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EFFECTS OF STIMULI PRESENTED BY SELECTED CHEMICAL EDUCATION MATERIAL STUDY (CHEM STUDY) FILMS ON INTELLECTUAL ABILITIES OF CHEM STUDY STUDENTS

Nathaniel Christopher Evans

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ABSTRACT

Nathaniel Christopher Evans

EFFECTS OF STIMULI PRESENTED BY SELECTED CHEMICAL EDUCATION MATERIAL STUDY (CHEM STUDY) FILMS ON INTELLECTUAL ABILITIES OF CHEM STUDY STUDENTS

This study was an investigation of the effectiveness of externally designed CHEM Study films used in conjunction with the CHEM Study course in high schools. In Experiment 1, a total of 180 first-year CHEM Study students who were in 8 existing CHEM Study classes took a prefilm test on stimuli presented by a selected CHEM Study film, prior to seeing it. Immediately following completion of the test, the experimental group viewed the film and the control group viewed a placebo film, and then all the Ss took a parallel form of the prefilm test as the postfilm test. There was a significant increase ($p < .01$) in number of correct responses on recall and understanding of facts due to the film presenting stimuli related to the instruction given. In Experiment 2, a different sample consisting of 38 second-year CHEM Study students who had been previously instructed using conventional methods in the relevant concepts were subjected to the same instructional procedures as in Experiment 1, using another CHEM Study film for review. Significant differences ($p < .01$) were obtained due to this review procedure with film closely related to the instruction given. A positive interaction between low prior knowledge of specifics and related film instruction was noted.

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N. C. E.

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CHAPTER 1

INTRODUCTION

Considerable research evidence exists to show that the educational effectiveness of films is influenced not only by the intrinsic forms of design and presentation, but also by the mode in which the materials are utilized (Lumsdaine, 1963). Unfortunately, many high schools are not in the position of producing their own science filmed instructional materials, especially demonstrations of sophisticated experiments, so that schools are not able to control or influence their design. Instead, schools use films obtained from external sources. In this case, only one route is open for schools to influence the effectiveness of these instructional materials by manipulating the conditions under which films are used.

Lumsdaine (1963) has stated that one of the major parameters relating to the utilization of film for instructional purposes is prefilm instruction. The purpose of prefilm instruction is to direct the learner's attention either to the general content of the instructional material to which he is to be exposed, or to identify for him the nature of the learning tasks to be accomplished. Kemp (1971) maintains that prefilm instruction itself differs from the subsequent instruction in that there are no specific learning objectives associated with it, other than that it is to inform the learner about what he is about to learn. It is thus an "advance organizer" (Ausubel, 1960) for the student in relation to the learning situation which follows. The forms prefilm instruction can take as an advance organizer are many. For example. summary statements about the content. both audio-visual and conceptual, of the film can be used, as can test questions relating to specific stimuli presented in it. Whatever specific form such prefilm instruction may take, Kemp predicts that it invariably improves the learning outcome on the part of the student.

A second major parameter relating to the utilization of film for instructional purposes is postfilm instruction (Kemp, 1971). Its rationale is that the showing of a film has the function of a stimulus situation so that information and ideas obtained from the films can form the basis for subsequent classroom discussions. Kemp thinks that the rationale seems sound and acceptable, yet in practice the procedure based on it has frequently been shown to lack educational effectiveness in certain degrees. In attempting to explain the ineffectiveness of postfilm instruction, Kemp has stated that, because a postfilm discussion takes place after film instruction has been given, stimuli or information missed by the learner cannot be recovered, hence the ineffectiveness of film instruction.

A third major parameter is "student participation" (Allen, 1957). Educational psychology has long recognized the value of the "active response" to be made by the learner in instructional situations and this is the basis of programmed learning (Skinner, 1954). Such responses are usually made to problems or questions programmed into a film, but can also be posed by the teacher on interrupting the showing of the film at suitable stages. Student responses are made overtly either verbally or by writing answers to questions. The posing of questions is not the only way in which some measure of active student participation can be achieved. The stoppage of film, for example, at five-minute intervals to allow students to take notes is another way of enhancing learning. It is believed that these stoppages provide the student with an opportunity to think about and reflect on what he has just seen. This would represent the situation where the active response is made in a covert form. When the questions are posed after, rather than during the film, they are of less educational benefit or value.

The fourth and final major parameter relating to the utilization of film for instructional purposes is "repetitive viewing" (Allen, 1957). The basis of this factor is that the rate at which both pictorial and verbal information is presented tends to be rather fast. As a result, students fail to absorb a significant amount of information after one viewing.

It would seem, then, that these parameters give some factors that can be manipulated to influence the effectiveness of externally produced films. The present study deals with Chemical Education Material Study (CHEM Study) films (Merrill & Ridgway, 1969; Collette, 1973), which are used in conjunction with the CHEM Study course in secondary schools.

The purpose of the present study was to evaluate the effect of stimuli presented by CHEM Study films upon certain learning outcomes under the condition in which prefilm instruction in the form of test questions was given, prior to seeing the film.

A second purpose of the present study was to find out just how useful CHEM Study films are for review. This question was considered in the light of what we know of instruction in the public school system. First, it is not well established at the present time whether a review with film has any effect on certain learning outcomes. Yet, the fact remains that this is one of the most frequent uses of film in schools (Woodman, 1972). Secondly, Pressey, Robinson and Horrocks (1959) have reported that approximately 66% of science concepts learned in high school and college courses are forgotten within two years.

Gay (1973) found that a review in the form of practice in solving mathematical problems using computer-assisted instruction enhanced retention of mathematical rules. But there is at least one problem with the method employed by Gay, namely, the high costs of a computer forbid such special attention. Without a computer, how is a teacher to cope with the task of giving preinstruction, feedback and postinstruction. all within a single class period of, say, fifty minutes. Lewis (1971) maintains that this task is extremely difficult and physically an impossibility for any teacher. Lumsdaine (1963) suggests that reproducible media such as film be used for review. It may be that a review with film is beneficial, but just how useful this instructional procedure is. is not well established.

Relevance to Educational Technology

This study is related to Educational Technology in two ways. First, Educational Technology is "the development, application and evaluation of systems. techniques and aids to improve the process of human learning" (British Council, 1973). In the context of evaluation of instruction, the present study is important to classroom teachers to know why learning systems including films produce the effects or changes they do on their students (Banathy, 1968). To illustrate: if teachers know why a lesson fails, they can revise it to make it more successful. And if they know why a lesson succeeds, they may be able to generalize to other lessons. In addition, teachers are aware that Educational Technology provides instructional pathways which, in terms of learning outcomes, are as good as many of the traditional procedures. Yet, many teachers remain sceptical about the potentialities of the new methods and techniques of instruction and so are reluctant to incorporate them into their own teaching schemes (Cleaves, 1966, and Kemp, 1971). To some extent, this attitude is understandable: too much is usually said and written about the technology of modern learning systems, and too little about their real educational value and effectiveness. In view of this situation, this study is important to the practising teacher.

Secondly, because it is the intent of the present study to identify instructional objectives of CHEM Study films, it can serve as a tool for research on comparative effectiveness studies. In fact, the comparative method of evaluation may initially be seen as an extension of the method used in this study.

