

## INFORMATION TO USERS

This reproduction was made from a copy of a document sent to us for microfilming. While the most advanced technology has been used to photograph and reproduce this document, the quality of the reproduction is heavily dependent upon the quality of the material submitted.

The following explanation of techniques is provided to help clarify markings or notations which may appear on this reproduction.

1. The sign or "target" for pages apparently lacking from the document photographed is "Missing Page(s)". If it was possible to obtain the missing page(s) or section, they are spliced into the film along with adjacent pages. This may have necessitated cutting through an image and duplicating adjacent pages to assure complete continuity.
2. When an image on the film is obliterated with a round black mark, it is an indication of either blurred copy because of movement during exposure, duplicate copy, or copyrighted materials that should not have been filmed. For blurred pages, a good image of the page can be found in the adjacent frame. If copyrighted materials were deleted, a target note will appear listing the pages in the adjacent frame.
3. When a map, drawing or chart, etc., is part of the material being photographed, a definite method of "sectioning" the material has been followed. It is customary to begin filming at the upper left hand corner of a large sheet and to continue from left to right in equal sections with small overlaps. If necessary, sectioning is continued again—beginning below the first row and continuing on until complete.
4. For illustrations that cannot be satisfactorily reproduced by xerographic means, photographic prints can be purchased at additional cost and inserted into your xerographic copy. These prints are available upon request from the Dissertations Customer Services Department.
5. Some pages in any document may have indistinct print. In all cases the best available copy has been filmed.

**University  
Microfilms  
International**

300 N. Zeeb Road  
Ann Arbor, MI 48106



1326197

**Chambers, Rebecca Anne**

ABILITY GROUPING IN A COLLEGE CHEMISTRY LABORATORY COURSE

*The University of Arizona*

M.S. 1985

**University  
Microfilms  
International** 300 N. Zeeb Road, Ann Arbor, MI 48106



PLEASE NOTE:

In all cases this material has been filmed in the best possible way from the available copy. Problems encountered with this document have been identified here with a check mark .

1. Glossy photographs or pages \_\_\_\_\_
2. Colored illustrations, paper or print \_\_\_\_\_
3. Photographs with dark background \_\_\_\_\_
4. Illustrations are poor copy \_\_\_\_\_
5. Pages with black marks, not original copy \_\_\_\_\_
6. Print shows through as there is text on both sides of page \_\_\_\_\_
7. Indistinct, broken or small print on several pages
8. Print exceeds margin requirements \_\_\_\_\_
9. Tightly bound copy with print lost in spine \_\_\_\_\_
10. Computer printout pages with indistinct print \_\_\_\_\_
11. Page(s) \_\_\_\_\_ lacking when material received, and not available from school or author.
12. Page(s) \_\_\_\_\_ seem to be missing in numbering only as text follows.
13. Two pages numbered \_\_\_\_\_. Text follows.
14. Curling and wrinkled pages \_\_\_\_\_
15. Other \_\_\_\_\_

University  
Microfilms  
International



ABILITY GROUPING IN A COLLEGE CHEMISTRY LABORATORY COURSE

by

Rebecca Anne Chambers

---

A Thesis Submitted to the Faculty of the  
DEPARTMENT OF CHEMISTRY  
In Partial Fulfillment of the Requirements  
For the Degree of  
MASTER OF SCIENCE  
In the Graduate College  
THE UNIVERSITY OF ARIZONA

1 9 8 5

STATEMENT BY AUTHOR

This thesis has been submitted in partial fulfillment of requirements for an advanced degree at The University of Arizona and is deposited in the University Library to be made available to borrowers under rules of the Library.

Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgment of source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the head of the major department or the Dean of the Graduate College when in his or her judgment the proposed use of the material is in the interests of scholarship. In all other instances, however, permission must be obtained from the author.

SIGNED: Rebecca Anne Chambers

APPROVAL BY THESIS DIRECTOR

This thesis has been approved on the date shown below:

W. T. Lippincott  
W. T. Lippincott  
Professor of Chemistry

24 July 1985  
Date

## ACKNOWLEDGEMENTS

I am thankful to Dr. W. T. Lippincott for his guidance during this project and in the preparation of this thesis.

## TABLE OF CONTENTS

	Page
LIST OF TABLES . . . . .	v
ABSTRACT. . . . .	vi
CHAPTER 1 . . . . .	1
INTRODUCTION AND REVIEW OF LITERATURE. . . . .	1
Research Procedure. . . . .	4
CHAPTER 2 . . . . .	7
PRESENTATION AND INTERPRETATION OF RESULTS . . . . .	7
Long-term Study . . . . .	7
Comparison and Interpretation of Post-test Scores (1977-1983). . . . .	7
Comparison and Interpretation of Grade Distributions (1980-1983) . . . . .	9
Comparison and Interpretation of Withdrawal Rates (1978-1983) . . . . .	14
Short-term Study . . . . .	14
Comparison and Interpretation of Final Examination Scores. . . . .	14
Comparison and Interpretation of Post-test Scores. . . . .	16
CHAPTER 3 . . . . .	21
SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS. . . . .	21
APPENDIX A: STANDARD PRE-TEST . . . . .	25
APPENDIX B: SAMPLE STANDARD POST-TEST. . . . .	29
APPENDIX C: FINAL EXAMINATION FOR SHORT TERM STUDY . . . . .	33
REFERENCES. . . . .	42

LIST OF TABLES

Table		Page
1	Comparison of Post-test Results (1977-1983) . . . . .	8
1b	Comparison of Normalized Post-test Results (1977-1983) . . .	10
2	Overall Grade Distributions (%) (1978-1983) . . . . .	11
3	Comparison of Grades Awarded by Track (%) (1980-1983) . . . .	12
4	Percentage of Each Grade Awarded by Track (1980-1983) . . . .	13
5	Withdrawal Rates (%) (1978-1983) . . . . .	15
6	Results of t-test. . . . .	17
7	Distribution of Final Examination Scores, Fall, 1983 By Track. . . . .	18
8	Results of t-test on Post-test Results . . . . .	20

## ABSTRACT

In the vast majority of introductory college chemistry laboratory courses no provisions are made for the differences in the abilities of the students.

