogen and 2.0 grams of oxygen are placed in a eudiometer tube. After the explosion, the uncombined gas remaining will be:
   (1) 0.1 grams of hydrogen
   (2) 0.4 grams of hydrogen
   (3) 0.4 grams of oxygen
   (4) 1.8 grams of oxygen

6. 64 grams of sulphur are burned completely in air. The weight of sulphur dioxide produced will be:
(1) 32 grams
(2) 64 grams
(3) 96 grams
(4) 128 grams

7. What weight of mercuric oxide will produce 50 gm. of oxygen?
(1) 339.1 gm.
(2) 737.3 gm.
(3) 678.1 gm.
(4) 368.5 gm.

8. What weight of oxygen could be produced from 100 gm. H_gO?
(1) 7.4 gm.
(2) 32.0 gm.
(3) 73.7 gm.
(4) 43.4 gm.

9. What weight of potassium chlorate would be required to produce 50 grams of oxygen?
(1) 63.8 gm.
(2) 255.2 gm.
(3) 382.8 gm.
(4) 127.6 gm.

10. In the balanced equation for the reaction of aluminum and oxygen to produce aluminum oxide, the coefficient for the aluminum will be:
(1) 1 (understood)
(2) 2
(3) 3
(4) 4

11. In the balanced equation for the reaction of nitrogen and hydrogen to produce ammonia, the coefficient for the hydrogen will be:
(1) 1 (understood)
(2) 2
(3) 3
(4) 4

12. Aluminum hydroxide, $Al(OH)_3$, has a formula weight of
(1) 78
(2) 46
(3) 132
(4) 76

13. In the balanced equation for the decomposition of potassium chlorate, the equation weight of potassium chlorate is
(1) 122.5
(2) 245.0
(3) 74.5
(4) 149.0

14. In the balanced equation for the reaction of zinc and hydrochloric acid to produce zinc chloride and hydrogen, the coefficient for the hydrochloric acid will be
(1) 1 (understood)
(2) 2
(3) 3
(4) 4

15. The type of reaction represented by the equation $AgNO_3 + NaCl \longrightarrow NaNO_3 + AgCl$ is
(1) single replacement
(2) combination (synthesis).
(3) double replacement
(4) decomposition (analysis)

16. Which of the following equations is correctly balanced?
(1) $Cl_2 + NaI \longrightarrow 2NaCl + I_2$
(2) $2Zn + CuSO_4 \longrightarrow ZnSO_4 + Cu$
(3) $H_2CO_3 \longrightarrow CO_2 + H_2$
(4) $3Fe + 4H_2O \longrightarrow Fe_3O_4 + 4H_2$

17. Of the following equations, the one representing single replacement is
(1) $CaO + H_2O \longrightarrow Ca(OH)_2$
(2) $Cl_2 + 2KBr \longrightarrow 2KCl + Br_2$
(3) $NaCl + H_2SO_4 \longrightarrow NaHSO_4 + HCl$
(4) $2HgO \longrightarrow 2Hg + O_2$

18. One mole of hydrated copper sulphate, $CuSO_4 \cdot 5H_2O$, is heated to dryness. The weight of water released will be
(1) 85 lb.
(2) 85 gms.
(3) 159.5 gms.
(4) 244.5 lb.

19. The type of reaction represented by the equation $S + O_2 \quad SO_2$ is
(1) combination (synthesis)
(2) decomposition (analysis)
(3) single replacement
(4) double replacement

20. Which of the following equations is correctly balanced?
(1) $Zn + HCl \longrightarrow ZnCl_2 + H_2$
(2) $Na + H_2O \longrightarrow NaOH + H_2$
(3) $Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2$
(4) $2HgO \longrightarrow 2Hg + O_2$

Atomic Weights: Aluminum 27, Chlorine 35.5, Copper 63.5
Hydrogen 1, Mercury 201, Potassium 39,
Oxygen 16, Sulphur 32

CHEMISTRY REVIEW TEST - CHAPTERS TWELVE AND THIRTEEN

For each question select the best answer from among the four choices provided. Record your answer as directed by your teacher.

PLEASE DO NOT WRITE ON OR MARK THIS QUESTION SHEET IN ANY WAY.

1. What will be the volume at S.T.P. of a gas which occupies 20 litres at 760 mm. Hg. and 40°C?
   (1) 18.7 l.
   (2) 21.3 l.
   (3) 25.4 l.
   (4) 17.4 l.

