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STOICHIOMETRY UNIT PROJECT

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ABSTRACT

STOICHIOMETRY UNIT PROJECT

By

Luann Marie Decker

Each student is a unique individual with his/her own personality and learning style. How does one teach to a varied group of individuals?

The Stoichiometry Unit Project is a basic chemistry unit that has been reconstructed to incorporate different teaching strategies so all of the different learning styles of the students may be embraced. The primary concern of this project was to provide the best possible learning environment for <u>all</u> of the students involved, keeping in mind their different learning styles.

A survey was given to every student to determine their learning-style preference(s). To insure that all of the students' learning styles were addressed, the following teaching strategies were incorporated: laboratory activities, demonstrations, lectures, computer interaction, hands-on activities, writing opportunities, and group activities.

Test scores and unit scores were compared to those of a previous year and although the difference between the years was not statistically different, overall grades did improve. Based on writings, which included comments from the students, it was also found that the students' attitude towards learning improved.

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INTRODUCTION

Stoichiometry is fundamental to understanding Chemistry. Stoichiometry is the study of the mass and molar relationships among the reactants and products in a chemical reaction. It is one of the most important units in any Chemistry class and unfortunately, is often a difficult one for students to master. Without a working knowledge of stoichiometry, students cannot understand and quantitatively evaluate equations.

Since the Stoichiometry Unit is so important in the Chemistry curriculum, I wanted to improve the way it was presented and hopefully procure better results. This unit is presented at the end of the first semester but the knowledge gained from this unit is then used throughout the second semester. In a previous college course entitled, Teaching Through Learning Channels, I had been informed about the different learning styles of individuals. I have always wanted to do more research on this subject and to incorporate the findings into my teaching.

Statement of the Problem and Rationale

Each individual has a diverse background of experiences that is exclusively his/her own - a distinct personality, attitude, and learning preference. So, how does a teacher, an individual who is also unique, reach all in a group of students with diverse backgrounds and learning styles?

Many studies (reviewed later in this document) have been done on the different learning styles of individuals. This study recognizes four major learning styles: visual, auditory, kinesthetic, and tactile. Many times it is difficult to discriminate between kinesthetic and tactile. Some references characterize the two learning styles as one. This study will define visual learners as those who prefer visual aides, such as pictures and diagrams as well as reading and note taking, as their primary learning preference. Auditory learners are those who prefer to listen while comprehending a new topic. Auditory learners will often just listen to a lecture and not take any notes until a later time. Kinesthetic learners want to actively participate in their learning through activities and practice problems. Tactile learners prefer hands-on laboratory activities. One resource (Bezos, 1996), which acknowledged three major learning styles - visual, auditory, and kinesthetic - recognized the general population as being composed of the following: 65% visual, 30% auditory, and 5% kinesthetic.

I wanted to know the composition of learning-style preferences in a typical Chemistry classroom. And, once finding this information, I wanted to teach using techniques that would incorporate all styles. I revised the Stoichiometry Unit because students have found it to be difficult in the past. I also felt that it needed more of a variety of activities to help reinforce the concepts being taught.

Demographics of the Classroom

The students in this study come from a county containing 80,669 people and a city of 40,210. Most of the people (96%) in this area are Caucasian. The remaining 4% are primarily Asian and Pacific Islanders, followed by a smaller portion of

African-Americans, Hispanics, and finally Native-Americans.

The community has a fairly high educational level with approximately 31% having some college training and with 35% holding a bachelor degree or higher. The principal employers in this area are two large chemical companies which require employees with high educational levels.

The poverty level in this city is lower than the state's average (city is 9.5% and the county is 11.1% compared to Michigan's at 13.1%). The per capita income for the city is $19,347 and the county is $15,615 compared to Michigan's $14,154. Based on this information most of the students are coming from an environment that is socioeconomically above average. As is true of any community, there are a few students in the school system who come from families struggling financially. My study contained a variety of students from diverse backgrounds that can vary not only from classroom to classroom but also from year to year. This diversity is a challenge to students and teachers alike.

The high school in this study is composed of 1380 students. It provides both a point-two level and a point-three level Chemistry course. The distinction between the two levels can be observed in the material covered and in the type of student. The point-three level course is faster paced and covers more material. The point-two level Chemistry class has students with a greater range of academic ability and social maturity. There are some very capable students who have a high interest in the sciences, while others mainly take the class to fulfill a science requirement or because it looks good on a college application. And, there are several students who take the class to be with their friends or to please their parents. In the beginning of each school year, I ask each student in the point-two level class to fill out an informal survey. One of the questions on this survey is, "Why are you taking this class?" Some of the responses are very interesting. For example, a few students responded that they took the class:

*"To help me with my future job choice."
*"Because I think Science is important."
*"Because I will need it later in life."

Then, there are others who responded:

*"Because I was told to."
*"Parents are making me."
*"Everyone else did."

Based on these reasons, one can see that there is quite a diverse selection of students in the point-two level classroom. This makes the classroom both intriguing and challenging.

I selected two of my classes, both at the point-two level, for this study. I chose to evaluate the fourth and sixth hour classes because two years ago I taught the same type of class during those two hours. I was attempting to eliminate one of the potential variables, time of day that the class was taught, since I have found that this often can make a difference, especially on test scores.

I sent home a permission slip, with the students, for their parents to sign giving me permission to use their students' scores in my study (Appendix B1). Not all of my students returned them. In my fourth hour, which had 23 students by the end of the six-week marking period, 17 forms were returned. While in my sixth hour class, 18 out of 25 forms were returned. I had a total of 35 students whose scores could be analyzed for this study. At semester break I lost one student due to a schedule change. As a result, the pretest/post-test comparison will have a sample size of 34 students instead of 35.

The study sample can be further analyzed to show that it was fairly equal in its gender distribution. Its gender distribution was 54.3% female and 45.7% male. Its ethnic make-up was mostly Caucasian (94.2%) with a smaller percentage of African-American origin (2.9%) and Asian origin (2.9%).

Literature Review : Learning Styles and Chemistry

If a person can be taught through materials and activities related to his/her main learning style, it is purported that person will ultimately learn more and perform better on tests. Research demonstrates that both low and average achievers earn higher scores on standardized achievement tests and attitude tests when taught through their learning style preferences (Dunn, 1996). Since the average classroom is such a diverse group of individuals, it is important that an instructor use a variety of teaching techniques that address each learning preference. As instructors, we need to change our focus to look at how we could combine the different teaching methods to effectively reach all students (Fairhurst and Fairhurst, 1995).

It is not easy to instruct outside of one's own learning style. Students tend to learn best from teachers who are the same type of learner as themselves (Fairhurst and Fairhurst, 1995). This is because most teachers will teach using the learning style they are most comfortable with and prefer. Teachers must learn to use a variety of techniques if they want to become more effective in the classroom.

First, teachers must recognize that students are individuals who will react differently to different stimuli. Individuals vary in their aptitudes for learning, willingness to learn, and the learning style(s) they choose to use while learning (Jonassen and Grabowski, 1993). Even though most instructors recognize these differences in students, they do not always know how or are not willing to change the way they teach. However, it is possible and desirable to adapt the nature of instruction to accommodate differences in ability, style, or preferences among individuals to improve learning outcomes (Jonassen and Grabowski, 1993).

This does not mean that a teacher must totally revise his/her teaching methods. Most learning theories focus primarily on the student's learning process without taking into account the needs and skills of the teacher (Fairhurst and Fairhurst,1995). It is unnecessary and impossible for a teacher to change his/her teaching techniques completely to fulfill every student's needs. It may not be appropriate to always accommodate learners' preferences or weaknesses, but rather to challenge the learner to learn using methods that are not preferred by that learner (Jonassen and Grabowski, 1993). A teacher should utilize a variety of techniques when teaching a difficult concept to ensure the different learning preferences of the individual students are addressed. It is also important that the students are exposed to teaching techniques relevant to learning styles they do not always prefer so that they may expand their capabilities. Teachers can provide positive reinforcement to a student's own learning style by adding a few carefully chosen activities (Fairhurst and Fairhurst, 1995).

My Stoichiometry Unit was designed to provide a better learning environment for all the students. Often teachers become complacent in their teaching style, using exclusively, the methods that they find most comfortable. The goal of this unit was to use a variety of teaching strategies in the Stoichiometry Unit, yet at the same time not to overwhelm the instructor with too many "new" ideas and techniques. Stoichiometry is often one of the toughest and most important unit for students. That is why I chose this unit to revise and hopefully, successfully incorporate, into the curriculum.