In this work the effectiveness of an ability grouped program at the University of Arizona Department of Chemistry was studied. The work consisted of two separate studies. The first study compared post-test scores and grade distributions over the six year history of the course Chemistry 104a. The second study was a more in depth study of two groups of students enrolled in the course during the Fall semester of 1983.

This study was designed to offer some insight into three areas. The first area was a question of the effectiveness of the program in achieving its goals and the second and third areas dealt with possible changes in the program.

The results of the studies were rather inconclusive, owing to the available data and the time frame involved in the experiment. In general, this study seemed to indicate that the weaker group did not exhibit the same level of achievement as the stronger group at the end of the course. It is, however, not possible from this study to determine to what extent, if any, the program is affecting the performance of either group.

## CHAPTER 1

### INTRODUCTION AND REVIEW OF LITERATURE

Every fall, approximately 1500 students enroll in Chemistry 104a, an introductory chemistry laboratory course, at the University of Arizona. These students have widely varying backgrounds with respect to their chemistry and mathematics levels. When the students were assigned to sections of the course without regard to their individual levels of preparation for taking the course, several problems resulted.

First, most of the instructors did not have a background in education, and found it difficult and frustrating to deal with such a divergent group of students. Secondly, the situation was also very frustrating for many of the students. Those who were well prepared to take the course were often bored and frustrated by the slow pace of the course. The less prepared students were also often frustrated because the instructors did not have the time to address these students' deficiencies. All in all, it was felt that the needs of the students were not being adequately met.

As a remedy to these problems, it was decided to create an ability grouped system for the course. It was hoped that by ability grouping the students, the course would be able to serve the needs of

the students more effectively. The well prepared students would not be frustrated by the less prepared students' deficiencies and the instructors of the less prepared students would be able to spend more time teaching the students the skills they lacked to succeed in a non-ability grouped course. One goal of the system was to help the less prepared students overcome their deficiencies so that at the end of the course, they would have attained the same level of achievement in the course as the well prepared students.

The students were grouped on the basis of their performance on a 15 minute pre-test administered during the first class meeting. All students' scores for that class meeting time were pooled, and the upper half was designated as Track A, while the lower half was designated as Track B. The students were then assigned to their respective laboratory sections.

The Track A students received a standard first semester laboratory program, while the Track B students were given an introductory exercise the first week, and supplemental material for the first half of the course. The Track B instructors were also instructed to spend more time explaining the chemical concepts and the mathematical operations involved in the course. Recently, the supplemental materials have been replaced with a more detailed laboratory textbook. At the end of the course, all students completing the course were given a 15 minute post-test designed to assess their level of achievement and compare different sections of the course. On the basis of the test results,

instructors were advised about the approximate numbers of A and B grades they should give, although instructors were allowed to set their own grading scales. Any significant deviation from the suggested numbers of A and B grades was to be discussed with the laboratory coordinator for approval.

Ability grouping minimized a number of the problems it was designed to address. Since the system had been used for approximately six years, it was decided to attempt a quantitative evaluation of its progress. My project was designed to determine the effectiveness of ability grouping on bringing about a convergence of skill development in an introductory college chemistry laboratory course. We felt this study was important in the determination of the future directions for the program. The questions to be addressed by this study were (1) was the program achieving one of its goals of bring the less prepared students' level of achievement up to the level of the well prepared students, (2) if so, could the program be improved to increase the level of achievement of all students, and (3) if the program is not achieving this goal, how can it be revised to move in this direction?

While there is a large body of literature concerned with ability grouping on the elementary level in reading and language arts, a thorough search of the literature revealed almost no studies on ability grouping at the post secondary level. Indeed, only one paper, by Smithson, was found (1). This study concerned itself with the effects of ability grouping on the performance of college physics students. His

results indicate that ability grouping does not significantly affect the performance of the higher ability students; they do as well in nongrouped sections as they do in grouped sections. However, poorer ability students perform at a higher level when placed in nongrouped sections.

A study on secondary students, done by Plewes in Luxembourg, indicates that ability grouping does indeed increase the performance of all students (2). Unfortunately, in this study the teaching methods employed for the two groups differed significantly. The mixed ability groups received self-paced, non-teacher centered instruction, while the ability grouped students received whole-group, teacher-centered instruction. Due to these differences, it may be difficult to determine which variable is primarily responsible for the author's results.

This lack of previous research makes this study even more important as a trailblazer.

#### Research Procedure

This project consisted of two separate studies. The first study was an analysis of the data, collected over the years, on the results of the tracking program. The second study was a direct comparison of two sets of students, one from each track.

In the first, or long term, study the various sets of information collected over the approximately six years of the program was analyzed to determine if any patterns in student achievement could be found. This data was collected over the years by the laboratory coordinator, and consisted of post-test results and grade distributions.

The second, or short term, study compared the scores of two groups of students, one from each track, to determine if the two groups showed the same level of achievement at the end of the course.

The two groups chosen were selected on the basis of (1) the time the section met, and (2) the characteristics of the instructors involved. The times chosen were Tuesday and Thursday 8:00 - 10:50 A.M., and Thursday 11:00 A.M. - 1:50 P.M. These times traditionally attract the more motivated students, and the students in these sections are usually the typical college students in terms of age and goals. The instructors were chosen on the basis of the characteristics of their teaching styles. All of the instructors chosen were demonstrably concerned with the education of their students, and all had similar teaching styles.