2. In the equation given, what volume of ammonia will be produced by the complete reaction of 60 l. of hydrogen with nitrogen? $N_2 + 3H_2 \longrightarrow 2NH_3$
   (1) 20 l.
   (2) 30 l.
   (3) 40 l.
   (4) 50 l.

3. A gas has a density of 2.59 gm/l at S.T.P. What is the molecular weight of the gas?
   (1) 63
   (2) 47
   (3) 52
   (4) 58

4. The specific gravity of a gas is 0.897. What is the molecular weight of the gas?
   (1) 32
   (2) 26
   (3) 44
   (4) 18

5. What volume of oxygen at S.T.P. will be produced by the complete decomposition of 20 gms. of potassium chlorate? $2KClO_3 \longrightarrow 2KCl + 3O_2$
   (1) 22.4 l.
   (2) 5.5 l.
   (3) 3.2 l.
   (4) 11.2 l.

6. What weight of mercuric oxide must be decomposed in order to produce 2 liters of oxygen at S.T.P.?
$2HgO \longrightarrow 2Hg + O_2$
(1) 38.75 gm.
(2) 53.27 gm.
(3) 29.23 gm.
(4) 41.62 gm.

7. A gas has a volume of 10 liters at 760 mm. Hg. and 21° C. If the pressure is held constant, at what temperature will the gas have a volume of 5 liters?
(1) -126°C.
(2) -37°C.
(3) 0°C.
(4) 10.5°C.

8. What is the specific gravity of propane gas, C_3H_8?
(1) 1.52
(2) 1.26
(3) 2.08
(4) 1.73

9. Three liters of a gas at 10°C is confined under a pressure of 770 mm. Hg. If the pressure is changed to 1200 mm. Hg. without change in temperature, what will be the new volume?
(1) 2.6 l.
(2) 1.9 l.
(3) 3.4 l.
(4) 1.3 l.

10. The formula for nitrous oxide is N_2O. What is its density in grams/liter at S.T.P.?
(1) 2.03 gm/l.
(2) 1.59 gm/l.
(3) 1.96 gm/l.
(4) 1.66 gm/l.

Atomic Weights: Nitrogen 14, Oxygen 16, Carbon 12
Hydrogen 1, Mercury 201, Potassium 39,
Chlorine 35.5.

CHEMISTRY REVIEW TEST - CHAPTER FOURTEEN

For each question, select the best answer from among the four provided. Record your answer as directed by your teacher.

PLEASE DO NOT WRITE ON OR MARK THIS QUESTION SHEET IN ANY WAY.

1. The type of crystal that is held together by attraction between positive ions and negative electrons is the
   (1) metallic crystal
   (2) molecular crystal
   (3) covalent crystal
   (4) ionic crystal

2. In $CuSO_4 \cdot 5H_2O$, the water is
   (1) held in chemical combination
   (2) physically trapped inside the crystal
   (3) absorbed
   (4) called water of efflorescence

3. Calcium acetate dissolves exothermically in water. The solubility of calcium acetate in water will be
   (1) unaffected by temperature change
   (2) greater at high temperature than at low temperature
   (3) greater than that of substances which dissolve endothermically
   (4) greater at low temperature than at high temperature

4. A small crystal of solute is added to a solution with the result that there is rapid precipitation of solute. The solution must have been
   (1) unsaturated
   (2) supersaturated
   (3) concentrated
   (4) saturated

5. Heat of solution is a result of
   (1) the heat absorbed when solute molecules are separated from each other
   (2) the heat given off when solute and solvent molecules combine
   (3) the net difference between (1) and (2)
   (4) an exothermic reaction

6. A solution which contains one gram-equivalent weight of solute per liter of solution is a
(1) formal solution (F)
(2) molar solution (M)
(3) molal solution (m)
(4) normal solution (N)

7. Solutions differ from other mixtures in that
(1) they are uniform throughout
(2) the components retain their original properties
(3) the components may be separated by physical means
(4) the composition is variable

8. A molecule of solute surrounded by molecules of solvent is said to be
(1) suspended
(2) saturated
(3) supersaturated
(4) solvated

9. The number of types of solution possible is
(1) 3
(2) 6
(3) 9
(4) 12

10. Non-polar solvents usually made good solvents for
(1) non-polar compounds
(2) polar compounds
(3) ionic compounds
(4) metallic compounds

11. A gas will be most soluble in a liquid at
(1) low temperature and high pressure
(2) low temperature and low pressure
(3) high temperature and high pressure
(4) high temperature and low pressure

12. Which of the following statements is not characteristic of the solute particles in a solution?
(1) they are molecular in size
(2) they can be removed by filtration
(3) they do not settle out on standing
(4) they are uniformly distributed throughout the solvent.