Comparison of Old Versus New

Stoichiometry is a standard topic in secondary chemistry classes. When revising the Stoichiometry Unit, I did not change the goals for the unit (Appendix B2). But, I think it is important to revise and incorporate new instructional techniques to prevent teaching stagnation and to maintain both instructor and student motivation and interest. By using different activities and teaching techniques, to incorporate the different learning styles of the students, they should be more motivated to learn. During each new school year, I try to incorporate fresh ideas and often find some to be successful while others are not. The successful ones are used again while the ineffective ideas are either revised or discarded.

The general procedure for teaching the unit in the former curriculum was to present the material through lecture, some demonstrations, and a few laboratory activities. The new, revised unit introduced a Hyperstudio computer program, entitled Polyatomic Ion Hyperstudio Program, designed by me to help students in the mundane, yet necessary, memorizing section of the unit. Hyperstudio is a computer program that can be used to enhance the presentation of material, by incorporating sound, graphics, and animation onto colored cards (slides). The new unit used less lecture and more student-focused projects and activities. It also incorporated many new laboratory exercises developed by me at Michigan State University.

I tried to focus on maximizing the success of the students by appealing to their individual learning styles. This was done in several different ways. First, new concepts were introduced at a level students could comprehend and master before moving on to a more difficult level. This step-by-step technique, which works with all learning styles, promotes student confidence and encourages students to feel capable of moving to the next level, thus increasing motivation.

> Success is one of the most essential motivator's for students in the classroom. It is very important for the instructor to have the first learning task on a level that everyone can reach and accomplish without failure (Hashway and Duke, 1992).

Another situation where student success was targeted was difficult problem solving. The best way to plan for success is to break the learning into smaller segments where all students can learn them (Hashway and Duke, 1992). Presentation of the material in smaller pieces will minimize cognitive load (Krieger, 1997). When tackling quantitative stoichiometry problems that involve three steps, the problems were broken down to these three steps instead of just one long and often confusing step. Students, especially those who are visual learners, benefit from this procedure.

Stoichiometry lectures were given for shorter periods of time and were used as a supplement, rather than the primary source for teaching a difficult concept. Short lectures, which included overhead visual aides, were often given for prelab purposes and the presentation of difficult concepts. This type of lecture benefits both the auditory and the visual learners. Provided that lecture is not used exclusively, it can be a valuable tool in the hands of a teacher who enjoys it (Fairhurst and Fairhurst, 1995).

New strategies were used to help students process information from short-term memory into long-term memory. These procedures included: 60-second power writes, a Pivot strategy, and a Type 1 writing. All of the above procedures are methods that help enable the students to transfer knowledge from short-term memory to long-term memory (Collins, 1992 and Elkins, 1997). All students, regardless of their learning-style preference(s), benefit from these procedures. Each procedure is defined and described in the Implementation section of this paper.

Over my eight years of teaching, I have found that it is important to challenge students if they are to learn. Sometimes, there is a fine line between what is too difficult and what is an obstacle that can be overcome. Since every student is a unique individual, the line may be different from person to person.

> A certain amount of challenge is required in order to increase the complexity of cognitive systems, in that if disequilibrium is not experienced, there is no motivation to change. On the other hand, too much challenge can be overwhelming and cause regression. The proper levels of support are also required; too little support can render the challenge overwhelming, while too much can make cognitive change unnecessary (Barrow, 1986).

In my experience, the Stoichiometry Unit definitely challenges the student to learn. Many students find the memorization of the polyatomic ions to be a tiresome task, yet it is necessary in the writing and naming of chemical formulas. Students often have difficulties in the mathematical calculations used in this unit, especially in the mastering of unit analysis. Unit analysis is a procedure used to convert mass of a reactant, for example, to the mass of a product in a particular chemical reaction. The point-two level students have a difficult time with memorizing and with concepts involving mathematical procedures.

IMPLEMENTATION OF THE UNIT

Pre-unit Preparation and Hyperstudio Program

The Stoichiometry Unit, in the curriculum, unofficially started when an informal prequiz was given to the students. I asked the students to write the formulas for the following ions: nitrate, carbonate, and sulfate. No one could successfully write these formulas. Following this, I gave the students the full list of polyatomic ions required for the unit (Appendix B3). This was done early, two weeks before the actual start of the unit, so that the students could get a good start on memorizing these formulas - a tedious task for some students, but a necessary one for the upcoming unit.

The polyatomic ions were presented in a color-coded fashion. Ions with a negative-one charge were written in red, negative-two ions in green, negative-three in blue, and the positive-one ions in purple. This was done because many of the students are visual learners and color coding the cards facilitates the memorization of the material.

The next day we were able to work on the Hyperstudio Polyatomic Ion Program, that I created, in the computer laboratory. I designed the program in three parts to help my students memorize the polyatomic ions and their charges (Appendix B3). Like the individual flash cards, each polyatomic ion on the computer was color coded. Sound and many mnemonic devices were featured in the program to aid in the memorization process.

The program starts by presenting the polyatomic ions on separate cards grouped by similar charges. The student may then proceed to a particular group and by clicking on the ion name card he wants to learn, he can hear its name and see its formula (Appendix D1). This first part of the program used auditory, visual, and kinesthetic teaching styles to present the information.

The second part of the program used a mnemonic device stack to uniquely present the ions with each card containing a "trick" to enhance memorization of the ion nomenclature and formula. This part of the program was very visual, auditory, tactile, and of course kinesthetic with cards containing pictorial, motion-incorporated, and auditory clues (Appendix D2).

The third part of the program included two quizzes in which the students could receive immediate feedback. Again, different learning styles were addressed. Each time, after a student answered a quiz question, a short portion of music played, indicating whether or not the answer was correct. Then, at the very end of the quiz, a student could get a visual read-out of his final results (Appendix D3).

The next few days were spent finishing the previous unit with a parallel effort by the students to keep studying the ion flash cards, they had made, at home. The next week, my class reviewed the polyatomic ions using the computer program that I had designed and then took a quiz on their ability to recognize the polyatomic ions (Appendix E2). This quiz is discussed later in this section and again in the Evaluation section.

General Outline of Unit

A general outline of the unit depicting when major concepts were taught, quizzes and tests given, and new laboratory procedures and new activities were done is outlined in Table 1 on the following page. A complete outline of the unit, including activities, can be found in Appendix A.

Learning Style Survey

A learning style survey was given to the classes at the beginning of the unit and evaluated (Appendix C1). Most of the students were aware of different learning styles and most agreed with their own results of the survey.

Most of my students favored one learning style over another, but there were a few who appeared to have a balance between two and sometimes even three learning styles. The learning style inventory that I used was a very brief and easy-to-interpret survey. My goal was not to determine each individual's exact learning preference but rather to show the class that they vary in their learning-style preferences. It also helped me to determine what type of activities would be more beneficial to my particular students.

Pretest, Post-test, Quizzes, and Tests

A pretest was given before the unit actually began (Appendix E1). The pretest was composed of a general overview of the Stoichiometry Unit. It was used to determine student background knowledge. The pretest's first section provided chemical formulas and asked for the name of the compounds. The second section provided the chemicals' names and asked for the formulas. The third section was a short answer section including questions on Mass-Mass Stoichiometry and identifying different chemical reaction types.

The pretest was given as a post-test, long enough after

Table 1 - Weekly Outline of the Stoichiometry Unit

	New Activities	Major Concepts
Week One	-Pretest -Learning Style Survey -Ion Quiz 2 (Compounds) -Pivot Activity -Chemistry Name Game -Oreo[R] Cookie Lab	-Naming and Writing Formulas -Mass Percent Composition
Week Two	-Empirical Formula Lab -Test 1 -Smore Lab	-Determining Empirical and Molecular Formulas
Week Three	-Chemical Reactions Lab	-Mole to Gram Conversions -Chemical Reaction Types -Balancing Equations -Mole to Mole Conversions
Week Four	-A Mole? Lab -Internet Computer Lab -Double Displacement Lab -Test 2 -Lab Survey	-Mass to Mass Stoichiometry

the pretest (six weeks), so that most of the students did not even recognize it. The Stoichiometry Unit, which took four weeks of class time, unfortunately actually encompassed a six-week period because of Christmas break.

Two polyatomic ion quizzes were given and evaluated during the unit. The first one (Appendix E2), mentioned earlier in the Hyperstudio section, was right after the implementation of the Polyatomic Ion Hyperstudio Program. The second quiz, which actually included the writing and naming of compounds which contained polyatomic ions, was given during the first week of the unit (Appendix E3). The results from both quizzes are discussed in the Evaluation section.