In total, the test group consisted of 103 students, 40 from Track A, and 63 from Track B. These students were given a common final examination, written by the instructors and me, and graded by me. The scores on this test and the standard post-test were analyzed to determine if there was a significant difference between the level of achievement of the two groups by the end of the semester.

The statistical analysis on this data consisted of a standard t-test of the means, using a 0.05 level of significance. The formula use to compute t was:

$$t = \frac{(\bar{x}_1 - \bar{x}_2) - d_0}{Sp \sqrt{1/n_1 + 1/n_2}}$$

where  $\bar{x}_i$  = mean of sample  $i$

$d_0$  = desired difference between means

$$S_p = \left( \frac{(n_1-1)S_1^2 + (n_2-1)S_2^2}{n_1 + n_2 - 2} \right)^{1/2}$$

$n_i$  = # of measurements in sample  $i$

$S_i$  = standard deviation of sample  $i$  (3)

The 0.05 level of significance means that the probability of committing a Type I error (rejecting a null hypothesis that should be accepted) is 0.05.

## CHAPTER 2

### PRESENTATION AND INTERPRETATION OF RESULTS

#### Long-term Study

##### Comparison and Interpretation of Post-test Scores (1977-1983)

The averages of both Tracks' scores can be found in Table 1. From this table, we can see that although there is always a difference between the Track A and the Track B scores, with the Track A students scoring higher, this difference seems to be generally increasing. No satisfactory explanation presents itself to account for the decrease in the difference for the Fall, 1983 scores.

A more striking result of this data is the overall drop in performance of the Track A students of 8.1 points, while the Track B students scores dropped 11.6 points. This may indicate that recent Track A and B students are less prepared to take the course than their predecessors had been. Of the two groups, the Track B students are even less prepared. This result also might indicate a drop in instructor expectations or teaching effectiveness. The available data offers no way to distinguish between these interpretations.

Other information, such as the overall performance of the students in the general chemistry program, and the extensive evaluation of instructors by staff and students suggests that neither

Table 1 - Comparison of Post-test Results (1977-1983)

Year	Track A%	Track B%	$\Delta\%$
1977	78.4	72.8	5.6
1978	69.8	68.6	1.2
1979	71.6	66.0	5.6
1980	65.7	61.2	4.5
1981	73.5	66.0	7.5
1982	73.3	64.8	8.5
1983	70.3	69.3	1.0

interpretation is correct. A more plausible explanation is that the difficulty of the test varied from year to year. Normalizing the results produces the figures in Table 1b.

#### Comparison and Interpretation of Grade Distributions (1980-1983)

Three different analyses of grade distributions were made in this study, and the results of are in Tables 2, 3, and 4.

The first of these comparisons, that of overall grade distributions, can be found in Table 2. This is not a very useful comparison tool. The overall distribution of grades is determined by the chemistry department based on examination scores, lab reports, and a standard developed over years of experience.

A more relevant comparison of grades can be found in Table 3, the comparison of grades awarded by Track. In this table, we see that a higher percentage of Track A students receive grades of A and B than do the Track B students. This, of course, means that a higher percentage of Track B students receive grades of C, D, or E. This would appear to indicate that overall, Track A students achieve on a higher level than do Track B students.

The most striking comparison of grade distributions is found in Table 4. This compares the percentage of each grade received by each Track, or what percentage of a particular grade was earned by either Track. It can be seen from this data, that over the years, the

Table 1b - Comparison of Normalized Post-Test Results (1979-1983)

Year	Track A%	Track B%	$\Delta\%$
1977	70.00	63.6	6.4
1978	70.0	68.8	1.2
1979	70.0	64.4	5.6
1980	70.0	65.5	4.5
1981	70.0	62.5	7.5
1982	70.0	61.5	8.5
1983	70.0	69.0	1.0

Table 2 - Overall Grade Distributions (%) (1978-1983)

Year	A	B	C	D	E	I	W
1978	18.5	30.7	26.2	4.0	5.5	0.33	14.6
1979	18.8	28.5	24.0	4.3	5.8	0.10	18.4
1980	19.9	28.6	20.2	3.2	6.0	0.75	21.8
1981	18.2	29.6	20.8	4.3	5.3	0.5	21.3
1982	N/V	N/V	N/V	N/V	N/V	N/V	N/V
1983	19.0	28.1	22.8	3.8	5.9	0.6	20.0

N/V = not valid due to building remodeling

Table 3 - Comparison of Grades Awarde by Track (%) (1980-1983)

Year	A	B	C	D	E	I	W
1980	23.7/ 16.1	29.4/ 27.8	19.4/ 20.9	2.4/ 3.9	5.7/ 6.2	0.24/ 0.25	19.0/ 24.7
1981	21.6/ 14.4	31.8/ 27.1	19.3/ 22.5	3.6/ 5.0	4.0/ 6.8	0.34/ 0.63	20.3/ 22.4
1982	N/V	N/V	N/V	N/V	N/V	N/V	N/V
1983	19.5/ 17.1	28.3/ 27.6	23.3/ 20.9	4.4/ 3.1	5.5/ 5.9	0.4/ 0.9	16.3/ 23.5

Key: Track A/  
Track B

N/V = not valid due to building remodeling

Table 4 - Percentage of Each Grade Awarded by Track (1980-1983)

Year	A	B	C	D	E	I	W
1980	60.1/ 39.9	51.9/ 48.1	48.6/ 51.4	40.4/ 59.6	48.5/ 51.5	50.0/ 50.0	44.1/ 55.9
1981	62.3/ 37.7	56.5/ 43.5	48.7/ 51.3	44.4/ 55.6	39.3/ 60.7	37.5/ 62.5	50.2/ 49.9
1982	N/V						
1983	57.7/ 42.3	57.1/ 42.9	57.6/ 42.4	64.9/ 35.1	54.1/ 45.9	33.3/ 66.7	45.8/ 54.2

Key:     Track A/  
          Track B

N/V = not valid due to building remodeling

percentages have remained relatively stable with the Track A students receiving 60% of the grades of A and B. This indicates that there is indeed a difference in performance levels of the two Tracks at the end of the course.