13. In dissolving a solid solvent in a liquid solvent, if one first pulverized the solute one would expect

(1) more of the solvent to dissolve before reaching saturation
(2) the same amount of solute to dissolve at a faster rate
(3) less of the solute to dissolve before reaching saturation
(4) no difference in either rate of solution or amount of solute required for saturation

14. The method most likely to result in the growth of larger crystals will be
(1) slow evaporation of a concentrated solution
(2) slow evaporation of a dilute solution
(3) rapid evaporation of a concentrated solution
(4) rapid evaporation of a dilute solution

15. Which of the following general statements is correct?
(1) a saturated solution will be concentrated
(2) a saturated solution will be dilute
(3) the degree of saturation and concentration of a solution are independent of each other
(4) an unsaturated solution cannot be concentrated

16. A molal solution of a non-electrolyte in water will have a freezing point of
(1) $1.86^{\circ}C$
(2) $-1.86^{\circ}C$
(3) $0.52^{\circ}C$
(4) $-0.52^{\circ}C$

17. Loss of water of crystallization by a crystal on exposure to air is called
(1) decrepitation
(2) deliquescence
(3) efflorescence
(4) hydration

18. A true solution is always
(1) saturated
(2) coloured
(3) heterogeneous
(4) clear

19. Which of the following is a true statement?
(1) oil and water are miscible
(2) agitation of a solution increases the amount of solute that will dissolve
(3) amorphous solids have a cubic crystal lattice
(4) alcohol and water are miscible in all proportions

20. Sodium chloride crystals are
(1) covalent
(2) molecular
(3) ionic
(4) metallic

APPENDIX E

CHEMISTRY REVIEW TEST ANSWERS

NAME ______________________________

NUMBER __________

1. ______
2. ______
3. ______
4. ______
5. ______
6. ______
7. ______
8. ______
9. ______
10. ______
11. ______
12. ______
13. ______
14. ______
15. ______
16. ______
17. ______
18. ______
19. ______
20. ______

Number right $\frac{\qquad}{20}$

Score expressed as a per cent ______%

TEST # ______

APPENDIX F

JOHN RENNIE HIGH SCHOOL

STUDENT'S NAME ________________

GRADE ____ HOME ROOM ____

SUBJECT TEACHER ________________

CHEMISTRY 10/11 January 1966.

IMPORTANT: A Periodic Chart is attached to the back of this examination and may be used for reference purposes.

VALUES SECTION A - Compulsory

30 I. Directions: For each statement or question, write on the separate answer sheet the number preceding the word or expression that, of those given, best completes the statement or answers the questions.

1. A true solution may be

   1. milky
   2. cloudy
   3. colored
   4. opaque

2. An emulsion is the dispersion of a

   1. liquid in a gas
   2. liquid in a liquid
   3. solid in a liquid
   4. gas in a solid

3. When a small crystal of sodium thiosulfate was added to a solution of sodium thiosulfate and shaken, several crystals settled at the bottom of the test tube. The original solution was

   1. dilute
   2. saturated
   3. supersaturated
   4. unsaturated

4. A solution that contains all of the solute it can normally dissolve at a given temperature is always

4. (cont'd)

   1. concentrated
   2. dilute
   3. saturated
   4. supersaturated

5. A substance that reacts with water to form a solution that turns litmus blue is

   (a) CaO (b) CO_2 (c) Fe_2O_3 (d) SO_2

6. A base is obtained by the reaction between cold distilled water and

   (a) copper (b) iron (c) potassium (d) silver

7. The law of multiple proportions is illustrated by

   1. HCl and H_2SO_4
   2. KCl and KBr
   3. NaCl and $NaClO_3$
   4. N_2O and NO_2

8. The element with atomic number 7 is likely to have properties similar to the element whose atomic number is

   1. 11
   2. 2
   3. 15
   4. 17

9. A chemical change occurs in the process of

   1. condensation
   2. fermentation
   3. melting
   4. solution

10. Solid nonmetals are generally

   1. brittle
   2. flexible
   3. conductors of electricity
   4. lenders of electrons