Two tests were given during the unit (Appendix E4). Both tests were almost identical to the two tests given in the former unit (1995-96). Because of this similarity a comparison, of the tests' scores was made, between the two years and is documented in the evaluation section of this paper.

Laboratory Exercises

All of the following laboratory exercises were new to the unit except for one, the Empirical Formula Lab, which was revised.

1) The Oreo® Cookie Lab was designed to provide an engaging and practical application of percent composition data (Appendix F1). The students were required to design their own laboratory procedure and to prepare a formal laboratory write-up which included an introduction, procedure, data sample, conclusion, and sources of experimental error. The students

could easily understand and apply what they had learned in the classroom. There was also the extra bonus of being able to eat the cookie after the data were collected.

2) The Empirical Formula Lab was a revised laboratory activity (Appendix F2). This laboratory activity was designed to provide practice for the calculations one must use to determine an empirical formula of a compound, using data collected in a laboratory environment.

3) The Smore Lab was used to introduce a new concept to the students instead of reinforcing a concept previously taught in the classroom (Appendix F3). It introduced the concept of Mass-Mass Stoichiometry using a familiar item - a smore. In case the smore is unknown to you, it is a graham cracker sandwich with a filling composed of a marshmallow and a chocolate bar. The students had to mass the reactants (graham crackers, chocolate bar, and marshmallow) and the final product (smore). They should have been able to apply the Law of Conservation of Mass at this point. Their data were used to answer Mass-Mass Stoichiometry questions related to smores. They then had to apply the learned knowledge to a "real" chemical reaction.

4) The Chemical Reactions!!! Lab was a series of reactions performed by the students using standard laboratory procedures (Appendix F4). Each student practiced identifying the different types of reactions (double displacement, single displacement, composition, and decomposition). They also practiced writing and balancing general equations.

5) The A Mole? Lab required students to use mole-to-mole stoichiometry in calculations (Appendix F5). This activity was used as a follow-up activity to classroom instruction.

6) The Double Displacement Lab introduced students to the idea of a limiting reagent compared to an excess reagent using a filtering technique (Appendix F6). Once again, they practiced Mass-Mass Stoichiometry calculations. Like most of the previous laboratory activities, it was designed to reinforce concepts taught in the classroom while giving the students a practical application of the theory.

The above laboratory activities helped to reinforce learning especially for the kinesthetic and tactile learners. All of the laboratory activities included write-ups that were collected by me for a grade. The Oreo® Cookie Lab required a formal write-up to be completed by each student. The other laboratory activities included data tables and questions that the students needed to complete as a substitute for a formal write-up. Student performances on these laboratory exercises are documented in the Evaluation section.

New Classroom Activities and Handouts

A flow chart, which I found on the Internet (Park, 1996), was adapted as a visual aid for learning the nomenclature of different types of compounds (Appendix B4). It was used to supplement a handout, which described how to name chemical compounds, and a lecture which included many examples.

The Chemistry Name Game was used as a tactile and kinesthetic method for learning the names of different ionic compounds (Appendix B5). Each student was given a card with either a metal ion, a polyatomic ion, or a number on it. Each student must silently locate three other students and make a match to form an ionic compound. Once partners were found, they could sit down to name their compound. Following the discussion, they disbanded into groups of two, to practice naming and writing compound formulas on a worksheet.

Memory-Writing Activities Explained

One of the new techniques used to help students transfer short-term memory into long-term memory is referred to as the 60-second power writing (Elkins, 1997). In this type of writing the instructor teaches a lesson, then the students are asked to turn their paper/notebook over and write a summary of what they just learned. They get 60 seconds in which to write all they can remember. This type of writing is a benefit to all types of learners, especially visual learners.

Another type of writing is referred to as a Type I (Collins, 1992). In this writing technique the instructor presents a question or problem that the students are asked to write about. The students must follow certain guidelines set by the teacher. These guidelines are very general and would include a set number of lines the student must write and a time limit in which they have to write. The writing is not judged necessarily on the concept of being right or wrong. This type of writing was used by this instructor to conduct informal surveys and to check for understanding (and misunderstandings) on certain concepts.

One other new technique that should be explained is the Pivot Activity (Elkins, 1997). In this activity the paired students face each other in close proximity. Each student has a question to answer or a process to explain. While the first student is answering (or explaining) their partner must listen. The listening partner may then ask for further explanation or may add to their partner's explanation.

The roles are then reversed as the listening partner becomes the teacher and the other the listener. This procedure benefits all students, especially auditory learners.

Survey of Laboratory Exercises and New Activities

A survey (Appendix C2) was given to the students at the end of the Stoichiometry Unit asking them to evaluate the six laboratory activities and the other new activities used in the unit. Many of the students' comments are used throughout the Evaluation section since their input is valuable and pertinent.

EVALUATION

Learning Style Survey Results

The learning style survey given to my students showed the following results (Figure 1).

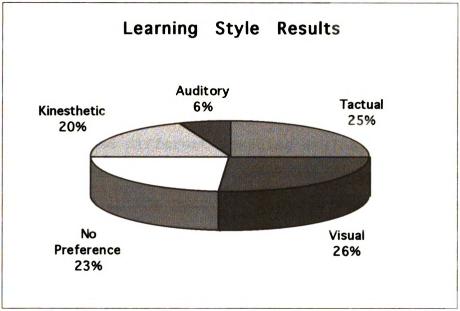

Figure 1 - Learning Style Survey Results

Clearly there was a variety of learning styles possessed by my students. The highest preferences were for tactile and visual learning. The results were anticipated. Many high school students are very active and prefer to learn in a hands-on way, so it is not surprising to find a high number of tactile learners. Most people (65%) in the general population are visual learners (Bezos, 1996), so it is expected to have many of my students preferring a visual method. The lowest preference in my survey was auditory (5.7%) which does not appear to be consistent with the 30% found in the normal population (Bezos, 1996). The percentage of students who did not seem to have a specific preference can be further broken down into the following: 75% of the no preference group included auditory as one of those preferences, 63% included tactile, 63% included kinesthetic, and 63% included visual as one of those preferences. I think it is expected for students, if they are interested in the sciences, to be kinesthetic and tactile learners since science tends to be a hands-on-type experience.

With these results, it was important that I as a teacher, use a variety of teaching techniques in order to incorporate all of these different learning styles. To be more effective, I needed to include many more laboratory exercises in the unit than I had in the past. I also needed to include as many visual aides as I could. And, even though auditory learning was a low preference, some students still preferred that method of learning and so it was important to include a few auditory activities.

Pretest and Post-test Comparison

The results from the pretest established that the students knew very little of the content area about to be taught. The mean score for the study group was 16.9% (2.2 points out of 13 points possible). The scores ranged from zero points out of thirteen (0%) up to seven points out of thirteen (53.8%).

Subsequently, the same test was given as a post-test to determine improvement. The students definitely showed an improvement from the pretest. The students' mean score was 70.0% (9.1 points out of 13 points possible). The scores ranged from four out of thirteen (30.8%) up to twelve out of thirteen (92.3%).

The students greatly improved (Table 2) in the area of naming and writing compound formulas (questions one through nine on the test). Approximately 50% of the students still had problems writing out an explanation on how to predict the possible mass of a product given the mass of the initial reactants, the reaction, and the chemical formulas (question ten on the test). Since I asked the students to explain the problem-solving procedure in words as opposed to actually solving the problem numerically, many students had a difficult time. Most students easily identified the types of reactions (question eleven). 91.2% of the students could identify at least one of the two reactions. 82.4% of the students correctly identified both reactions. Two separate statistical tests, the Chi Square and a t-test, showed a significant difference in the comparison of the pretest and the post-test data, calculated at the 0.01 level.