It should be noted that some Track B students do receive grades of A and B. This suggests that there are some students whose skills do improve in the ability grouped system.

#### Comparison and Interpretation of Withdrawal Rates (1978-1983)

Table 5 is a comparison of the withdrawal rates of the two Tracks. This data indicates that more students in Track B fail to complete the course than those in Track A. This may be another indication that the program is not addressing the needs of the students, but there is no way to determine how many of these students would have withdrawn from the course if it were not grouped. There is also no way to determine how many students who did complete the ability grouped course would have withdrawn from a nongrouped course.

#### Short-term Study

##### Comparison and Interpretation of Final Examination Scores

A more in depth study of the effectiveness of ability grouping was performed during the Fall of 1983. Two groups of students, one from each Track, were compared based upon the results of the standard post-test and a final examination. A statistical analysis was performed, using the standard t-test of the means at a level of

Table 5 - Withdrawal Rates (%) (1978-1983)

Year	Overall	Track A	Track B
1978	14.6	N/A	N/A
1979	18.4	N/A	N/A
1980	21.8	19.0	24.7
1981	21.3	20.3	22.4
1982	N/V	N/V	N/V
1983	20.0	16.3	23.5

N/A = not available

N/V = not valid due to building remodeling

significance of 0.05. A summary of the results of this analysis may be found in Table 6. It can be seen from this data that at the 0.05 level of significance, the null hypothesis must be rejected for the case of the comparison of the scores of the Track A and B students. This means that at the end of the course, the two groups of students had not attained the same level of achievement.

In comparing the performances of the two groups, we see that the average score for all students was 68, with a standard deviation of 20, while the comparable figures for Track A are 78 and 17, and 61 and 19 for Track B.

Another interesting comparison can be made between the distribution of final examination scores for the two groups. These distributions can be found in Table 7. It is interesting to note that of the Track A students, only one student (2.5%) received a score of less than 50, while ten students (25%) received scores of 90 or greater. In comparison, 18 students (29%) from Track B received scores less than 50, and only two students (3%) received scores of 90 or greater. This would once again seem to indicate a definite difference in the levels of achievement between the two groups.

#### Comparison and Interpretation of Post-test Scores

The standard post-test is a 15 minute test given to each student enrolled in the course at the end of the course. Its major use is to

Table 6 - Results of t-test for Final Exam Scores

Results of t-test

Level of Significance = 0.05

Critical Value  $t > 1.960$  $H_0$  = There is no difference between the average scores.

<u>Combination</u>	<u>t</u>	<u>Conclusion</u>
Track A & B	4.64	Reject $H_0$

Table 7 - Distribution of Final Examination Scores, Fall, 1983 By Track

Score	Track A		Track B	
	# of Scores	%	# of Scores	%
90 & above	10	22	2	32
80-89	9	22.5	9	14.3
70-79	8	20	11	17.5
60-69	9	22.5	15	23.8
50-59	3	7.5	8	12.7
40-49	0	0.0	6	9.5
30-39	0	0.0	9	14.3
20-29	1	2.5	1	1.6
10-19	0	0.0	2	3.2
00-09	0	0.0	0	0.0

standardize grade distributions, thus insuring that a grade earned in any particular section of the course would be earned in any other section of the course.

A statistical analysis (t-test) was performed on the post-test scores for the test groups, and the results can be found in Table 8. This test indicates that the null hypothesis must be accepted. That is, that no significant difference can be found between the scores of each group. This would seem to contradict the results obtained from the final examination. However, it is generally assumed that a longer test be more reliable (4), and I feel that the final examination tested on the higher cognitive levels of application and analysis, while the post-test is concerned mostly with the lower knowledge and comprehension levels (5). For these reasons, I feel that while the results of the post-test cannot be ignored, they must be viewed in a less significant light than the final examination results.

Table 8 - Results of t-test on Post-test Results

$H_0$ = There is no difference between the means of the two groups		
Level of significance = 0.05		
Critical value to $>1.960$		
Combination	t	Conclusion
Track A & B	0.56	Accept $H_0$

## CHAPTER 3

### SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Due to the limited amount of data available, no definite conclusions can be drawn from this study. However, the results seem to indicate that the ability grouping program may not be achieving its goal of bringing the less prepared student's level of achievement up to the level of the well prepared student. This conclusion is based on the results of the long term study of post-test results, grade distributions, and withdrawal rates, and the short term study of final examination scores. These results indicate that there does seem to be a significant difference between the levels of achievement of the two groups of students at the end of the course.

It is, however, impossible to determine how much, if any, the ability grouping program helps the less prepared students. This is due to there being no measure of the students' abilities before the course that can be correlated with their performance at the end of the course. The existing pre-test and post-test do not measure the same quantity. The pre-test measures skills that are thought to be necessary to take the course. The post-test measures knowledge which is supposed to be

gained by taking the course, and the skills tested by the pre-test are not represented in the post-test.

Another area that cannot be addressed by the available data is if the ability grouping program affects the achievement of the well prepared students. The high final examination scores of the Track A students may indicate that some of the students are not being challenged by the course.

A final area of concern for this study is that of instructor attitude. In other words, since the majority of the instructors have no background in educational methodology, the Track B instructors may actually be unconsciously depressing the performance of their students. If this self-fulfilling prophecy syndrome is occurring, a mixed ability group program may eliminate or lessen this problem.

In order to address these concerns, I would suggest that two further studies be performed. The first study would be conducted similarly to the present study. A group of students would be grouped using the current method. Then, each group would be given an extensive pre-test which would cover the material to be presented in the course. At the half-way point of the course, another examination could be given, and a final examination could be given at the end of the course. The two groups would be given the same instruction that is currently used. The results of the examinations would yield information about the effectiveness of the program, specifically, what actually happens to the gap between the two groups.