In this Chapter, it was stated that because teachers have no way of influencing the instructional procedure and design of externally produced films, they could influence their effe eness by manipulating certain conditions under which films are used, such as prefilm instruction. The question was also raised in the present study whether students who had been previously instructed in the relevant concepts could benefit from a review with film. The relevance of these problems to Educational Technology was presented from two positions - that of the classroom teacher and of research involving comparative effectiveness studies. Chapter 2 will discuss previous research which focussed attention on conditions under which films are used. Chapter 3 will discuss the method used to conduct this study and the procedures for administering treatments. In Chapter 4, the results of the treatments will be presented and their implication will be discussed in Chapter 5.

CHAPTER 2

REVIEW OF RELATED RESEARCH

In this Chapter, previous studies investigating the educational effectiveness of film instruction will be reviewed. The review will stress major conclusions, findings, and methods of these studies. The review will be presented under the following subheadings: (1) Effects of postfilm instruction; (2) Effects of prefilm instruction; (3) Effects of repetitive viewing; (4) Effects of student participation, and (5) Effects of a review with film.

Effects of Postfilm Instruction

One of the early experiments (Snow, Tiffin, & Seibert, 1965) showed that filmed physics lecture demonstrations are as effective as live lecture demonstrations in teaching college students. The same authors have stated that "there were no special introductory or concluding remarks by the instructor, nor were there film interruptions or repetitions" (p. 316). Other findings of that study indicated that subjects with low numerical and verbal aptitudes, but with high prior knowledge of physics, performed significantly better ($p < .01$) on immediate recall tests in the film mediated condition than subjects in the live lecture condition. In an attempt to explain the superiority of film for low-ability high previous knowledge subjects, the investigators thought that filmic presentation of physics demonstration experiments provided visualization which the live presentation could not match. It is interesting to note that the instructional materials used in that study were developed by the investigators for a specific audience whose characteristics were known to the researchers. Therefore, their acceptability for other institutions would be limited.

Recently, Woodman (1972) has cautioned teachers not to rely on Physical Science Study Committee (PSSC) films to "teach specific subject-matter or to improve understanding of science" (p. 276). This conclusion was drawn on the results of a study which attempted to find out whether students who saw selected PSSC films would attain high scores on the PSSC achievement tests, and on the Test of Understanding Science (TOUS). In that study, Woodman randomly assigned three intact groups of PSSC students to their treatments. These groups had been previously instructed in the relevant concepts. To one group, Woodman showed no films at all; this group utilized the film period for additional class discussion. The second group was shown 15 PSSC films closely related in topic coverage to the corresponding PSSC achievement tests, and the third group was shown 15 PSSC films which had few, if any, topics in common with the corresponding PSSC achievement tests. Woodman found that the adjusted means of the scores for the no-film group was significantly higher ($p < .05$) than those for the related film group, and in most cases significantly higher ($p < .05$) than those for the unrelated film group. These findings were observed in 8 of the 9 schools that participated in the experiment. It is important to note that Woodman's study lacked a theoretical basis, and therefore the results of that study are overspecific and uninterpretable. Thus the conclusion drawn from that study is hardly justified on the basis of the results obtained.

Effects of Prefilm Instruction

Stein (cited by Allen, 1957), made an effort to discover whether a prefilm test with knowledge of results, followed by showing a film, would produce more learning of factual content than showing the film either once or twice without a prefilm test. Stein found that a prefilm test, which had identical, sequentially-ordered items, and employing complete knowledge of results, immediately followed by film showing, produced significant greater learning and retention than any other method investigated. Stein concluded that the effectiveness of a prefilm test depended on giving the learner items in the prefilm test which were identical with the items in the postfilm test in combination with giving the learner the answers to those items immediately after the learner has attempted to answer them.

Lumsdaine, Sulzer, and Kopstein (1969) found that subjects who were given a written prefilm test before a film showing demonstrated superior performance on micrometer reading than subjects who had not received a prefilm test. The theoretical basis of that study was that "gains in effectiveness seem to depend on using some means to focus attention on particular aspects of the material being presented - or about to be presented, so as to make these stand out from possible competing perceptions" (Lumsdaine, 1963, p. 641).

Ebel, Noel, and Bauer (1969) contend that improvement of learning from a course utilizing media is complicated by various sources of learning that are measured by unit and course tests. Miller and Brown (cited by Ebel et al. 1969), showed that substantial increases in learning through media do occur when test items are based upon what was taught rather than upon course objectives. Church and his group (cited by Ebel et al. 1969), found a learning gain score for a class utilizing media that was 67% greater than that obtained by the normal class.

More recently, Kemp (1971) presented to his subjects test questions on the visual, aural and audio-visual content of an instructional film, prior to seeing it, and their perception of these stimuli was compared with that of a control group which saw the film without "advance organizer" (Ausubel, 1960). The results of that study showed that the attainment of the experimental group exceeded that of the control group by about 20%.

Effects of Repetitive Viewing

MacTavish (cited by Kemp, 1971) found that a second viewing increased the learning of factual information from films by about 30%, relative to the average attainment reached after the initial viewing. Further viewing did little to increase the learning outcome beyond the level reached after the second viewing. After the fourth showing, the test results indicated a decrease in achievement. Kemp explained this phenomenon in terms of student fatigue.

Effects of Student Participation

Allen (1957) has reported several studies that lead to the unanimous conclusion that learner participation during a film showing greatly increased learning from a film. For example, student participation in the form of answering questions programmed into the film produced gains that were significant at the .02 level. Ash and Carlton (cited by Allen, 1957), investigated the effectiveness of note-taking and showed that the film only group performed significantly better ($p < .01$) than the film group that took notes, and significantly better ($p < .01$) than the film group that took notes, and then reviewed notes before taking the postfilm test. From that study, it was concluded that note-taking actually interfered with learning.

Effects of a Review with Film

In one of the few studies cited by Lumsdaine (1963), Shettel (1956) demonstrated that the loss of material learned from conventional instruction could be prevented by showing a filmed version of the instruction just before its use in teaching or practical application was required.

Summary of Related Research

Findings briefly reviewed in this Chapter clearly indicate that the educational effectiveness of films is influenced significantly by the manner in which they are utilized in instructional situations. But nearly all the studies cited in this study, employed conventional films whose instructional objectives are difficult to identify. In many instances, the films used dealt with factual information. On the other hand, CHEM Study films present highly structured subject-matter which makes their design and presentation more difficult.

CHAPTER 3

METHOD

Purpose

In Chapter 1, it was indicated that, because teachers are not able to influence the design of instructional films externally produced, they could do so by manipulating the conditions under which science films are used. The empirical evidence discussed in Chapter 2 suggests that the theory of prefilm instruction provides a major route open for teachers to influence the educational effectiveness of these films. Because a prefilm test in the form of test questions would direct the attention of the learner to stimuli presented by a film, the educational effectiveness of a film would be expected to increase. The first purpose of the present study was therefore to find out how effective a selected CHEM Study film was for teaching chemical concepts. The second purpose of the present study was to determine the value of a selected CHEM Study film for review. To assess the value and educational effectiveness of these films, the following hypotheses were formulated:

1. CHEM Study students who see a selected CHEM Study film which presents stimuli related to a CHEM Study prefilm test will demonstrate greater comprehension of chemical concepts than CHEM Study students who see a selected CHEM Study film which presents few, if any, stimuli in common with the corresponding CHEM Study prefilm test.