Table 2 - Pretest and Post-test Results

student #	Pretest points	Post-test points	Percent improvement
1.	1	5	31
2.	2	11	69
3.	2	9	54
4.	0	4	31
5.	7	12	38
6.	2	5	23
7.	2	8	46
8.	4	10	46
9.	0	9	69
10.	1	5	31
11.	2	10	62
12.	1	8	54
13.	2	9	54
14.	1	7	46
15.	2	10	62
16.	3	11	62
17.	2	8	46
18.	4	9	38
19.	2	9	54
20.	2	12	77
21.	2	10	62
22.	4	12	62
23.	1	7	46
24.	2	7	38
25.	3	10	54
26.	5	11	46
27.	1	9	62
28.	1	12	85
29.	3	11	62
30.	1	10	70
31.	2	11	69
32.	1	4	23
33.	1	11	77
34.	6	12	46

Polyatomic Ion Quiz Comparison

The students were given two quizzes on their knowledge of the polyatomic ions. The first asked the students to identify the polyatomic ions (Appendix E2) and the second asked the students to identify compounds containing polyatomic ions (Appendix E3). Two separate statistical tests (Chi square and t-test) showed no statistical relationship, at the 0.01 level, between the two quizzes. Yet, as one looks at the results, one can see there were fewer failing grades (Figure 2). This indicates a positive association to the Polyatomic Ion Hyperstudio Program since I required students, who did not receive a C grade or higher on the first quiz, to spend extra time working on the computer program after school. As one can see, by comparing scores on the first quiz to those on the final quiz, the extra time helped improve scores, particularly in the B and C range. The number of failures certainly decreased and the number of scores above average (C grade) therefore increased.

The Polyatomic Ion Hyperstudio Program was designed to envelope all learning styles - visual, kinesthetic, tactile, and auditory. All the students inventoried, by means of a Type I writing and a survey (Appendix C2), made positive comments about the program. A comment by one student summed up the feelings of many with the following, "It was nice to have a change of pace and use the computers." Overall, I was very pleased with the program and how it "spiced" up the classroom by providing a different method of presentation. While using it, I observed that the students stayed on task with great interest. Also, in the writing sample mentioned earlier, 47% of the students noted that they had never even used a Hyperstudio program before.

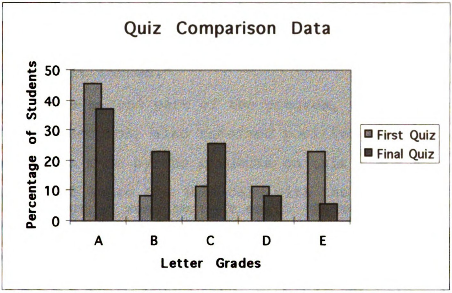

Figure 2 - Comparison Between Quiz One and Two

Laboratory and Classroom Activities

A survey was given to the students asking them to evaluate the classroom activities and laboratory exercises completed in the Stoichiometry Unit (Appendix C2). The survey asked the students what they liked about the activity, what they did not like, suggestions to improve the activity, and finally what they had learned from the activity. Many of their comments will be included in the following section.

According to this survey, the Polyatomic Ion Hyperstudio Program was a success. The students seemed to enjoy it as a new kind of presentation. Many students made positive comments. The first part of the program, the section introducing the ions using auditory and visual cues, received comments stating that the program helped them in the pronunciation of the ions. Other comments included:

*"I thought it was a very cool program and I would put it on my computer."
*"I think it really helped me to understand what we have been studying in class."
*"I think it's fun and it's a different way of memorizing hard formulas."
*"It rocked."

The second part of the program, which was the mnemonic device section, also received positive feedback. Some comments made by the students on this stack included:

*"I liked the joke card with the cat. It was corny, but it was the best card. It made me remember the ion."
*"It did help me get ideas for little ways to remember things and it will definitely help me memorize."

The third part of the program, the quiz section, even received positive reviews. Some student comments included:

*"I liked the fact that there's a quiz at the end so you can see how much you've learned while using the program."
*"I think the program was pretty cool, especially with the music and everything. It was like using flash cards and it was cool how you could tell you got the answer right when the music would play."

The comments were all positive and the program allowed all of the students to interact in such a way that they enjoyed learning.

For another computer experience, I used computers in the library to introduce all of my students to various web sites on the Internet related to Chemistry. My students enjoyed the experience despite system difficulties and lengthy log-on times. Some of their comments included:

*"It helped me review stoichiometry."
*"It was a new and out of the ordinary method of teaching stoichiometry."
*"We should do this more often."

Most of the students enjoyed visiting the different web sites, which benefited the visual, kinesthetic, and tactile learners.

The Chemistry Name Game, which targeted the kinesthetic and tactile learner, was a fun and alternative endeavor for most students. Some comments included: "It was a better way to learn than a lecture" and "It helped me figure out how to write a compound." My favorite comment, "It got the whole class actively involved," showed that it definitely was a good activity. It is often very difficult to find an activity in which all students are involved. This activity forced everyone to get up, move around, and actively participate.

The Pivot Activity was a great way for students to determine for themselves how well they really understood the material they were to explain. It provided auditory and kinesthetic learners a chance to use their preferred learning methods. Some student comments to this effect were:

*"It was a good way to see if you understood it."
*"We got to teach each other one-on-one."
*"It's easier for me to learn through my peers, so it helped."

Some other positive aspects to this style of learning is that it helps shyer students speak out. One student commented, "I think I learned to not be afraid to speak up and answer or ask a question," and another student said, "It gave me a chance to talk to one of my peers and show them what I knew."

The Oreo® Cookie Lab was one of the students' favorites. It was an easy, yet important, exercise that reinforced the concept of percent composition of a substance. The students liked it because it was easy to understand and very open-ended. Some of their comments included:

*"It was fun to be able to relate the lab to (one's) own life."
*"We got to have fun while working."
*"Since we made up the procedures it was easier and I knew what I was doing. It was probably the best lab we did all year."

The results of the laboratory exercise were quite good, mostly A grades and B grades with a small percentage of failures (Figure 3). The failures resulted mainly from students not handing the exercise in. Everyone who did hand in a laboratory write-up did a very nice job and seemed to enjoy it.

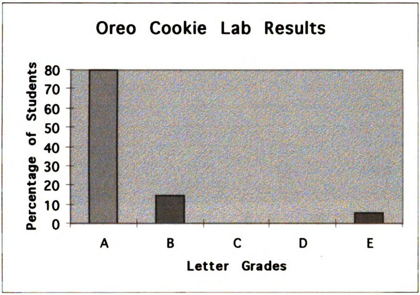

Figure 3 - Oreo[R] Cookie Laboratory Results

The laboratory activity, the <u>Empirical Formula Lab</u> was a revised exercise from the former unit. I kept it because it was a good laboratory exercise for practicing the steps to determine a formula from collected data. The students did not find it particularly exciting but did agree it was a worthwhile laboratory activity. Many agreed it helped them to learn how to calculate formulas and also gave them practice in writing a chemical equation. One comment summing this up by a student was, "I learned how to write formulas."

The results of this laboratory exercise are very similar to the previous laboratory exercise (Figure 4). Those students who took the time to finish the activity did a very nice job but again, there were a few who failed to complete the assignment.

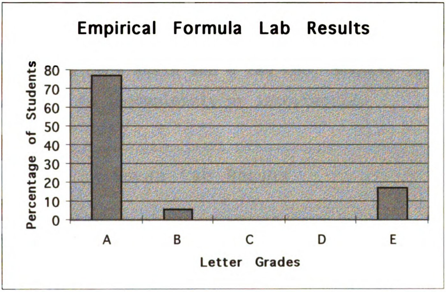

Figure 4 - Empirical Formula Laboratory Results

The Smore Lab, another tasty laboratory exercise, was used as an introductory activity instead of the typical reinforcement-type exercise. It helped students to understand the concept of Mass-Mass Stoichiometry. Some students proclaimed, "It helped me in mass-mass problems." The timing of this laboratory activity, right before Christmas, was great. The informality of the laboratory activity lent itself to the season. A student commented, "It was a good one to do before break and it was also very tasty." Some of the students did not like the fact that it was used as an introduction and felt I should have lectured on the topic beforehand. However, I believe the students need to be more responsible for their learning and it was a good way to introduce the topic. The laboratory exercise showed a practical analogy to Mass-Mass Stoichiometry and was fairly straight forward.

The results showed that most of the students did a wonderful job, receiving an A grade (Figure 5). However, there were a few students who did not even hand in the exercise once again and a few who, despite turning the project in, did so incompletely or incorrectly.

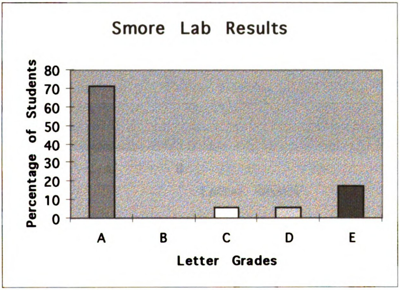

Figure 5 - Smore Laboratory Results

The Chemical Reactions!!!Lab was an excellent activity to illustrate a variety of different chemical reactions. Many students enjoyed the variety of techniques used in this exercise. One student commented, "I liked watching all the different reactions and I liked the opportunity of doing this lab." The students once again did a nice job on this laboratory activity as shown in the results (Figure 6). The results did show a wider scattering of grades than the previous laboratory exercises. I believe this was due to the fact that the students had to write out chemical reactions, a difficult task to learn and one where small mistakes are often easily made.