A second recommended study would determine if it is the program that is helping the less prepared student, or if some other variable is responsible for any gains made by the students.

In this study, a test group would be split into three groups. These groups would be a Track A group, a Track B group, and a Mixed group. The students in this Mixed group would be identified to the experimenter as Track A and B, but not to the instructor. The Track A and Mixed group would receive the current Track A instruction, and the Track B students would be given the current Track B instruction. As in the first proposed study, the students would be given an extensive pre-test, midterm test, and post-test.

The results of these tests could then be statistically analyzed. The results of this analysis should help determine if ability grouping is effective, and for the Mixed group, if heterogeneous grouping and Track A instruction is harmful to the less prepared student.

In lieu of these studies, and based on this study and my experiences, I would make the following suggestions for the current program.

If the course continues to be ability grouped, I would require more remedial work for the less prepared students. This could take the form of extra discussion sections or reestablishment of the supplemental material for these students. I would also recommend that the instructors assigned to teach these students receive extra instruction on teaching methods.

If the course is not to be ability grouped, but less prepared students are to be identified, extra help sessions could be offered. These would be open to all students, but the less prepared could be encouraged to attend these sessions. This system might allow the department to raise its standards and challenge the well prepared students.

Another alternative is to discontinue the ability grouping, and to offer a wider variety of courses. Students could be placed in an appropriate level course based on the results of an extensive placement test. If necessary, those students who are truly deficient could be placed in a non-credit remedial course. Successful completion of this course would be a prerequisite for placement in a credit course.

In conclusion, I feel this study has proved to be somewhat valuable. It has provided a starting point for further studies, and it has provided some information and insight on the effectiveness on the current course.

APPENDIX A

STANDARD PRE-TEST

PRE-LAB DIAGNOSTIC TEST

This test is designed to help you and us to determine how well prepared you are to begin laboratory work in Chemistry 104A. It will have NO bearing on your grade. In fact, cheating will have a detrimental effect because we will assume that you know more than you actually do. Please write the letter of the correct answer in the space provided for the multiple choice questions and the correct answer in the blank for all other questions. This test will be graded and discussed immediately upon completion.

SCORE: number correct  
out of 25

Part I: MATHEMATICS Select the answer that is equal to the first number.

\_\_\_\_\_ 1)  $2.4 \times 10^3 =$  A) 240 B) .0024 C) 2400 D)  $\frac{1}{2400}$

\_\_\_\_\_ 2)  $2.4 \times 10^{-3} =$  A) 240 B) .0024 C) 2400 D)  $\frac{1}{2400}$

\_\_\_\_\_ 3)  $10^6 \times 10^4 =$  A)  $10^{10}$  B)  $10^{24}$  C)  $10^2$  D) 64

Indicate the number of significant figures in each number.

\_\_\_\_\_ 4) 452.82          \_\_\_\_\_ 5)  $4.68 \times 10^7$           \_\_\_\_\_ 6) 0.00512

Solve each of the following equations for X.

X = \_\_\_\_\_ 7)  $4X - 3 = Y$

X = \_\_\_\_\_ 8)  $\frac{X + 6}{7} = 3$

X = \_\_\_\_\_ 9)  $(3X)^2 = 81$

X = \_\_\_\_\_ 10)  $(X + 1)^2 = Y + 5$

Part II: CHEMICAL TERMINOLOGY From the KEY LIST select a formula for each of the substances described in each question.

- |                                       |                    |                    |
|---------------------------------------|--------------------|--------------------|
| _____ 11) This is an acid             |                    | <u>KEY LIST</u>    |
| _____ 12) This is a base              | A) CH <sub>4</sub> | C) HCl             |
| _____ 13) This is a salt              | B) NaOH            | D) CO <sub>2</sub> |
| _____ 14) This is an organic molecule |                    | E) KCl             |

From the KEY LIST select a formula for each of the substances described in each question.

- |   |   |  |
|---|---|--|
| _____ 15) This is sulfuric acid   |   | <u>KEY LIST</u>                                    |
| _____ 16) This is iron (II) sulfate   | A) Na <sub>2</sub> SO <sub>4</sub>                      | D) Fe <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> |
| _____ 17) This is sulfate ion   | B) NaHSO <sub>4</sub>                                   | E) SO <sub>4</sub> <sup>-2</sup>                   |
| _____ 18) This is sodium sulfate  | C) H <sub>2</sub> SO                                    | F) FeSO  |
| _____ 19) Consider the preparation of 1 M H <sub>2</sub> SO <sub>4</sub> from 6 M H <sub>2</sub> SO <sub>4</sub> . 10 ml of the 6 M H <sub>2</sub> SO <sub>4</sub> will require the addition of how many milliliters of distilled water to produce a 1 M solution of H <sub>2</sub> SO <sub>4</sub> ? |   |  |
|   | A) 10    B) 30    C) 50    D) 60    E) it can't be done |  |
| _____ 20) 500 ml of 6 M NaBr is added to 500 ml of 1 M Na <sub>2</sub> SO <sub>4</sub> . What is the final concentration of Na <sup>-</sup> ?   |   |  |
|   | A) 1 M    B) 3 M    C) 3.5 M    D) 4 M    E) 6 M        |  |

From the KEY LIST select the response that best describes what would happen if you were to spill each of the following reagents on the skin of your forearm.

- |   |                                  |                 |
|---|----------------------------------|-----------------|
| _____ 21) 18 M H <sub>2</sub> SO <sub>4</sub> |                                  | <u>KEY LIST</u> |
| _____ 22) 0.1 M NaOH                          | A) a soothing action             |                 |
|   | B) immediate destruction of skin |                 |
|   | C) a burning action              |                 |
|   | D) a soap-like action            |                 |
|   | E) no perceptible action         |                 |

From the KEY LIST identify each of the pieces of laboratory equipment pictured below.