2. CHEM Study students will demonstrate greater comprehension of chemical concepts as a result of a review with a selected CHEM Study film which presents stimuli closely related to the prereview film test than CHEM Study students who receive a review with a selected CHEM Study film which presents few, if any, stimuli in common with the corresponding prereview film test.

Stated in null form, the hypotheses to be tested were:

1. There is no significant difference in CHEM Study achievement test as measured by a postfilm test, between CHEM Study students who see a selected CHEM Study film which presents stimuli related to a CHEM Study prefilm test and CHEM Study students who see a selected CHEM Study film which presents few, if any, stimuli in common with the corresponding CHEM Study prefilm test.
2. There is no significant difference in CHEM Study achievement test as measured by a postreview film test, between CHEM Study students who receive a review with a selected CHEM Study film which presents stimuli closely related to the prereview film test and CHEM Study students who receive a review with a selected CHEM Study film which presents few, if any, stimuli in common with the corresponding prereview film test.

In the present study, "CHEM Study" refers to an educational program which stresses chemical principles and learning facts by using or applying them to new or parallel situations.

A "CHEM Study film" is an externally produced film defined as a visual substitute in CHEM Study for actual laboratory work presented through a motion picture.

"Comprehension" refers to the number of correct responses on posttest.

"Concepts" are things or ideas a student should learn from the relevant chapter in the CHEM Study textbook or from a CHEM Study film.

"Stimuli" are things that will influence a change in the behaviour of the learner presented through film.

Experiment 1

Subjects. This experiment investigated the educational effectiveness of a selected CHEM Study film for teaching material which had not been previously taught to the class. The Subjects were 180 tenth-graders from 2 different high schools in the County of Chambly, Quebec, Canada. At the time of the experiment, all Subjects (Ss) belonged to 8 existing classes of students registered in Part I of the CHEM Study course. One hundred-and-six of these Ss attended a regional high school (1) which offered a wide range of educational programs and 89 Ss attended a traditional high school (2) offering a restricted educational program. At each school. Ss were not randomly assigned to their respective classes but were registered depending upon their class schedules and attempts by the administrators to keep the classes approximately equal in size. Scholastic Aptitudes for Ss at the regional high school, as measured by the Otis Quick-Scoring Mental Ability Test ranged from 90 to 131, with class median IQ scores of 106.16, 107.5, 110, and 110.5. At the traditional high school, IQ scores ranged from 95 to 142, with class median scores of 111.5, 117, 120.5 and 122.5. Table 1 presents median IQ scores for intact groups by school and treatment. All Ss had been in their respective classes since September, 1974, and were in their first year of studying CHEM Study. Prior experience of the Ss with science material consisted of elementary science in the form of Introductory Physical Science (IPS), or Life Science. Ss had previous experience with instruction using CHEM Study films but none had seen before the films used in this particular study. At each school, class groups were instructed by the same teacher who was trained in CHEM Study methodology.

Instructional Materials for Experiment 1

Two CHEM Study films were used in Experiment 1 to investigate their educational effectiveness. The film viewed by the experimental group was entitled "Ionization Energy", and had been included in the list of supplementary material at the end of chapter 9 of the Teachers' Guide for Chemistry Experiments and Principles (McClellan et al. 1968). This film showed how ionization energies were measured and other concepts presented in that film included trends in ionization energies across a row of the periodic table, successive ionization energies for a single element and relation of chemical properties to ionization energy and electron configuration. The film viewed by the control group was

Table 1

Median IQ Test Scores for Intact Classes

by Treatment and School

School	Treatment	Median
1	n = 31 (26)*	106.16
	n = 26 (21)	110.5
	n = 25 (23)*	107.5
	n = 24 (23)	110.0
2	n = 17 (17)*	120.5
	n = 18 (16)	111.5
	n = 26 (26)*	117.0
	n = 28 (28)	122.5

Note: Numbers in parentheses indicate the number of students who completed all tests.

*Denotes experimental group.

entitled "Chemical Equilibrium". This film was also included in the list of supplementary material in chapter 13 of the Teachers' Guide. The film presented the concepts of equilibrium which were part of the instructional material to be learned in Part II of the CHEM Study program. Both these films were 16 mm sound motion pictures, in colour and ran for approximately 22 minutes. Animation techniques, such as figure-animation found in the animated cartoon and moving arrows, were employed to direct attention of the student to successive salient parts of the pictorial material or to illustrate a concept. The selection of the films was based on two factors, namely, the authors' recommendation that the films should be utilized to teach subject-matter discussed in the appropriate chapters and the hierarchial nature of the subject-matter.

Experiment 2

Subjects. This experiment investigated the effectiveness of a review procedure using a selected CHEM Study film. Thirty-eight eleventh graders drawn from two existing CHEM Study classes attending the regional high school were Ss for the experiment. An attempt was made to include a sample drawn from another high school, but students from that school were excluded from this study for incorrectly completing the IQ tests. There were originally 26 and 32 students in each class, but 10 students from each class were lost due to an extra-curricular activity that required these Ss to miss their normal chemistry class on the day the films were shown. This left 16 and 22 students in each class and the median IQ test scores for each of these groups were 110 and 116.6, respectively. The characteristics of these

Ss were similar to the ones described for Experiment 1, with the exception that Ss for Experiment 2 were registered in Part II of CHEM Study and were in their second year of studying CHEM Study material. Also, these Ss had been previously instructed in the relevant chemical concepts. There was a time interval of 4 weeks between initial learning and review of the concepts.

Instructional Materials for Experiment 2

Two CHEM Study films entitled "Electrochemical Cells" and "Acid-Base Indicators" were employed for review. The design and presentation mode of these films was the same as the films described in Experiment 1. Both films ran for approximately 20 minutes each. Special materials, difficult or time-consuming to demonstrate by usual methods in the classroom were presented by these films. The electrochemical cell film was totally irrelevant to the instruction given. The acid-base indicator film was utilized by the experimental group to observe the effects of aqueous hydrogen ions ($H^{+}{}_{(aq)}$) on indicators. Mathematical rules and computation of exponential numbers commonly employed to depict equilibrium constants were included in the presentation.

Instrumentation

Prefilm Instruction. This instruction was provided in the form of test questions on stimuli presented by the film. The test was designed to discover the S's knowledge of the concepts of ionization energy. It consisted of 10 multiple-choice type of questions to be completed in 12 minutes. Appendix A is a sample of the prefilm test. Test items were obtained from "Cahier de Notes des Films du CHEM Study" (Bourgeois & Dupré, 1972). The English translation was made by the head of the science department at the regional high school and revised by one of the authors before the test could be administered to Ss.