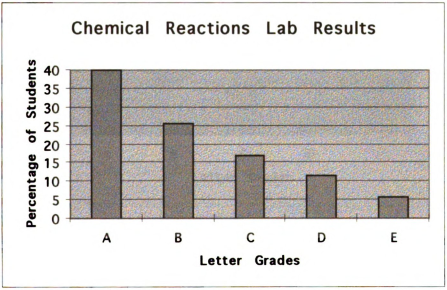

Figure 6 - Chemical Reactions Laboratory Results

The laboratory exercise entitled, A Mole? Lab, was another successful laboratory exercise. Many students liked the bubbling reaction. Comments to this effect included, "I liked the reactions that occurred" and "I really liked seeing how the sodium bicarbonate and hydrochloric acid reacted. It was pretty interesting to watch."

This exercise, which incorporated mole-to-mole stoichiometry calculations was difficult for some students because of the mathematics involved. The results of the laboratory exercise showed a smaller percentage of A grades. Yet, the number of passing grades on this exercise were still fairly high while the number of failing grades were low (Figure 7).

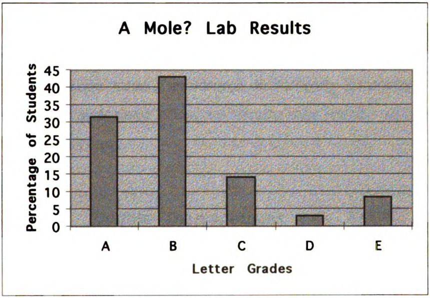

Figure 7 - A Mole? Laboratory Results

The last laboratory exercise , the Double Displacement Lab, proved to be a "great way to teach stoichiometry," according to one of my students. The laboratory exercise seemed to be extremely interesting to the students as one summed it up by saying, "The reaction made a cool looking substance." Another student said, "It helped me to comprehend stoichiometry and percent error." Another one commented, "I learned that aqueous substances go through filter paper and the "water" can still be clear while containing something that's dissolved." I thought this was an interesting observation since I often forget some concepts that seem to be obvious to me are not always that apparent to the student.

The results, for this exercise, were not recorded as a letter grade but rather as either excellent, satisfactory, or unsatisfactory (Figure 8). As one can see from the results, the highest percentage was under the category of excellent. Unfortunately, the percentage of unsatisfactory was higher than desired. This lower percentage can be explained by a next-day test and an end-of-the-marking period deadline. During this time, students have many projects due in other classes and need time to study for their upcoming examinations.

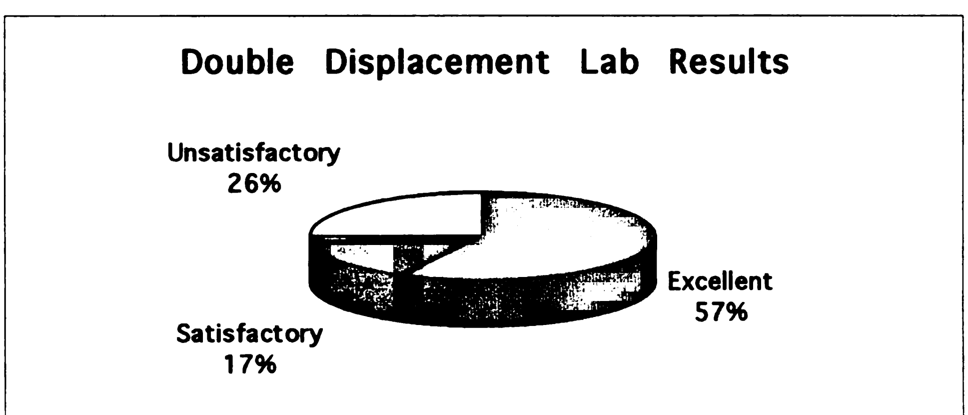

Figure 8 - Double Displacement Laboratory Results

Comparison of Test and Unit Results to Those of Two Years Ago

Since I taught the same class two years ago (point-two Chemistry) during the same hours, I thought it would be interesting to compare the results between the two years, since the tests were almost identical. It is difficult to do a scientific study using students as subjects as it is not possible to control all of the variables. Students vary from year to year and so the classroom environment and makeup does too.

In the past, including two years ago, I taught the unit using more lecture and less hands-on activities. I was not aware of the literature about learning styles and how to teach using different methods to accommodate those learning styles.

Since the unit is always interrupted by Christmas break, there were actually two tests given. Plus, it is such a long unit that I like to divide the unit into smaller sections. When looking at the data for Test 1 (Table 3), one can see that the mean score for the new unit was higher (79%) than the mean score for the previous, former unit (72%). These results were very pleasing since the students had to take the test two days before Christmas break and they were excited and ready to leave for vacation. Two statistical tests were done (Chi square and t-test) to see if there was a significant difference in the data, at the 0.01 level, comparing the two years, but no significant relationship was found. By looking at the percentage results (Figure 9) one can see there was an improvement in grades. There was a higher percentage of students with A grades and a lower percentage with failing grades in the new unit.

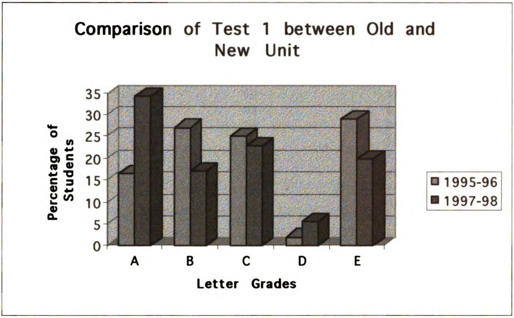

Figure 9 - Test 1 Comparison Using Letter Grades

Table 3 - Percentage Test Scores Comparing Old to New Unit

# of students	Test 1(95-96)	Test 1(97-98)	Test 2(95-96)	Test 2(97-98)
1.	73	64	54	54
2.	75	91	81	96
3.	77	85	79	96
4.	79	97	60	92
5.	88	36	90	40
6.	86	88	92	71
7.	71	94	77	83
8.	36	103	96	88
9.	55	82	75	83
10.	84	52	56	54
11.	84	103	77	105
12.	25	88	10	88
13.	82	76	90	71
14.	79	91	100	104
15.	91	55	100	29
16.	46	70	48	63
17.	80	100	96	105
18.	32	61	54	50
19.	96	79	98	96
20.	98	76	77	46
21.	48	79	42	40
22.	91	97	100	96
23.	102	55	79	21
24.	80	55	75	67
25.	50	76	38	92
26.	38	82	31	46
27.	100	42	92	38
28.	79	100	46	105
29.	89	91	71	105
30.	88	79	83	75
31.	86	42	88	42
32.	70	106	98	100
33.	66	97	10	83
34.	98	76	100	40
35.	54	82	29	75
36.	59		65	
37.	0		0	
38.	70		79	
39.	59		58	
40.	89		92	
41.	86		81	
42.	57		29	
43.	79		96	
44.	88		94	
45.	71		79	
46.	57		15	
47.	96		67	
48.	75		38	
	Mean %	Mean %	Mean %	Mean %
	72	79	68	73

In 1995-1996 we had a shorter Christmas vacation than in 1997-1998, with three weeks between Christmas break and final exams, rather than the two weeks between Christmas break and final exams when I taught the new unit. As a result, the new unit was significantly condensed. The students did well considering the time constraints and the fact that they wanted and needed to start preparing for their exams. By looking at the percent scores for Test 2 (Table 3), one can see that the mean score for the new unit (73%) was better than the mean score for the previous, former unit (68%). At the 0.01 level, two statistical tests were done (Chi square and t-test) to see if there was a significant difference in the comparison of the two years' data and no significant relationship was found. When looking at the percentage results one can see there was some improvement from two years ago to this year (Figure 10). In the new unit, their was a higher percentage of students with A and B letter grades, than in the older unit.