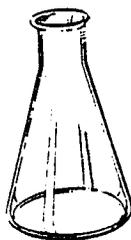
\_\_\_\_\_ 23)

\_\_\_\_\_ 24)

\_\_\_\_\_ 25)

KEY LIST

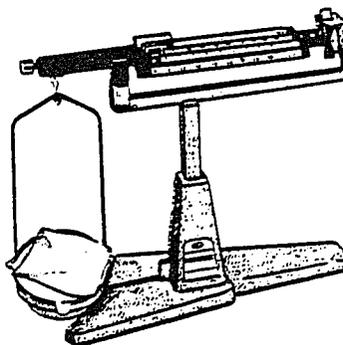
- A) pipet
- B) buret
- C) graduated cylinder
- D) Buchner funnel
- E) Erlenmeyer flask
- F) analytical balance
- G) beam balance
- H) side-arm flask



23



24



25

APPENDIX B

SAMPLE STANDARD POST-TEST

Chemistry 104a  
POST-LAB TEST

Section \_\_\_\_\_ Score \_\_\_\_\_/30

This test is being given to help us to evaluate where your class stands relative to the other sections of 104a. Your instructor's grade distribution could be influenced by your class scores on this test.

Part 1: (one point per question)

A. From KEY LIST A select the one technique that was demonstrated in the indicated experiment

KEY LIST A

- |  |                            |
|--|----------------------------|
| _____ 1) Determination of antacid tablet strengths (#10).    | A) Chromatography          |
| _____ 2) Spectroscopic identification of cations (#7c).      | B) Titration               |
| _____ 3) Determination of optimum reaction conditions (#6b). | C) Absorption Spectroscopy |
| _____ 4) Separation of components A, B, and C (#2).          | D) Emission Spectroscopy   |
|  | E) None of the above       |

B. For each of the questions in part I A above, indicate which kinds of analysis the experiment demonstrated by choosing the correct response from KEY LIST B.

KEY LIST B

- |                       |                          |
|-----------------------|--------------------------|
| _____ 5) (Question 1) | A) Quantitative Analysis |
| _____ 6) (Question 2) | B) Qualitative Analysis  |
| _____ 7) (Question 3) | C) Both A and B          |
| _____ 8) (Question 4) | D) None of the above     |

- C. From KEY LIST C, select the one piece of equipment most necessary to best perform the indicated operation. You are to consider only those items on the list.

KEY LIST C

- |  |                       |
|--|-----------------------|
| _____ 9) Determination of the melting point of an organic substance.                 | A) Buret              |
|  | B) Crucible           |
|  | C) Funnel             |
| _____ 10) Determination of the absorbance spectrum of a colored solution.            | D) Graduated Cylinder |
|  | E) Pipet              |
|  | F) Thermometer        |
| _____ 11) Performance of spot tests to determine the presence of ions in a solution. | G) Spectroscope       |
|  | H) Spectrophotometer  |
| _____ 12) Titration of an unknown solid with a known solution.                       |                       |

- D. The KEY LIST represents the labels of reagent bottles commonly available in the lab. From this list, select the reagent described in each question.

KEY LIST D

- |  |  |
|--|--|
| _____ 13) Add 6M ammonia dropwise until a precipitate just begins to form. | A) 6M NaOH                             |
|  | B) 6M $\text{NH}_4\text{OH}$           |
| _____ 14) Add 6M acetic acid until the solution is just barely acidic.     | C) 6M $\text{HNO}_3$                   |
|  | D) 6M $\text{CH}_3\text{COOH}$         |
| _____ 15) Add a few drops of dilute nitric acid.                           | E) 6M $\text{H}_2\text{C}_2\text{O}_4$ |
|  | F) 15M $\text{HNO}_3$                  |
| _____ 16) The most dangerous reagent on the list.                          |  |

PART II: (two points per question)

- \_\_\_\_\_ 17) A student weighed a sample on an analytical balance and reported the weight in his report as being 3.02. Of course this is not correct, and the student was docked an appropriate number of points for this mistake. How should he have reported this value to avoid losing any points.

- 18) A student performed the following steps in doing experiment 7d (measurement of absorbance vs wavelength).
- 1) He turned on the spectrophotometer.
  - 2) With an empty cuvette in the sample compartment, he set the meter to read "0% T."
  - 3) He removed the cuvette and filled it half full with distilled water, replaced it in the sample compartment and set the meter to read "0 absorbance."
  - 4) He removed the cuvette, emptied it and filled it with his unknown solution. He then placed the cuvette back into the spectrophotometer, closed the lid and took a reading in absorbance units.

This procedure is incomplete. Certain important operations were omitted. You are to discuss the two most important omissions by first stating the step and then the omitted operation.

Part III: (two points per question)

For the next five questions, you are to identify the pieces of lab equipment indicated by your instructor. Each item was used this term in the lab. If the equipment is used to make measurements, indicate the units of measurement of the particular piece of equipment that you used this term in this course. If the item is not used for measurement, write "NONE" in the appropriate space.

	<u>NAME</u>	<u>UNITS</u>
19)	_____	_____
20)	_____	_____
21)	_____	_____
22)	_____	_____
23)	_____	_____

APPENDIX C

FINAL EXAMINATION FOR SHORT TERM STUDY

CHEMISTRY 104a  
FINAL EXAMINATION  
FALL, 1983

NAME (PRINT) \_\_\_\_\_ MATRIC NO. \_\_\_\_\_

SECTION NUMBER \_\_\_\_\_

INSTRUCTOR \_\_\_\_\_

SIGNATURE \_\_\_\_\_

DIRECTIONS:

1. There are 13 questions to this exam. Make sure you have all of them before you begin.
2. Answer all questions in the space provided.
3. For problems requiring calculations, show all work!!!! No credit will be given for bare answers. Underline final answers.
4. Stapled to this exam, you will find a piece of graph paper for question #10, and a page of useful information.
5. Be sure you print your name on this page and sign it. Any exam without a name on it will be given a grade of zero.
6. This exam will not be returned to you. Check with your instructor about reviewing it after it has been graded.