The investigator had planned to use standardized CHEM Study Achievement Tests Series 1, 1968, for Chemistry Experiments and Principles (McClellan, Davis, Haenisch, MacNab & O'Connor), but a preview of the film presenting stimuli related to the prefilm test revealed that Series 1 had few test items on stimuli presented by the experimental film.

The prefilm test measured two levels of comprehension which were identified using Bloom's taxonomy (Hedges, 1968). Level 1.00 of comprehension referred to knowledge of specifics such as terminology or simple recall of facts. Forty percent of the test items measured this ability. Level 2.00 of comprehension referred to understanding demonstrated by the S's ability to interpret or apply concepts of ionization energy or to state the implications of these concepts. Test reliabilities based on the answers of 47 and 33 Ss were .49 and .33, respectively. These values were calculated using the K-R formula 20 (Dick & Hagerty, 1971). The low values were consistent with the assumption underlying this formula and were due to the length of the test and the low inter-item correlation.

Prereview Film Instruction. The prereview film test was designed to measure the S's previous knowledge of the concepts of acid-base indicators and chemical equilibrium in chemical reactions. Appendix B is a sample of the prereview film test. The source of test items was Bourgeois and Dupré (1972). The test consisted of 10 multiple-choice type of questions to be completed in 12 minutes. Forty percent of the questions measured knowledge of specifics and 20% of the questions measured each of the following abilities: interpretation of data of an experiment, application of a concept and computation of exponential numbers. Test reliability based on the answer sheets of 38 Ss was .31. Again, this value was computed using the K-R formula 20 (Dick & Hagerty, 1971).

Criterion Measures for Experiment 1 and 2. The criterion measures used in Experiment 1 and 2 were identical to the prefilm test and prereview film test, respectively. The only difference was that the order of test items was altered.

Scholastic Aptitude Tests. The Ss' IQ scores were obtained using "Otis Quick-Scoring Mental Ability Tests: Gamma Tests FM 'high schools and colleges'" (Otis & Lennon, 1967). The test consisted of 80 items and required 30 minutes to complete.

Experimental Design 1 and 2

The design of Experiment 1 and 2 followed that recommended by Morgan & Brouillette (1969), as shown in Table 2. At each school, the investigation of Experiment 1 was made with two intact groups of students viewing the film presenting stimuli related to the prefilm test and two intact groups viewing the film presenting stimuli unrelated to the prefilm test. Experiment 2 was conducted with a sample consisting

Table 2

Design of Experiment 1 and 2 using IQ and Pretest Scores as Covariables

Covariables	*Treatment	Posttest Scores
X_1X_2	Related film instruction	Y
	$^{a}n = 89$	
	$^{b}n = 22$	
X_1X_2	control	Y
	$^{a}n = 91$	
	$^{b}n = 16$	

Note: [a]Number of Ss who completed all tests in Experiment 1.

[b]Number of Ss who completed all tests in Experiment 2.

*Treatment is the independent variable.

X_1, IQ scores; X_2, Prefilm test scores or Prereview film test scores.

Y, criterion measure.

of two intact groups of students drawn from the regional high school. All intact groups were randomly assigned to their treatments and the dependent variable (achievement) was measured using a parallel form of the pretest as the posttest.

Procedure for Experiment 1 and 2

Experiment 1 and 2 were conducted in two consecutive days during the month of May, 1975. Each day's testing required 50 minutes for each group. Testing and film showing were done in the same classroom during the regular chemistry class period. Treatments were administered by the regular teacher and all Ss did not know beforehand of the tests until the day of testing. Ss were told that the tests were designed to discover what they knew about the instructional materials. The IQ tests were administered on the same day at both high schools but film instruction was separated by a day with groups at the regional high school receiving their instruction a day earlier. The schools were located about five miles apart, and thus there was no reason to believe that Ss would discuss the tests or the films.

The first day was devoted to administering the IQ tests. On the second day, all Ss took a prefilm test, received their respective film presentations, and then took a parallel form of the prefilm test as the postfilm test, all in 50 minutes. Ss in each treatment group viewed their selected film without interruptions. The group viewing the film presenting stimuli on the prefilm test was called the related film group and the group viewing the film presenting stimuli unrelated to the prefilm test was called the unrelated film group. Ss recorded their answers directly on the test papers.

Data Analysis

Because of an administrative difficulty to randomize Ss into groups, multiple-covariance techniques (Ferguson, 1971) were employed to reduce variance due to IQ and prior knowledge of the Ss. To control variability due to experimental error, replicated experiments were performed to increase confidence in the results of Experiment 1 (Winer, 1971).

Throughout this particular study, the test of significance was set at .01 level. The data for all groups were tested statistically using the analysis of covariance following the BMD04V program (Dixon, 1971) for the CDC 6400 computer. This program had the advantages of providing the investigator with t-tests to compare treatment groups on the covariables.

Subjects' answer sheets were scored by hand using a punched key which was placed over the S's answer sheet. The scoring key was prepared from the answers provided by the three regular teachers and the researcher. Scoring was done by counting the number of correct responses. All items were assigned the same point-value. Following the recommendation by Mehrens and Lehmann (1973), no correction formula was used for guessing. Item analysis was performed using the procedures in Tuckman (1972).

CHAPTER 4

RESULTS

Experiment 1

Experiment 1 tested the null hypothesis that there is no significant difference in CHEM Study achievement test as measured by a postfilm test, between CHEM Study students who see a selected CHEM Study film which presents stimuli related to a CHEM Study prefilm test and CHEM Study students who see a selected CHEM Study film which presents few, if any, stimuli in common with the corresponding CHEM Study prefilm test. Achievement of the several groups on the postfilm test is shown in Table 3. As can be seen from this table, the adjusted means of any pair of groups, four pairs in all, showed a marked difference, a fact which is shown by gain scores for the experimental groups, which lie between 30% and 84%. Table 4 presents a summary of the analysis of covariance which reveals a consistently significant related film instruction effect, average F (1, 41) = 44.41, $p < .01$. This value was far beyond the expected value of F (1, 41) = 7.31.

The test of homogeneity of between-group regression lines using IQ as a covariable yielded in all comparisons t-values which were not significant at the .01 level. But with regard to prior knowledge, the analysis showed that one of the four pairs of treatment groups (n = 23 and n = 23) had nonparallel regression lines. An examination of the raw data revealed that the control group reported a mean score initially higher on the prefilm test. Although the experimental group started

Table 3

Mean IQ and Pre/Postfilm Test Scores in

Experiment 1 by Group and School

Group	IQ	Prefilm	Postfilm	Adjusted Postfilm	% Gain Score
REGIONAL HIGH SCHOOL					
(morning)					
Related film (n = 26)	108.30	3.61	6.57	6.65	84
Unrelated film (n = 21)	112.14	3.61	3.42	3.33	
(afternoon)					
Related film (n = 23)	106.4	3.82	6.26	6.58	74
Unrelated film (n = 23)	111.39	4.56	4.73	4.41	
TRADITIONAL HIGH SCHOOL					
(morning)					
Related film (n = 17)	116.23	4.76	6.35	6.21	30
Unrelated film (n = 16)	112.9	4.68	4.25	4.37	
(afternoon)					
Related film (n = 26)	118.15	4.50	7.03	7.09	57
Unrelated film (n = 28)	118.78	4.75	4.82	4.76	

Note: The experimental group is the related film group and the control group is the unrelated film group.