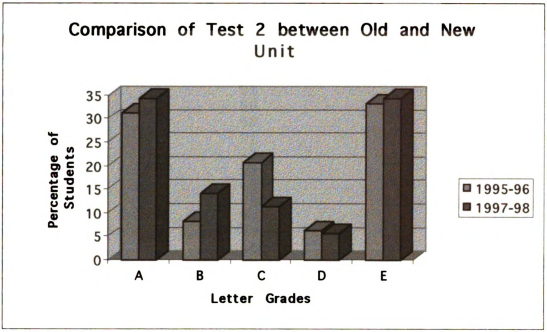

Figure 10 - Test 2 Comparison Using Letter Grades

The final comparison was between the entire unit grades from the new-unit version (1997-98) and the former-unit version (1995-96). The data were checked at the 0.01 level, using two statistical tests (Chi square and t-test). The statistical tests did not show a statistically significant improvement when comparing the data for the two units.

A comparison of the mean scores for the two years (Table 4) shows that students in the new unit did score 9% higher. In addition, Figure 11 shows that in the new unit, there was a higher percentage of students with A grades, a high percentage of B grades, and a lower percentage of failing grades, when compared to those of the older unit.

Table 4 - Unit Grades Comparing Old to New Unit

# of students	Unit % grades 1995-96	Unit % grades 1997-98
1.	74	70
2.	63	91
3.	81	80
4.	80	100
5.	89	58
6.	91	78
7.	77	87
8.	69	98
9.	69	86
10.	68	53
11.	72	105
12.	17	84
13.	85	91
14.	87	83
15.	71	65
16.	39	82
17.	85	106
18.	58	65
19.	96	91
20.	76	71
21.	38	71
22.	96	102
23.	89	46
24.	80	84
25.	63	94
26.	54	70
27.	92	62
28.	63	100
29.	86	92
30.	85	84
31.	89	63
32.	81	84
33.	55	79
34.	100	79
35.	52	85
36.	52	
37.	9	
38.	71	
39.	75	
40.	92	
41.	84	
42.	58	
43.	87	
44.	84	
45.	70	
46.	39	
47.	87	
48.	74	
	Mean % 1995-96	**Mean % 1997-98**
	72	81

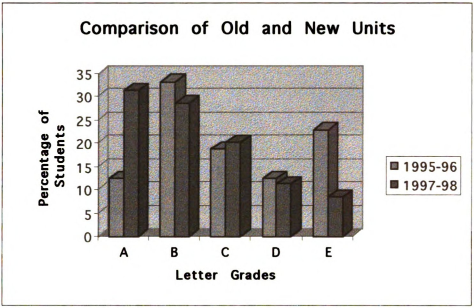

Figure 11 - Unit Comparison Using Percent Grades

Arranging the grade data by year (Figure 12) shows that the new unit certainly had a larger percentage of students with A grades compared to the other grades. Each letter grade, following the A grades, reveals a decline in number, with the smallest allotment in the failure category. These are excellent results. Overall, it shows more students excelled in the new unit. And, it also showed the gradual regression in scores the former unit did not have.

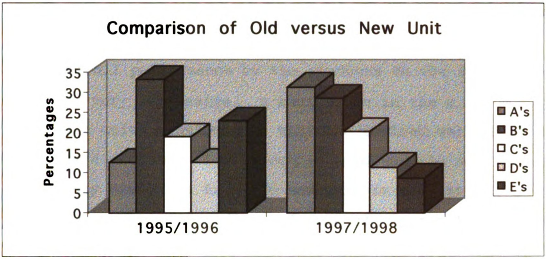

Figure 12 - Unit Comparison Using Percent Grades
Rearranged by Year

CONCLUSION

Overall performance by the students on the Stoichiometry Unit was very impressive. A mean score in the B range, for a difficult unit, convinced me that the revised version of the unit was a success. I will continue to use the activities and laboratory exercises from the new unit in the future.

Years ago, the traditional role of the teacher was to be a source and presenter of knowledge. Now, with advancements in technology and different requirements in the work force, students need to be more self-motivating learners. They must be more active in their roles as learners. At the same time, teachers must assume a greater role as a facilitator of learning. Every student learns in their own unique way. A teacher must be able to accommodate the many different types of learners and, therefore, are required to be flexible and encompassing in their teaching techniques. By providing an assortment of activities relevant to the different learning styles, the teacher will be more likely to reach and inspire each and every student.

The Stoichiometry Unit provided this assortment. It provided auditory stimulation through the use of lecture, the Pivot Activity, classroom discussions, and the Polyatomic Ion Hyperstudio Program. It provided visual prompts through the use of overheads within the lecture, reading and writing assignments, the Polyatomic Ion Hyperstudio Program, written instructions for the laboratory exercises, and worksheets. It also provided kinesthetic activities through the use of the Chemistry Name Game, worksheets with practice problems, and the Polyatomic Ion Hyperstudio Program. And finally, it supplied tactile activities by implementing many laboratory exercises.

All of these practices were beneficial and instrumental to teaching. I plan to use them again next year. In addition, I plan to implement the exercises that I found to be especially successful, such as the Pivot Activity, more often throughout the unit and in other units, too. Time was a restricting factor this past year. I truly believe that the timing for Test 2 (right before final exams) had a major impact on the unfavorable scores. Unfortunately, there is little I can do about the scheduling of examinations. Possibly, with more time within the unit for assimilation activities, the test scores will improve.

Test scores are convenient but not always the best method for evaluating student achievement and understanding. This is why I use many different methods of assessment. These methods include homework assignments, Type-1 and other writing assignments, and of course, laboratory exercises. To accurately reflect input of these activities into student learning, I compared the Units' scores. The New Unit's scores showed good results and significant improvement over the previous version of the unit.

Students are our most valuable asset. They deserve an education that will challenge and motivate them. By incorporating different teaching methods that address different learning styles into the classroom, a teacher can provide an atmosphere conducive to learning. Teachers need to become more aware of the differences in students and learn to accommodate those differences. The new Stoichiometry Unit, which implemented a variety of teaching methods, was a first step in the right direction. I plan to alter other units within the Chemistry curriculum by incorporating a variety of learning-style activities.

We, as teachers, should be positive role-models and motivate students to do their best. That is why it is important for instructors to demonstrate their willingness to incorporate new teaching methods. If we expect our students to be successful in the ever-changing future we need to be able, and willing, to change.

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BIBLIOGRAPHY

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APPENDICES

Appendix A

Daily Outline of Unit

Calendar Date	**Overview of Class**
Monday: 11/24/97	*Prequiz *Students made color-coded flash cards of polyatomic ions
Tuesday: 11/25/97	*40 minutes spent on computer program to help memorize polyatomic ions *Type I writing done as an informal assessment tool
Tuesday: 12/2/97	*40 minutes spent on computer program for polyatomic ions *Quiz over polyatomic ions
Monday: 12/8/97	***Actual beginning of Stoichiometry Unit:** *Pretest given *Oxidation number review *Flow chart on naming *60-second power writing *Learning Style Survey
Tuesday: 12/9/97	*Handouts: Goals of Unit, Packet on "How to Name Compounds", oxidation number worksheet, naming compounds worksheet. *Practice: assigning of oxidation numbers,writing formulas, and naming compounds
Wednesday: 12/10/97	*Hand in homework-naming compounds worksheet *Quiz on compounds *Pivot Activity *Name game and worksheet *Handout on % composition and worksheet
Thursday: 12/11/97	*homework check *Name game *Mass % worksheet - went over *Homework: Read/notes on pages 207-208, problems 1-3 pages 209-211, problems 16,17

Appendix A (cont'd)

Friday: 12/12/97	*<u>Oreo^{R} Cookie Lab</u>
Monday: 12/15/97	*Homework problems - went over *Empirical formula notes *Handout worksheet on empirical formulas - class work and homework
Tuesday: 12/16/97	*Students showed and explained their answers to worksheet on the blackboard *Handout Worksheet II for homework *Prelab and Lab - <u>Empirical Formula Lab</u>
Wednesday: 12/17/97	*Finish 12/16 lab by massing dry products *Work on lab in class *Review for test
Thursday: 12/18/97	*Test *Homework: read/notes on pages 238-251, problems 7A: 1,2 section review problems: 8,10,11,13
Friday: 12/19/97	*<u>Smore Lab</u> introducing Stoichiometry problems
***Christmas Break**	
Monday: 1/5/98	*Handout goals for second half of the unit *Hand back and go over test 1 *Review naming rules *Assign problems over formula weights, determine molar mass, and conversions from grams to moles and vice versa *Hand back and go over labs
Tuesday: 1/6/98	*Notes on types of reactions *Practice sheet on balancing and determining types of reactions *Prelab

Appendix A (cont'd).