\*\*\*\*\*  
GRADE WAIVER

I give \_\_\_\_\_ permission to post my final grade  
(Instructor's Name)  
in Chemistry 104a in a public manner.

\_\_\_\_\_  
Student's Signature

\*\*\*\*\*  
\*\*\*\*\*DO NOT MARK BELOW THIS LINE\*\*\*\*\*

SCORES

1. _____	6. _____	11. _____	B2. _____
2. _____	7. _____	12. _____	Total _____
3. _____	8. _____	13. _____	
4. _____	9. _____	sub _____	
5. _____	10. _____	B1. _____	

1. Joe Chemist wished to prepare 4M nitric acid from concentrated acid. He cautiously went over to the fume hood and retrieved a bottle of HCl (conc.). As he carried (with both hands) the bottle back to his workspace, his safety goggles fell out of his pocket and became tangled in his sandal, causing him to lose his balance. He spilled some acid on his bare knee. Cleverly, he poured some dilute NaOH solution on his knee to neutralize the acid. Back at his workspace, he measured 10 ml of acid using the triple beam balance. Slowly, with stirring, he poured in the water. Unable to contain his excitement, he knocked over his beaker of ethanol, which was heating over a low flame, onto his unfinished introduction. Frustrated, he grabbed his sandwich and went home. He was subsequently given a failing grade for the course. What did he do wrong? (Find at least 8)

2. Cosmos Klutz wanted to weigh out some NaOH on the analytical balance, so he performed the following steps.
  1. Cosmos went over to the balance, and checked to see if it was level.
  2. With the doors open and nothing on the pan, he moved the arrest layer to full release and set the zero.
  3. He returned the lever to full arrest and dumped the NaOH pellets onto the balance pan.
  4. Cosmos then closed the doors and moved the arrest lever to partial arrest.
  5. He noted the approximate mass, and dialed it in.
  6. He turned the lever to full release, dialed in the final mass, and recorded it on his data sheet.
  7. He moved the lever to full arrest, opened the door, and removed the NaOH pellets.
  8. Cosmos closed the door and returned all the weights to zero.

The observant instructor promptly killed poor Cosmos because he did not use the balance correctly. List at least 2 things he did wrong, and what he should have done.

3. On the reagent bench, you find the following solvents
- 1) dichloromethane
  - 2) distilled water
  - 3) 6M HNO<sub>3</sub>

Which of them would you use to separate:

- a) C<sub>13</sub>H<sub>8</sub>O and LiCl
  
- b) Cu(NO<sub>3</sub>)<sub>2</sub> and PbO
  
- c) C<sub>6</sub>H<sub>4</sub>Cl<sub>2</sub> and MgO

The following table may be useful

	Pb <sup>++</sup>	Li <sup>+</sup>	Cu <sup>++</sup>	Mg <sup>++</sup>
Nitrate, NO <sub>3</sub> <sup>-</sup>	W	W	W	W
Oxide, O <sup>-</sup>	A	A	a	A
Chloride, Cl <sup>-</sup>	A	W	W	W
Sulfate, SO <sub>4</sub> <sup>=</sup>	a	W	W	W

Abbreviations: W water soluble  
 A insoluble in water but soluble in acids  
 a insoluble in water but sparingly in acids

7. Christine Chemist performed a TLC experiment. What do the letters TLC stand for?
8. Give a practical use for TLC.
9. Given  $E = 4.84 \times 10^{-12}$  ergs, to what wavelength of light does this correspond?
10. Phillip Photon's lab notebook contained the following information.

<u>Concentration</u>	<u>Absorbance</u>
$1.0 \times 10^{-3}$ M	0.220
$2.0 \times 10^{-3}$ M	0.451
$3.0 \times 10^{-3}$ M	0.662
$4.0 \times 10^{-3}$ M	0.871
Unknown # 23564	0.523

Using the graph paper provided, construct a calibration curve for the data, and determine the concentration of his unknown.

11. Assume the following data for the indicator X:

HInd form: yellow

Ind<sup>-</sup> form: blue

a) Write an equilibrium equation for this indicator in acid solution.

b) An increase in H<sub>3</sub>O<sup>+</sup> will yield which color?

c) An increase in OH<sup>-</sup> will yield which color?

12. What is the relationship between acid and base at an endpoint?

13. The following page came out of Tommy Titration's notebook.

<u>mass of KHP</u>	<u>Volume NaOH</u>	
1.1264 g	15.22 ml	
1.2201 g	16.34 ml	
1.2169 g	15.24 ml	KHP = KHC <sub>8</sub> H <sub>4</sub> O <sub>4</sub>
1.2099 g	14.63 ml	

Calculate:

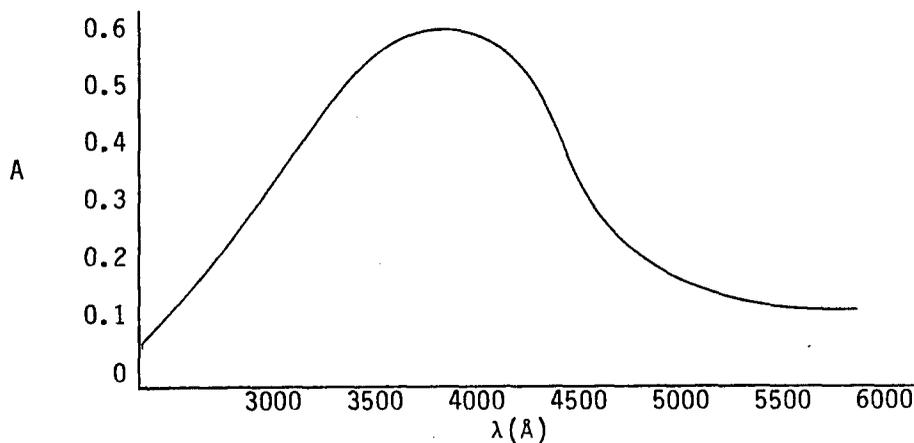
a) Average molarity of NaOH

b) Average deviation for molarity of NaOH

\*\*\*\*\*BONUS QUESTIONS\*\*\*\*\*

B1. Explain why you would need to use a spectroscope when doing a flame test on a multicomponent unknown.