11. A chemical property of a substance is its

   1. color
   2. combustibility
   3. density
   4. state

12. An atom loses two electrons; it then becomes an ion with a charge of

    (a) +2 (b) -2 (c) +4 (d) zero

13. In general, an atom will form a positive ion most easily if the

    1. size of the atom is large
    2. size of the atom is small
    3. charge on the ion is large
    4. atom appears below hydrogen in the activity series

14. An atom containing 9 protons, 10 neutrons and 9 electrons has a mass number of

    (1) 9 (2) 18 (3) 19 (4) 28

15. In chemical changes, metals generally

    (1) gain electrons
    (2) lose electrons
    (3) neither gain nor lose electrons
    (4) share electrons

16. Isotopes of the same element have different numbers of

    a) atoms b) electrons c) neutrons d) protons

17. The most active halogen is
    1. bromine (Z = 35)
    2. chlorine (Z = 17)
    3. fluorine (Z = 9)
    4. iodine (Z = 53)

18. The correct formula for sodium chlorite is

    (1) NaClO (2) $NaClO_3$ (3) NaCl (4) $NaClO_2$

19. SO_4 is (a) an acid (b) a compound (c) a radical (d) a salt

20. The physical property that is most important in determining the method of <u>collection</u> of a gas in the laboratory is its

    (1) boiling point

20.(cont'd.)

(2) color
(3) odor
(4) solubility

21. A deutron (deutrium nucleus) has a charge of

1. + 1 and a mass of 1
2. + 1 and a mass of 2
3. + 2 and a mass of 1
4. + 2 and a mass of 2

22. If 8 milliliters of uncombined oxygen remain after exploding oxygen with 4 milliliters of hydrogen, the number of milliliters of oxygen that were originally mixed with the hydrogen was

(1) 12 (2) 2 (3) 10 (4) 4

23. Hydrogenation is a process used to prepare

1. heavy water
2. hydrogen from natural gas
3. radioactive isotopes
4. solid fats from vegetable oils

24. A metal that readily displaces hydrogen from cold water is

(a) aluminum (b) iron (c) platinum (d) sodium

25. When iron reacts with a dilute acid, the hydrogen obtained comes from

(a) the iron (b) the water (c) the acid
(d) the air

26. The number of atoms in a molecule of Epsom salts, $MgSO_4 \cdot 7H_2O$, is

(1) 9 (2) 20 (3) 24 (4) 27

27. Water of hydration may be removed from a crystal by

1. deliquescence
2. heating
3. high pressure
4. freezing

Values

28. When 90 grams of water are electrolyzed, the greatest weight of oxygen that can be obtained is

(1) 10 gms. (2) 60 gms. (3) 80 gms. (4) 89 gms.

29. One molecular weight of any gas at standard conditions of temperature and pressure contains the same number of

1. atoms 2. electrons 3. ions 4. molecules

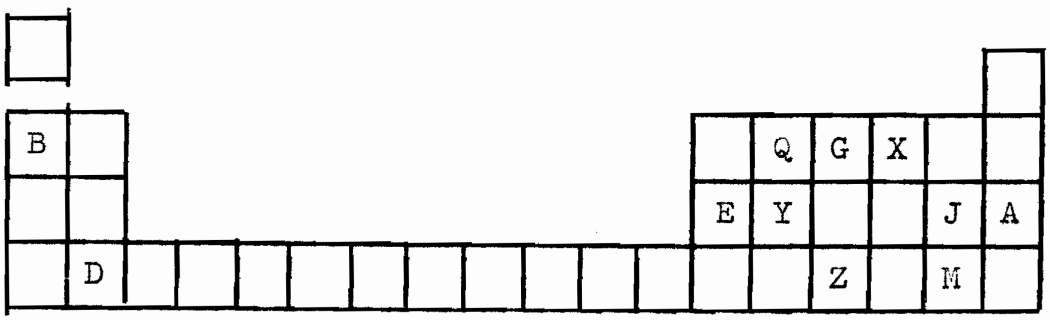
30. The molecular weight of $Ca(OH)_2$ is

(a) 57 (b) 58 (c) 74 (d) 114

SECTION B

DIRECTIONS: Answer ALL questions in this section.