Wednesday: 1/7/98	*Quiz *<u>Chemical Reactions Lab</u>
Thursday: 1/8/98	*Mole city handout *Practice conversions of moles to grams and vice versa *Mole to Mole problems introduced
Friday: 1/9/98	*Hand back quiz/answer questions *Hand back lab/answer questions *Go over homework on balancing *Prelab
Monday: 1/12/98	*<u>A Mole? Lab</u> (HCl and $NaHCO_3$)
Tuesday: 1/13/98	*Internet Computer Lab - practice stoichiometry
Wednesday: 1/14/98	*Prelab and Lab (<u>Double Displacement Lab</u>)
Thursday: 1/15/98	*Finish lab *Review for test
Friday: 1/16/98	*Test 2 *Lab Survey

***Exam Week**

Week of: 1/26-28/98	*Post-test

Appendix B1

Permission Slip

December, 1997

Dear Parents,

Over the past several years I have been working on courses to fulfill the requirements of a Masters of Science degree through Michigan State University. For the next four to five weeks I will be completing my thesis project. In order to accomplish this, I will be asking your child to fill out a survey to find out the type of learning style that he/she prefers. Then, we will be working with many different teaching techniques so that all of the learning styles are incorporated into the classroom. My primary concern will be to provide the best learning environment for all of the students involved.

Through this process I will be using your childrens' course work, grades and comments to formulate conclusions about the success of these teaching styles. Students' names will not be used in the project and will remain confidential.
Please sign below, in the appropriate blank, regarding your feelings on this issue and return via your student to me.

Michigan State University's policy requires me to get your acknowledgement of this process. If you have any questions please feel free to call me or my Science Department Head. I may be reached at Herbert Henry Dow High School (839-2482) or at home (689-4891). Dorothy Horan , Science Department Head, may be reached at Herbert Henry Dow School (839-2482).

Sincerely,

Luann K. Decker
Chemistry Teacher

Student's Name______________________________ Hour________

______________________ Yes, You may use my student's data.

______________________ No, you may not use my student's data.

Appendix B2

Stoichiometry Goals

Part 1: Chemical Formulas

The student should be able to:

1. define and distinguish between the terms empirical formula and molecular formula.

2. determine the mass percentage composition from the formula for a compound.

3. write the chemical formula for ionic and covalent compounds.

4. establish the empirical formula for a compound from:
   a. mass percentage composition data
   b. relative mass data
   c. rules of inorganic nomenclature and valences

5. establish the molecular formula for a compound from empirical formula data and molecular mass data.

Part 2: Chemical Equations--Inorganic Reactions

The student should be able to:

1. understand the quantitative benefits of a chemical formula equation over a word equation

2. write correctly balanced chemical formulas from word equations.

3. identify the following types of reactions from the given equation:
   a.composition b.decomposition
   c.single displacement d.double displacement

4. compute mass-mass problems using the mole method

Appendix B3

Polyatomic Ion List

1+ ion

*ammonium = NH_4^{1+}

1- ions

*acetate = $C_2H_3O_2^{1-}$

*bisulfate = HSO_4^{1}

*bicarbonate = HCO_3^{1-}

(hydrogen carbonate)

*nitrate = NO_3^{1-}

*nitrite = NO_2^{1-}

*hydroxide = OH^{1-}

*permanganate = MnO_4^{1-}

*cyanide = CN^{1-}

HALOGEN GROUPS

*perchlorate = ClO_4^{1-}

*chlorate = ClO_3^{1-}

*chlorite = ClO_2^{1-}

*hypochlorite = ClO^{1-}

*perbromate = BrO_4^{1-}

*bromate = BrO_3^{1-}

*bromite = BrO_2^{1-}

*hypobromite = BrO^{1-}

*perfluorate = FO_4^{1-}

*fluorate = FO_3^{1-}

*fluorite = FO_2^{1-}

*hypofluorite = FO^{1-}

*periodate = IO_4^{1-}

*iodate = IO_3^{1-}

*iodite = IO_2^{1-}

*hypoiodite = IO^{1-}

Appendix B3 (cont'd).

2- ions

*carbonate = CO_3^{2-}

*chromate = CrO_4^{2-}

*dichromate = $Cr_2O_7^{2-}$

*sulfite = SO_3^{2-}

*sulfate = SO_4^{2-}

*oxalate = $C_2O_4^{2-}$

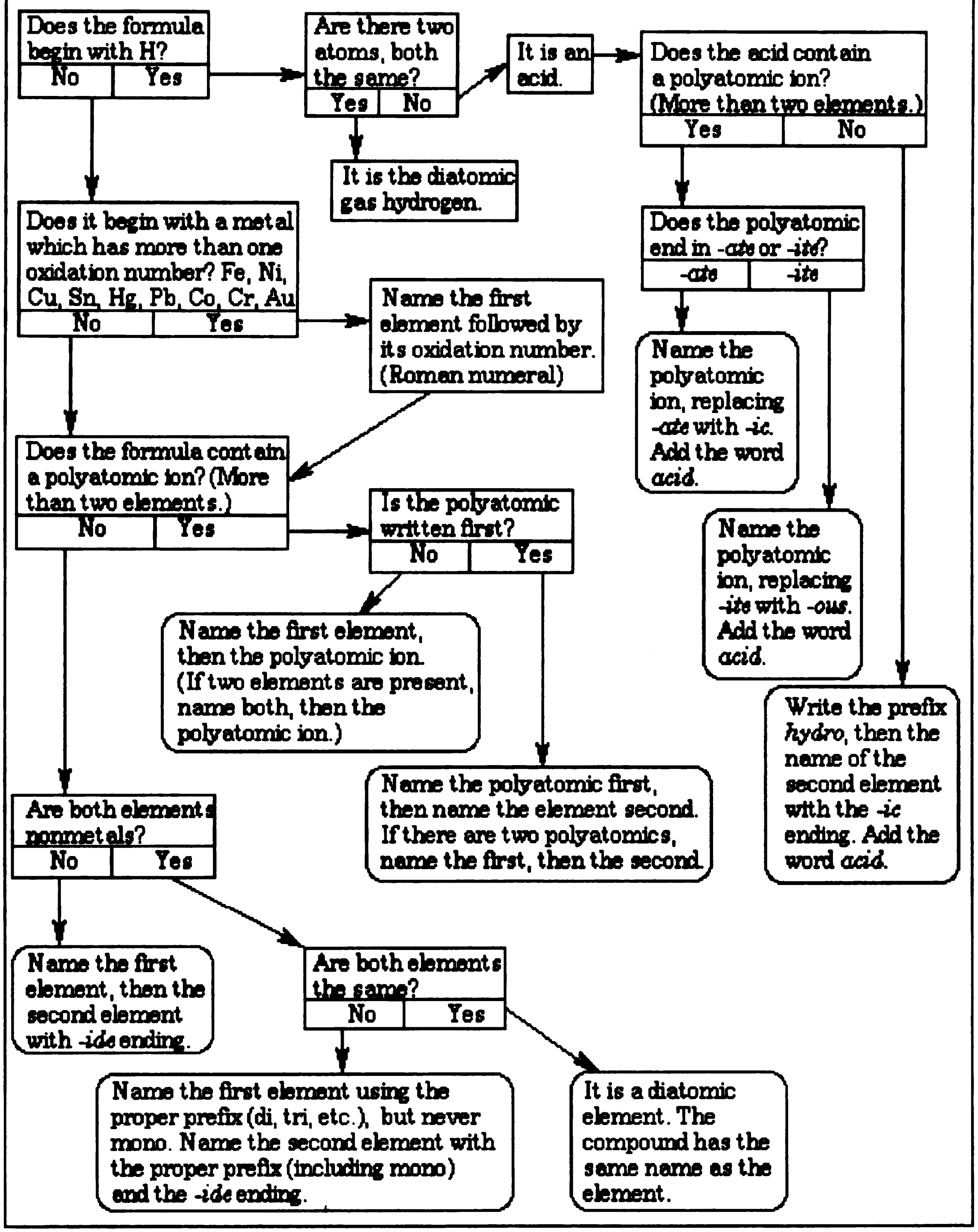
3- ions

*phosphate = PO_4^{3-}

*phosphite = PO_3^{3-}

Flow Chart for Naming Simple Inorganic Compounds

The flowchart is adapted from p. 131-132 of the February 1983 issue of the *Journal of Chemical Education*.



Appendix B5

Chemistry Name Game

Objective: Student will demonstrate ability to:

1. Communicate effectively with classmates without talking.
2. Recognize a correct formula for an ionic compound.
3. Write the name of the ionic compound after creating its formula.