B2. Pick the best wavelength to use for a Beer's Law plot from the following absorption spectrum.



Good luck on the rest of your finals. Have a happy holiday season.

## USEFUL INFORMATION

Planck's Constant  $6.6262 \times 10^{-27}$  erg-sec

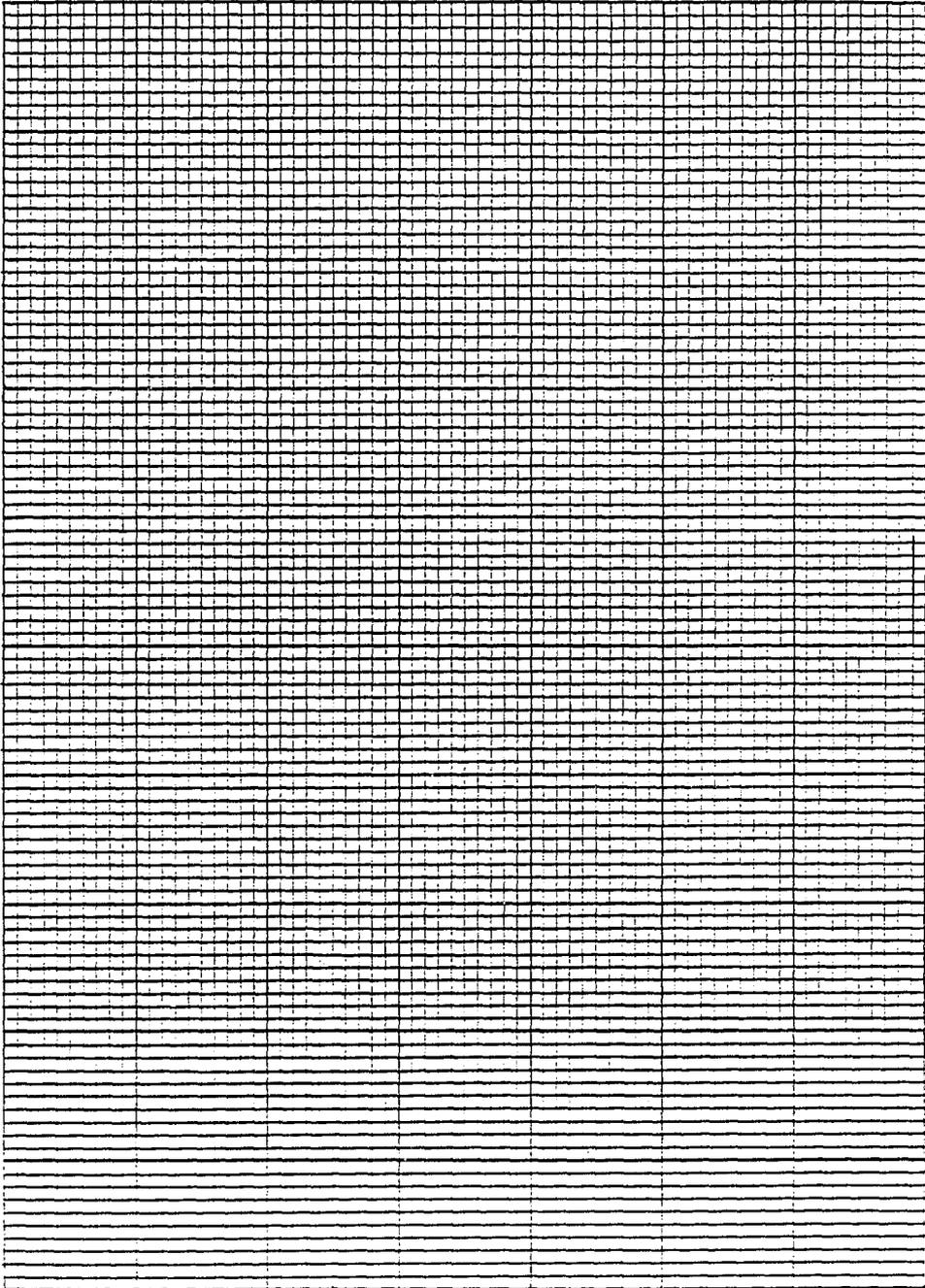
## Atomic Masses

H = 1.00797

O = 15.9994

K = 39.102

C = 12.0115



## REFERENCES

1. J. R. Smithson, Two Experiments in Homogeneous Sectioning of Students in General Physics, presented at the American Association of Physics Teachers Meeting, February, 1971, New York.
2. John A. Plewes, "Mixed-Ability Teaching - A Deterioration in Performance", Journal of Research in Science Teaching, 16, No. 3, (1979) 229-36.
3. Ronald E. Walpole and Raymond H. Myers, Probability and Statistics for Engineers and Scientists, 2nd Ed., (New York: Macmillan Publishing Co., Inc., 1978) 238-79.
4. N. L. Gage and David C. Berliner, Educational Psychology, Third Edition, (Boston: Houghton Mifflin Company, 1984) 666.
5. Gage and Berliner, p. 57-9.