Table 4

Summary of Analysis of Covariance for

Adjusted Postfilm Test Scores in Experiment 1 by School

Source of Variation	Sum of Squares (SS)	Degrees of Freedom (DF)	Mean Squares (MS)	F-Ratio
REGIONAL HIGH SCHOOL				
(morning)				
Treatment (Between)	122.04	1	122.04	
Error (Within)	57.26	43	1.33	91.63*
Treatment plus Error (Total)	179.31	44		
(afternoon)				
Treatment (Between)	47.60	1	47.60	
Error (Within)	70.38	42	1.67	28.40*
Treatment plus Error (Total)	117.98	43		
TRADITIONAL HIGH SCHOOL				
(morning)				
Treatment (Between)	27.67	1	27.67	
Error (Within)	74.87	29	2.58	10.71*
Treatment plus Error (Total)	102.55	30		
(afternoon)				
Treatment (Between)	73.18	1	73.18	
Error (Within)	78.76	50	1.57	46.45*
Treatment plus Error (Total)	151.94	51		

*$p < .01$.

below the control, it performed significantly better ($p < .01$) on the postfilm test than the control group.

In an attempt to establish a relationship between film instruction and lesson objectives, it was found that the film presenting stimuli on the prefilm test positively interacted with certain intellectual abilities. Specifically, the related film was effective in promoting the learning of terminology, facts, and knowledge of ways and means of dealing with specifics (application). Figure 1 presents the mean percentage of correct responses on 10 postfilm test items. As can be seen from Figure 1, the related film was highly successful in presenting learning situations demanding factual knowledge. But on learning situations demanding application of principles, the related film was less effective than in teaching factual information.

The average percentage gains in the number of correct responses for experimental groups at both high schools were 79% and 45%. The relatively low percentage increase for Ss at the traditional high school was due to the ceiling imposed by the test. Some of the Ss at this school did very well on the prefilm test and would most likely have shown more improvement if the test had allowed it.

Item analysis of the pretest scores revealed that 60% of the questions had satisfactory item difficulty between .33 and .67 (Tuckman, 1972); see Table 5. But discrimination indices were high above .67. This suggests that two-thirds or more of the Ss at the regional high school who got the 10 test questions right were in the high third group.

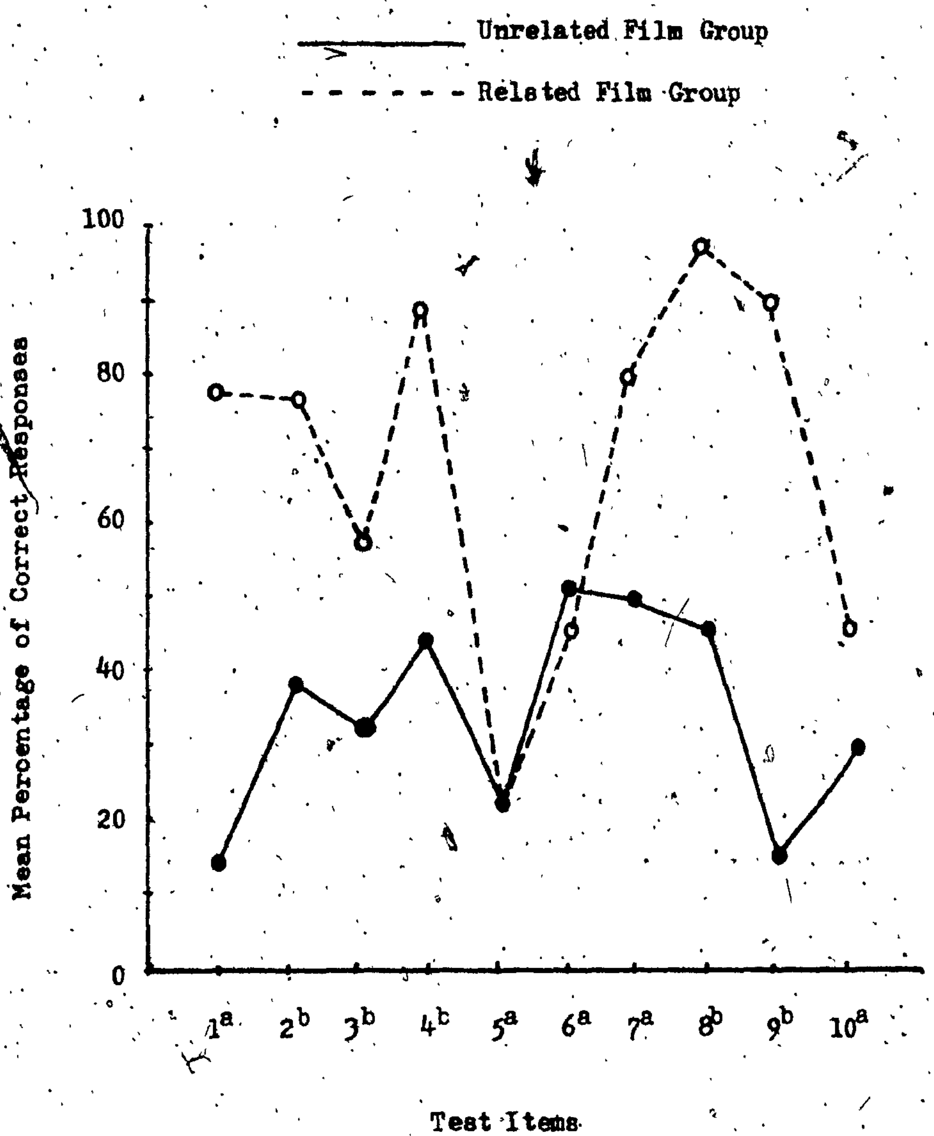

Figure 1. Mean percentage of correct responses on 10 postfilm test items for unrelated film group and related film group in Experiment 1.

[a]factual knowledge

[b]application

Table 5

Sample Item Analysis on Prefilm Test Scores from among a Group of Fifty-four at the Regional High School in Experiment 1

Item	Number of High 1/3 Who Pass	Number of Low 1/3 Who Pass	Index of Difficulty	Index of Discriminability
1	4	1	.78	.80
2	1	0	.90	1.00
3	10	2	.50	.83
4	12	5	.26	.70
5	3	1	.82	.75
6	8	1	.60	.80
7	9	2	.52	.81
8	10	1	.52	.81
9	7	3	.56	.70
10	8	0	.65	1.00

Note: These measures of difficulty and discrimination follow those from Tuckman (1972, p. 154).

For Ss at the traditional high school, item difficulty ranged from .22 to .72; as shown in Table 6. Again, it can be seen from this table that 60% of the questions had satisfactory item difficulty. Taking into consideration item discrimination, it is reasonable to conclude that instruction with the related film was more beneficial to Ss with low prior knowledge than with high prior knowledge Ss.