5 II. Base your answers to questions A through E on the following hypothetical periodic chart. Record your answers on the separate answer sheet provided



A. Which pair of elements forms a compound possessing the strongest ionic character?

(1) B and D (3) Q and M

(2) B and X (4) Q and Y

B. Which element, when combined with hydrogen, produces an acid-forming compound?

(1) A (3) E

(2) B (4) M

Values

C. Which pair of elements is most likely to combine to form compounds by sharing electrons?

(1) A and Q (3) J and M

(2) A and Y (4) D and M

D. Two elements that have similar valences are

(1) B and D (3) G and X

(2) E and Y (4) G and Z

E. Which element has a zero valence?

(1) J (3) X

(2) A (4) B

4 III. (a) In one sentence state the usual laboratory method for the preparation of hydrogen. Write the correctly balanced equation for the reaction.

4 (b) Draw a labelled diagram of the apparatus used in part (a).

4 (c) Briefly describe the industrial preparation for this gas and write the equation for the reaction.

5 (d) Sixteen liters of hydrogen at S.T.P. were produced in a chemical reaction. If this gas was compressed until it occupied a volume of eight (8) liters at 20°C, what pressure would it exert?

2 IV. (a) State the Law of Conservation of Mass.

2 (b) When does the above law not apply? Explain

4 (c) Prepare a table which shows a comparison of the properties of mixtures, solutions and compounds.

Values

8 (d) Define FOUR of the following:

i. element
ii. atomic number
iii. molecule
iv. mass number
v. periodic law
vi. valence electrons

4 V.(a) Write formulas for each of the following:

i. zinc chloride
ii. potassium chlorate
iii. magnesium fluoride
iv. hydrogen sulphide
v. ferric carbonate
vi. mercuric sulphate
vii. ferrous sulphite
viii. potassium perchlorate

4 (b) Give the names of the following compounds or elements.

i. Li_2SO_4
ii. NaClO
iii. Pt
iv. Ag_2S
v. AlF_3
vi. NH_4NO_3
vii. $FePO_4$
viii. Na_2O_2

SECTION C

DIRECTIONS: Answer question 6 and any TWO other questions from this section.

6 VI Briefly describe what is OBSERVED in each of the following and write the chemical equations for the reactions that occur.

(a) A burning splint is inserted into a jar of pure hydrogen

(b) Hydrogen is passed over heated cupric oxide

(c) A jar containing equal volumes of chlorine and hydrogen is exposed to bright sunlight

1 VII (a) Name the scientist who was chiefly responsible for the latest major change in the periodic table.

4 (b) Describe briefly the experiment he used and show how he formulated the present periodic table in terms of the results he obtained.

Values

4 (c) Determine the percent water of hydration in $Na_2SO_4 \cdot 10H_2O$

1 VIII (a) Define chemical bond

4 (b) 1. Using electron dot formulas show how the compound beryllium chloride is formed.

2. What type of bond will exist in this compound?

4 (c) If 40 liters of hydrogen are allowed to react with 60 liters of chlorine

i. what volume of hydrogen chloride would be produced?

ii. what volume of which starting material would be left over?

CHEMISTRY EXAMINATIONS

JOHN RENNIE HIGH SCHOOL

January 1966

ANSWER SHEET

STUDENT'S NAME .... TEACHER ....

GRADE .... HOME ROOM ....

SECTION A

QUESTION I

1.	11.	21. ....
2.	12.	22. ....
3.	13.	23. ....
4.	14.	24. ....
5.	15.	25. ....
6.	16.	26. ....
7.	17.	27. ....
8.	18.	28. ....
9.	19.	29. ....
10.	20.	30. ....