Experiment 2

Turning to the data concerning the second null hypothesis, there were also significant differences due to the effects of the review procedure with the film related to the instruction given [F (1, 34) = 27.16, $p < .01$]. The null hypothesis stated that there is no significant difference in CHEM Study achievement test as measured by a post-review film test, between CHEM Study students who receive a review with a selected CHEM Study film which presents stimuli closely related to the prereview film test and CHEM Study students who receive a review with a selected CHEM Study film which presents few, if any, stimuli in common with the corresponding prereview film test. As shown in Table 7, the test was significant beyond the .01 level [F (1, 34 = 7.44].

A t-test for homogeneity of regression for each of the covariables reported in the present study indicated that this assumption could not be met in the case of prior knowledge of the Ss. Although the control group was superior on prior knowledge, the experimental group did better on the postreview film test as a result of the review procedure with the related film. Table 8 presents pre/postreview

Table 6

Sample Item Analysis on Prefilm Test Scores from among a Group of Thirty-three at the Traditional High School in Experiment 1

Item	Number of High 1/3 Who Pass	Number of Low 1/3 Who Pass	Index of Difficulty	Index of Discriminability
1	8	0	.63	1.00
2	10	2	.45	.83
3	11	3	.40	.78
4	12	5	.22	.70
5	7	0	.68	1.00
6	9	1	.45	.75
7	12	2	.36	.85
8	12	4	.27	.75
9	5	1	.72	.83
10	6	2	.63	.75

Note: These measures of difficulty and discrimination follow those from Tuckman (1972, p. 154).

Table 7

Analysis of Covariance for Adjusted Postreview Film Test Scores in Experiment 2

Source of Variation	Sum of Squares (SS)	Degree of Freedom (DF)	Mean Squares (MS)	F-Ratio
Treatment (Between)	37.12	1	37.12	
Error (Within)	46.46	34	1.36	27.16*
Treatment plus Error (Total)	83.59			

*$p < .01$

Table 8

Mean IQ and Pre/Postreview Film Test Scores in Experiment 2 by Group

Group	IQ	Prereview	Postreview	Adjusted Postreview	% Gain Score
Related film (a)	114.13	6.13	8.36	8.64	41
Unrelated film (b)	112.[illegible]7	7.00	6.93	6.55	

Note: (a) Experimental Group. (b) Control Group.

means on stimuli presented by the selected CHEM Study film by group. As can be seen from Table 8, the experimental group improved its performance by as much as 41%. Surprisingly, the postreview mean of the control group was lower than its prereview mean. This may be explained in terms of the notion of interference which holds that the acquisition of new information interferes with the retention of the old (Smith & Rohrman, 1970). In this case, the interference may have resulted from the use of the film which was unrelated to the instruction given.

In order to evaluate some factors that may have been related to the significant difference found between the groups, achievement on individual test items was compared. As shown in Figure 2, test items (4, 5, & 6) appear to have accounted for the observed difference due to the effectiveness of related film instruction in presenting factual information. However, the control group maintained its superior achievement on 40% of the test items even though the experimental group had made some gains after seeing the related film. A factor that may have operated in the control group was numerical ability to compute exponential numbers. Exactly why items 2 and 8 produced lower post-review test scores in comparison with the control group was difficult to explain within the limits of this particular study. These items merely required recall of terminology presented by the related film.

Item analysis of prereview film test scores presented in Table 9, revealed that 30% of the items were too easy for both groups

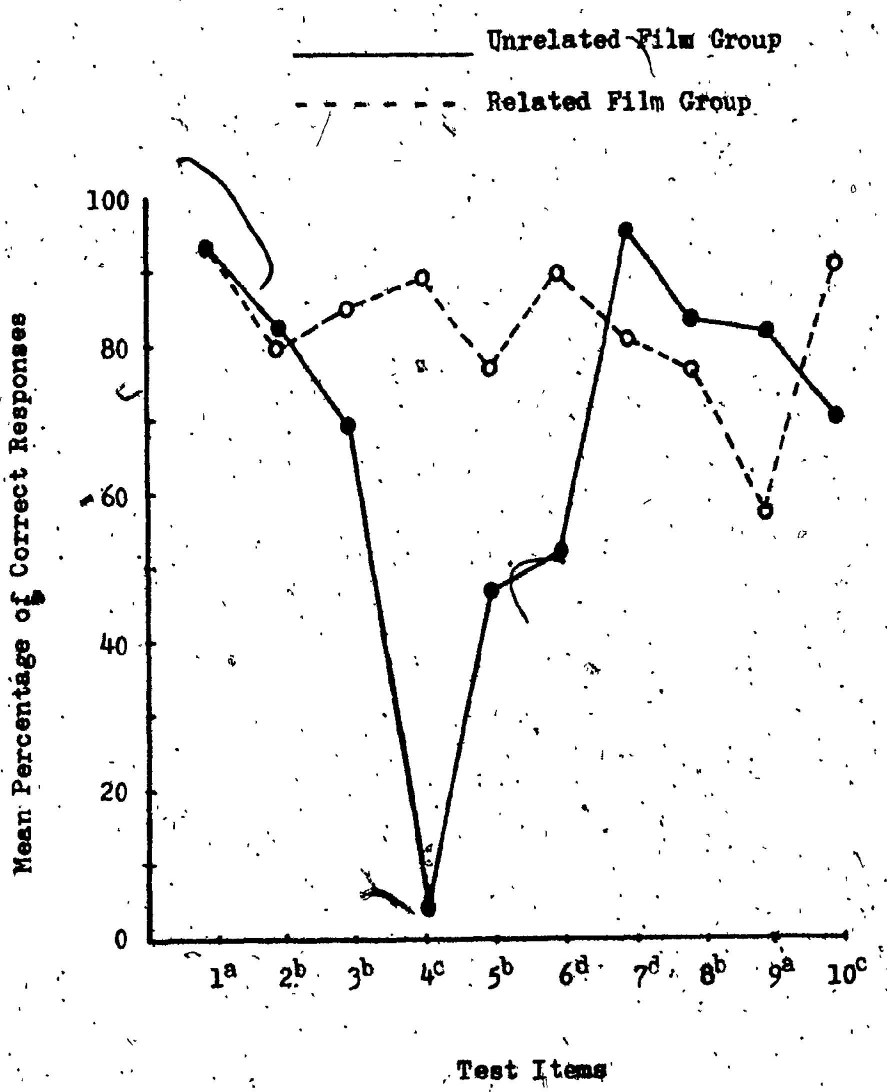

Figure 2. Mean percentage of correct responses on 10 postreview film test items for unrelated film group and related film group in Experiment 2.

[a] Application

[b] Knowledge of specifics

[c] Computation of exponential numbers

[d] Interpretation

Table 9

Sample Item Analysis on Prereview Film Test Scores from among a Group of Fifty-eight in Experiment 2

Item	Number of High 1/3 Who Pass	Number of Low 1/3 Who Pass	Index of Difficulty	Index of Discriminability
1	17	17	.02	.50
2	16	8	.31	.66
3	12	7	.45	.69
4	1	0	.97	1.00
5	15	5	.42	.75
6	8	7	.57	.59
7	16	15	.11	.51
8	17	8	.57	.61
9	17	3	.42	.85
10	16	5	.40	.76

Note: These measures of difficulty and discrimination follow those from Tuckman (1972, p. 154).

since fewer than .33 got them wrong. That is, the difficulty index was below .33 (Tuckman, 1972). One item was too difficult since more than .67 got it wrong. This was one of the items which instructed Ss on the computation of equilibrium constant. Test scores on the post-review test revealed that 90% of the Ss in the related film group got it right, while only 5% of the Ss in the control group got it right. Probably, the unrelated film group had no prior experience with the method of computing equilibrium constant as demonstrated by the related film. However, the results do show that computation of equilibrium constant can be effectively taught by film.

Fifty percent of the items had discrimination indices above .67 (Tuckman, 1972). This implies that these items clearly separated the low prior knowledge Ss from high prior knowledge Ss on the factors being measured, or that two-thirds of the Ss who passed the 10 prereview film test items were in the high third group. For this reason, the data on the postreview test suggests that the review procedure with related film was more effective with low prior knowledge Ss.

Chapter Summary

In this Chapter the results of Experiment 1 investigating the educational effectiveness of a selected CHEM Study film for teaching chemical concepts under the condition in which prefilm instruction was given, were presented. The analysis of covariance indicated a consistent significant effect due to related film instruction, average $F(1, 41) = 44.41$, $p < .01$. These results were obtained with 4 experimental groups whose attainment on the postfilm test was compared with 4 control groups which saw a different CHEM Study film which presented stimuli unrelated to the prefilm instruction. On the average, there was a gain score of 60% for the related film group.

Evaluation of film instruction on the basis of lesson objectives also indicated that instruction with the related film was effective in promoting mastery of specifics and ways and means of dealing with specifics (application). The effect on the ability to learn factual information was greater than on the ability to apply chemical principles due, perhaps, to the rate at which information was presented.

Item analysis of prefilm test scores revealed that 60% of the questions had satisfactory index of difficulty between .33 and .67 (Tuckman, 1972). Discrimination indices were high above .67. Taking this consideration into account, it was reasonable to conclude that related film instruction was more effective with low prior knowledge Ss.

Presented in this Chapter were also the results of Experiment 2 which investigated the value of a selected CHEM Study film for review given 4 weeks later following original learning. The results indicated a significant difference due to the review procedure with the related film $F(1, 34) = 27.16$, $p < .01$. These results were obtained even though the control group was superior on one of the covariables, namely, prior knowledge. The related film group improved its performance on factual information by about 41%.

As in Experiment 1, item difficulty and item discrimination led to the conclusion that the review procedure with the related film was more effective in raising scores of low prior knowledge Ss.

CHAPTER 5

DISCUSSION

These results should be considered in the light of several factors. First, the same general results from two different high schools leave little doubt that the CHEM Study films used in the present study can be relied upon to teach specific subject-matter. Second, these Experiments clearly show that film instruction was more effective with low prior knowledge students, particularly in learning factual information. This finding seems to support a previous study (Snow et al. 1965), which claims the existence of a negative relationship between low prior knowledge and film instruction. Third, these Experiments do show that film instruction on tasks demanding application of knowledge was less effective than in factual information learning. It is possible that the rate of presenting this kind of information was higher than would be deemed appropriate for the purpose of initial learning and, therefore, with only one viewing of film, some Ss did not absorb a significant part of the information presented. Fourth, not only did the film prove itself of value as an instructional vehicle, but did accomplish within a single class period of 50 minutes, what normally takes several periods of teaching using conventional methods of instruction. In addition, the film used in Experiment 2 demonstrated that it can be relied upon to facilitate a review of chemical concepts.

Implications and Limitations

Before proceeding to a discussion of the implications of this research, three limitations of the study must be presented. First, the use of intact classes to which students had been assigned as part of the schools' normal procedures posed a threat to internal validity. This problem was dealt with in Experiment 1 by using more than one intact class at each school per film condition and randomly assigning intact classes to treatment conditions. This solution was uneconomical because repeated testings at each school could have resulted in students having knowledge of the instructional material before the experiment started. Second, the loss of 20 Ss in Experiment 2 due to an extra-curricular activity seems to have introduced a bias in the control group. Although the loss was spread across the two treatment conditions, the control group gained an advantage in prior knowledge. This difference may well explain the superiority of the control group in this study on tasks demanding application of knowledge. Third, another weakness of the present study was the inability of the researcher to conduct a pilot study. This could have resulted in the paper-and-pencil tests having conservative estimates of reliability - .49 and .31. Fortunately, the tests can be interrupted as, at least, some indication of a degree of criterion-related validity where criterion is expert judgement of the researcher and the three regular teachers (Mehrens et al. 1973).

With these limitations in mind, several implications can be drawn from the results of this research:

1. The CHEM Study films have been suggested as an integral part of the Chemical Education Material Study (CHEM Study) course, but the standardized achievement tests that accompany this program are open-book tests and reportedly have been designed to test the student's

ability to apply the principles learned in the laboratory to new and parallel situations (McClellan et al. 1968). Since the CHEM Study films are an integral part of the course, other tests besides the Standardized Achievement Tests Series 1 are necessary such as classroom tests (Mehrens et al. 1973). These tests are known to help the teacher decide whether a particular unit or concept needs reteaching. Mehrens and Lehmann maintain that these tests provide optimal learning on the part of the student and optimal teaching on the part of the teacher. The producers of CHEM Study films do not, however, seem to have recognized the need to produce tests which accompany their films. This need can be met by each local education authority preparing its own tests. One would hope that the preparation of these tests at the local level would lead to standardized procedures for using these films.

2. A major factor that seems to have contributed to the success of related film instruction is prefilm instruction in the form of test questions on stimuli presented by the films. This implies that teachers should use a prefilm test before showing a film to their students. Gerhard (1972) has observed that few teachers are familiar with the pretest. This implies that teachers rarely use it and the result is that many learners are often needlessly subjected to the review syndrome which serves to produce classroom problems that can readily be avoided. The present study has demonstrated that the review syndrome can be avoided by providing faster and more effective communication between the teacher and the learner. When asked to comment on classroom behaviour of <u>Ss</u> who participated in this research, the

teachers who helped to conduct these experiments thought that their students had viewed the films as they had never done before. The same teachers reported that the prefilm test had helped them identify the misconceptions of their students about chemical concepts.

3. Finally. teachers should be aware of the great potential of a film as an instructional device, particularly for instructing students with low prior knowledge. The problem of low prior knowledge students is critical in schools experimenting with mixed-ability classes (Sturgess, 1973). By utilizing CHEM Study films under the conditions of the present study, this problem can be minimized. In addition, the procedures have the advantage of integrating these films with established teaching techniques.

From the evidence presented in this study, there would seem to be every reason to promote and encourage the use of CHEM Study films. However, one must be clearly aware of the dangers in the use of film, particularly as far as it relates to students' morale and attitudes. Close contact between student and teacher ought to remain one important component of our educational practice and this will probably do much to increase the acceptability of film amongst teachers and students. One way of maintaining this contact is by finding out just how students view CHEM Study films. Brandou (1966), for example, has shown that CHEM Study teachers highly rated CHEM Study films because they find them relevant to what they teach. It is possible that there may be a relationship between CHEM Study film and student attitudes towards the CHEM Study course taught by film.