SECTION B

QUESTION II

A.	C.	E. ....
B.	D.	

PERIODIC TABLE

1 H 1.008																	2 He 4.00
3 Li 6.94	4 Be 9.01											5 B 10.8	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.0	10 Ne 20.2
11 Na 23.0	12 Mg 24.3											13 Al 26.9	14 Si 28.1	15 P 31.0	16 S 32.1	17 Cl 35.5	18 Ar 39.9
19 K 39.1	20 Ca 40.1	21 Sc 45.0	22 Ti 47.9	23 V 51.0	24 Cr 52.0	25 Mn 54.9	26 Fe 55.9	27 Co 58.9	28 Ni 58.7	29 Cu 63.5	30 Zn 65.4	31 Ga 69.7	32 Ge 72.6	33 As 74.9	34 Se 79.0	35 Br 79.9	36 Kr 83.8
37 Rb 85.5	38 Sr 87.6	39 Y 88.9	40 Zr 91.2	41 Nb 92.9	42 Mo 96.0	43 Tc (99)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.4	see below 57-71	72 Hf 178.5	73 Ta 181.0	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.2	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po 210	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	see below 89-															

57 La 138.9	58 Ce 140.1	59 Pr 140.9	60 Nd 144.3	61 Pm (147)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0

89 Ac (227)	90 Th 232.1	91 Pa (231)	92 U 238.1	93 Np (237)	94 Pu (242)	95 Am (243)	96 Cm (247)	97 Bk (245)	98 Cf (251)	99 Es (254)	100 Fm (253)	101 Md (256)	102 Lw	103 Fm

most stable known isotopes shown in parentheses

BEACONSFIELD HIGH SCHOOL

GRADE 11 CHEMISTRY January 18, 1966

NAME: ______________ SUBJECT TEACHER: ________

(40) SECTION A

Choose the correct answer and enter the approved letter on your paper in a vertical column beside the number

1. The following is a unit of volume

 a) centimeter c) gram
 b) degree d) liter

2. An example of a chemical change is:

 a) condensation of steam c) dissolving of sugar
 b) corrosion of metal d) melting ice

3. In a chemical change the weight of the reacting substances compared to the weight of the product is

 a) never the same c) less
 b) always the same d) more

4. The total number of atoms represented by $C_3H_5(NO_3)_3$

 a) 11 c) 15
 b) 20 d) 17

5. A gas occupies 600 ml. If the pressure is tripled while the temperature is constant, the new volume is:

 a) 200 ml. c) 600 ml.
 b) 300 ml. d) 1800 ml.

6. When gases combine chemically there is a simple whole number ratio between their:

 a) masses c) volumes
 b) densities d) temperatures

7. The atomic number of Iodine is 53. One of its isotopes has a mass of 128. The isotope has the following number of neutrons.

a) 53 c) 128
b) 75 d) 181

8. In its present form the Periodic Law states that the chemical properties of elements are periodic functions of:

a) atomic mass c) atomic number
b) atomic weight d) isotopic weight

9. Hydrogen for use in the reduction of copper oxide may be dried by means of:

a) calcium chloride c) hydrogen chloride
b) carbon tetra chloride d) sodium chloride

10. From its position in the electromotive series, the metal which decomposes water most rapidly is:

a) Mg c) Na
b) Pb d) Cu

11. Oxides of non-metals are called:

a) basic anhydrides c) acids
b) acidic anhydrides b) bases

12. The chemical properties of an element are determined by:

a) the electrons in the valence shells
b) the combining power (valence) of its atoms
c) the number of neutrons contained in the nucleus
d) the atomic weight of the atom

Match the following:

13. The prefix centi means a) one million

14. The prefix micro means b) one hundredth

15. The prefix mega means c) one thousand

d) one millionth

Fill in the blanks beside the numbers with the appropriate answer.

16. Solutions containing more dissolved solute than a solution in equilibrium are said to be ....

17. Reactions evolving heat are ....

18. The relative density of a gas compared to hydrogen as a standard is called its ....

19. If 22.4 liters of hydrogen, H_2 contains 6.02×10^{23} molecules, then 22.4 liters of methane, CH_4, contain the following number of molecules at the same temperature and pressure ....

20.
21. If 10 ml. of hydrogen is mixed with 4 ml. of oxygen in a eudiometer tube and sparked, the gas remaining is .... and measures .... ml.

22. The molecular formula of octane is C_8H_{18}, the empirical formula is ....

23. Heavy water consists of oxygen and ....

24. The density of a gas compared to air as a standard is called its ....

25. The correct formula for ferrous oxide is ....

26. 6,400,000 expressed in powers of ten is ....

Identify each reaction as: a) synthesis, b) analysis, c) simple displacement, d) double displacement.