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APPENDIX A: SAMPLE PREFILM TEST

SUBJECT: CHEM STUDY (PART I)

NAME: ______________________
(please print)

CLASS GROUP NUMBER:

TIME: 12 minutes

TEST 1 (A)

N.B: This Test is designed to discover things you know about ionization energy. Read each question carefully before attempting to answer it. Some questions ask you to complete a statement and others ask you to select the best statement from among the four choices. Answer all the questions in the space provided.

1. The atomic number of Na is 11. In the reaction of Na and Cl, which valence electron of Na passes to the Cl atom?

   (A) 3p electron

   (B) 2s electron

   (C) 3s electron

   (D) 2p electron ( )

2. The ionization energy is the minimum energy required to

   (A) give an electron to a gaseous atom

   (B) take away an electron from a gaseous atom

   (C) give an electron to an atom of a solid

   (D) remove an electron from an atom of a solid ( )

3. Which statement best describes a characteristic of monochromatic light?

   (A) It has a unique wave length

   (B) It has more than one wave length

   (C) It comes from a mercury lamp

   (D) It has low frequencies ( )

4. One experimental method of providing an atom with energy to cause ionization is

   (A) neutron bombardment

   (B) electron bombardment

   (C) alpha bombardment

   (D) all of these ( )

5. When adequate frequency is used to ionize atoms, electrons travel

   (1) to the anode

   (2) to the cathode

   (3) to the two electrodes

   (4) randomly

   Which of the above statements is CORRECT?

   (A) (1)

   (B) (2)

   (C) (3)

   (D) (4) ( )

6. Which of the following statements best explains why helium (He) has a greater ionization energy than sodium (Na)?

   (A) He is a gas at room temperature

   (B) He is a monoatomic element

   (C) He electrons are closer to the nucleus

   (D) He is on the left-hand side of the periodic table ( )

7. If you consider the rare gases (noble gases) in their order He, Ne, Ar, Kr, you would expect one of the following statements to be true of ionization energy.

   Pick the CORRECT STATMENT

(A) Ionization energy would decrease from He to Kr

(B) Ionization energy would increase from He to Kr

(C) Ionization energy would increase first, and then decrease from Kr

(D) Ionization energy would vary irregularly. ( )

8. Energy of all monochromatic light may be measured using the equation

(A) E = hv

(B) v = hE

(C) h = vE

(D) E = h/v ( )

9. Ionization energy may be expressed in volts or kilocalories. To change volts to kilocalories

(1) you multiply by a factor of 2.31

(2) you divide by a factor of 2.31

(3) you multiply by a factor of 23.1

(4) you divide by a factor of 23.1

Which of the above statements is CORRECT?

(A) (1)

(B) (2)

(C) (3)

(D) (4) ( )

10. If you consider the second period from right to left, which of the following statements might be expected to be TRUE concerning ionization energy?

(A) Ionization energy would decrease regularly

(B) Ionization energy would increase regularly

(C) Ionization energy would remain the same

(D) None of these ( )

APPENDIX B: SAMPLE PREREVIEW FILM TEST

SUBJECT: CHEM STUDY (PART II)

NAME: ____________________
(please print)

CLASS GROUP NUMBER:

TIME: 12 minutes

TEST 1 (A)

N.B: This Test is designed to help you review the concepts of chemical equilibrium and acid-base indicators. Read each question carefully before attempting to answer it. Some questions ask you to complete a statement and others ask you to select the best statement from among the four responses. Answer all the questions in the space provided.

1. A solution of HCl in water, citric juice and vinegar change the color of litmus from blue to pink. They are, therefore, examples of

   (A) bases

   (B) neutral solutions

   (C) acids

   (D) simple indicators ( )

2. Which of the following is the best description of 'acid-base indicators'?

   (A) they donate protons in acid medium

   (B) they accept protons in basic medium

   (C) they accept or donate protons at the same time

   (D) they accept and donate protons with change of color ( )

3. Which of the following particles is the cause of the difference between a yellow ion (HBb) and a blue ion (Bb^-)?

   (A) a nucleon

   (B) a neutron

   (C) a proton

   (D) an electron ( )

4. What is the equilibrium expression (constant) for the reaction:

$$HBb + H_2O \rightleftharpoons H_3O^+ + Bb^-$$

(A) $K = \frac{[H_3O^+][Bb^-]}{[HBb^-][H_2O]}$

(B) $K = \frac{[HBb][H_2O]}{[H_3O^+][Bb^-]}$

(C) $K = \frac{[H_3O^+][Bb^-]}{[HBb]}$

(D) $K = [H_3O^+]$ ( )

5. In the equation: $HBb + OH^- \rightleftharpoons H_2O + Bb^-$, the basic form of the indicator is represented by:

(A) HBb

(B) Bb^-

(C) OH^-

(D) H_2O ( )

6. Methyl orange (HMo) indicator was used in an experiment consisting of a number of acid solutions of various concentrations and the results obtained were tabulated as shown below:

H_3O^+	Color
10^{-3}	red
10^{-4}	orange
10^{-5}	yellow
10^{-6}	yellow

What is the equilibrium constant of HMo?

(A) 10^{-3}

(B) 10^{-4}

(C) 10^{-5}

(D) 10^{-6} ( )

7. Which of the following equations denotes the strongest acid?

		K
(A)	$HCl_{(g)} \rightleftharpoons H^+_{(aq)} + Cl^-_{(aq)}$	2×10^{6}
(B)	$H_2SO_{4(l)} \rightleftharpoons H^+_{(aq)} + HSO^-_{4(aq)}$	1×10^{2}
(C)	$CH_3HOOH_{(aq)} \rightleftharpoons H^+_{(aq)} + CH_3COO^-_{(aq)}$	18×10^{-5}
(D)	$H_2S_{(aq)} \rightleftharpoons H^+_{(aq)} + HS^-_{(aq)}$	1.0×10^{-7} ( )

8. Which of the following properties would a solution have if it is acid?

(A) Solution accepts hydrogen ions

(B) Solution neutralizes hydrogen ions

(C) Solution ionizes hydrogen ions

(D) Solution liberates hydrogen ions ( )

9. When NaOH is dissolved in distilled water, the resulting solution will show that

(A) $[H_3O^+] = [OH^-]$

(B) $[H_3O^+] > [OH^-]$

(C) $[H_3O^+] < [OH^-]$

(D) $[H_3O^+][OH^-] = 10^{-7}$ ( )

10. In equation: $C_6H_5COOH_{(aq)} \rightleftharpoons H^+_{(aq)} + C_6H_5COO^-_{(aq)}$

$$K_A = \frac{[H^+][C_6H_5COO^-]}{[C_6H_5COOH]}$$

$H^+ = 8 \times 10^{-4}M$ and $C_6H_5COOH = 1.0 \times 10^{-2}M$.

What is the K_A (acidity constant) of C_6H_5COOH ?

(A) 3.2×10^{-4}

(B) 6.4×10^{-4}

(C) 3.2×10^{-5}

(D) 6.4×10^{-5}

( )