27. $KOH + HCl \longrightarrow KCl + HOH$

28. $2KClO_3 \longrightarrow 2KCl + 3O_2$

29. $Fe + H_2SO_4 \longrightarrow FeSO_4 + H_2$

30. $H_2O + SO_2 \longrightarrow H_2SO_3$

(Questions 1 - 30 are worth 1 mark each)

(2) 31. A gas has a volume of 115 mls. at 20°C and 483 mm. of pressure. What is its volume if the temperature is raised to 80°C. and the pressure to 760 mm.

a) $115 \times \frac{760}{483} \times \frac{293}{353}$ c) $115 \times \frac{20}{80} \times \frac{483}{760}$

b) $115 \times \frac{483}{760} \times \frac{353}{293}$ d) $115 \times \frac{80}{20} \times \frac{483}{760}$ ....

(2) 32. What volume of hydrogen measured at S.T.P. results from the reaction of 1.00 gram-atom of Aluminum with an excess of hydrochloric acid?

$$2Al + 6HCl \longrightarrow 2AlCl_3 + 3H_2$$

a) 3 x 22.4 liters c) 1.5 x 22.4 liters
b) 2 x 22.4 liters d) 22.4 liters ....

(2) 33. A compound contains 46.2% carbon and 53.8% nitrogen by weight. At S.T.P. 11.2 liters of the gas weighs 26 grams. The molecular formula is:

a) CN c) C_2N_2
b) CN_2 d) C_4N_4 ....

(2) 34. The weight of 500 ml. of a gas is .3 gram. The density is approximately:

a) .3g/l c) 13.4g/l
b) .6g/l d) .6

(2) 35. One gram of hydrogen at S.T.P. occupies:

a) 1 ml c) 11,200 ml
b) 2 ml d) 22,400 ml

SECTION B

(4) 1. Describe with the air of a diagram the usual method of the preparation and collection of hydrogen gas.

(2) 2. a) Write the equation for the reaction which takes place in question 1.

b) State two reasons why the gas can be collected as shown in your diagram.

(4) 3. Distinguish between the terms efflorescence and deliquescence. Give an example of each type of compound.

(4) 4. Name the types of impurities found in natural waters that can be removed by ordinary distillation, and the one type of impurity which is not removed from water by this process.

(4) 5. Define basic anhydride, and illustrate with an equation.

(20) SECTION C

(4) 1. Explain and illustrate the Law of Definite Composition.

(4) 2. 100 cc of O_2 and 100 cc of H_2 are mixed in an eudiometer tube. If a spark were passed through the tube, a reaction would occur. Name and state the law that would be used in determining the volume of oxygen that would react.

(4) 3. Enunciate the theory which explains the effect of ionized solutes on the freezing point and boiling point of water.

(2) 4. a) Define valence in terms of the electron theory.

(2) b) The magnesium atom has two valence electrons and the chlorine atom has seven valence electrons.
i. what is the valence of chlorine? Of magnesium?
ii. what type of bond is formed between these atoms?

(2) 5. a) What are two ways in which the modern Theory of the Atom differs from Dalton's Atomic Theory?

(2) b) In Group VII A of the Modern Periodic Table of the Elements, the activity of the elements decreases as the elements go down the table from Fluorine to Iodine. Explain why this happens.

(20) SECTION D

SEE END OF PAPER FOR ATOMIC WEIGHTS.

(4) 1. Calculate the empirical formula of a substance which shows the following composition:

Aluminum 15.8% Sulphur 28.1% Oxygen 56.1%

Show the sulphur and oxygen in the form of a radical in the final answer.

Name this compound.

(4) 2. In the reaction $CaO + H_2O \longrightarrow Ca(OH)_2$ calculate the amount of $Ca(OH)_2$ in grams which is formed from 140 grams CaO.

(4) 3. What weight of calcium would be required to produce 5.6 liters of hydrogen when the calcium reacts with water?

(4) 4. 23.0 grams of a non-electrolyte dissolved in 1000 g. of water freezes at -0.93° C. What is the molecular weight of this substance?

(2) 5. a) What weight of aluminum chloride $AlCl_3$ is needed to make 1 liter of a 1 Normal solution?

b) What weight of this substance is needed to make 1 liter of a 1 Molar solution?

Given Atomic Weights

Al 27, Ca 40, H 1, C 12, O 16,
S 32, Cl 35.5, N 14.