Activities:

1. Review rules for naming ionic compounds including the STOCK SYSTEM and polyatomic ions.

2. NAME GAME:

a) Each student will be given a card that contains: either a number (representing a subscript), an anion, or a cation.
b) The students will then leave their seats and begin looking for their "match". Each student will need to find three others so that a complete compound can be formed (an anion followed by a subscript and then a cation followed by a subscript).
c) Once the match is made the four will sit together. No talking is allowed until all four are sitting as a group!
d) Once all of the students are sitting, each group will share its compound's name and formula. The class will vote on whether or not it is a match by showing thumbs up or down. If the vote is thumbs down the class must correct the match.

Assessment:
Informal assessment will take place during the above activity as the teacher observes the students for appropriate learning behavior. The teacher will only interrupt student work if there appears to be severe problems in understanding the activities by several students. Formal assessment will be the correcting of the worksheets collected at the end of the second activity.

Appendix B5 (cont'd).

IONIC COMPOUNDS (working in groups of two)
Name:__________________________ and
____

Complete the following problems as a PAIR CHECK exercise. First student do number one while partner checks. Second student do number two while first student checks, and so on.

Part I:
1. Na_2S________________________________

2. K_2SO_4________________________________

3. LiOH________________________________

4. Rb_2O________________________________

5. $Mg_3(PO_4)_2$________________________________

6. $Al_2(C_2O_4)_3$________________________________

7. SnO_2________________________________

8. $Ca(MnO_4)_2$________________________________

Part II: Identify the ions used and write a formula for each compound given its name.

9. calcium hydroxide______________________________

10. aluminum sulfide______________________________

11. tin (II) sulfate______________________________

12. chromium (VI) oxide___________________________

13. barium iodide_________________________________

14. strontiun nitrate_____________________________

Appendix C1

Learning Style Survey

------- 1. Are you aware of the rhythm of people's names?

------- 2. Do you notice and adjust a picture that is not hung straight?

------- 3. Do you do any crafts, such as knitting, carpentry, cooking, gardening?

------- 4. Do you feel annoyed by crowds in a museum or by people standing in the aisle of the supermarket?

------- 5. Do you play a musical instrument?

------- 6. Do you have a good sense of direction?

------- 7. Do you react strongly to climate?

------- 8. Can you quickly tell what you like most about your shape?

------- 9. Are you proud of your handwriting?

------- 10. Do you respond strongly to color?

------- 11. Can you easily identify a familiar voice on the telephone?

------- 12. Do you have Good spatial sense? For example, could you do a rough sketch of the layout of the building you go to school in?

------- 13. Can you identify a car by the sound of the motor?

------- 14. Do you think noise pollution is as serious as garbage pollution?

------- 15. Can you quickly say what you like least about your shape?

------- 16. Do you find that eye contact is second nature to you when you speak to one or more people?

------- 17. Can you pick out an animal that moves like you?

------- 18. Are you aware of how others speak?

------- 19. Do you enjoy: art, sculpture, graphics, outstanding TV commercials?

------- 20. Do you hate to sit still?

------- 21. Do you like black/white photography or films?

Appendix C1 (cont'd).

------- 22. Do you respond to gesture and touch in everyday life?
------- 23. Are you aware of how others move?
------- 24. Do you like poetry and/or commercial jingles?
------- 25. Do you enjoy dancing?
------- 26. Do you enjoy drawing, painting, sculpting?
------- 27. Do you enjoy doodling?

<u>Communication Modes</u> - <u>Evaluation Guide</u>

A = 1, 5, 11, 13, 14, 18, 24
V= 2, 6, 10, 12, 19, 21, 26
T = 3, 5, 7, 9, 16, 22, 27
K= 4, 8, 15, 17, 20, 23, 25

Appendix C2

Stoichiometry Lab/Activity Survey

For each activity listed below please explain:

A. What you liked about the activity
B. What you didn't like about the activity
C. Ways to improve the activity
D. What you learned from the activity(did it help you?)

1. Oreo[R] Cookie Lab:

A.

B.

C.

D.

2. Smore Lab:

A.

B.

C.

D.

3. Empirical Formula Lab (Zinc chloride lab):

A.

B.

C.

D.

4. Chemical Reactions Lab (Starting with Cu wool):

A.

B.

C.

D.

5. A Mole? Lab (sodium bicarbonate and hydrochloric acid):

A.

B.

C.

D.

Appendix C2 (cont'd).

6. Double Displacement Lab:
    A.

    B.

    C.

    D.

7. Internet Computer Activity:
    A.

    B.

    C.

    D.

8. Polyatomic Ion Hyperstudio Program:
    A.

    B.

    C.

    D.

9. Chemistry Name Game (with cards):
    A.

    B.

    C.

    D.

10. Pivot Activity (turned to a single partner to explain a concept):
    A.

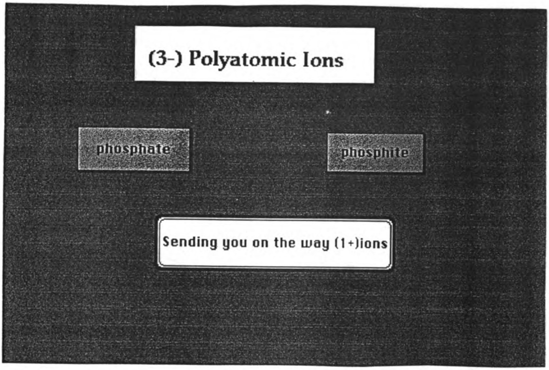
    B.

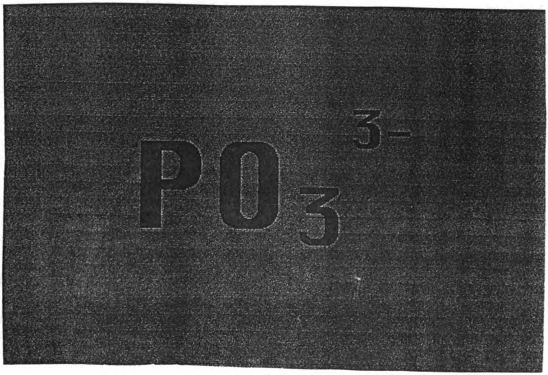
    C.

    D.

Appendix D1

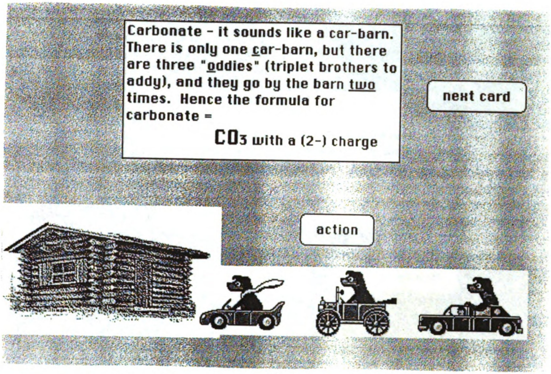
Polyatomic Ion Stack Sample Cards

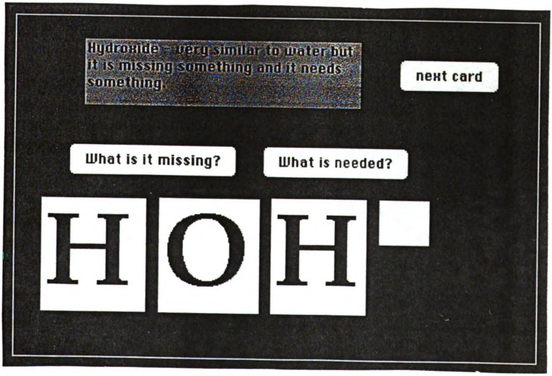




Appendix D2

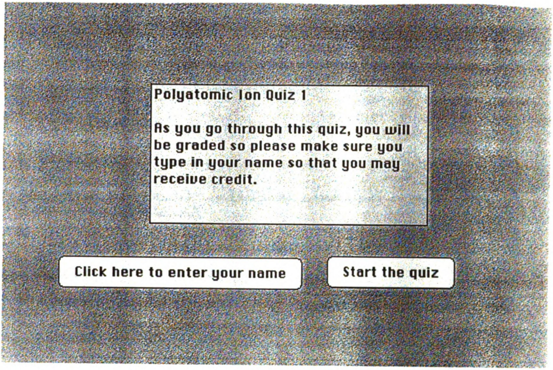
Mnemonic Stack Sample Cards

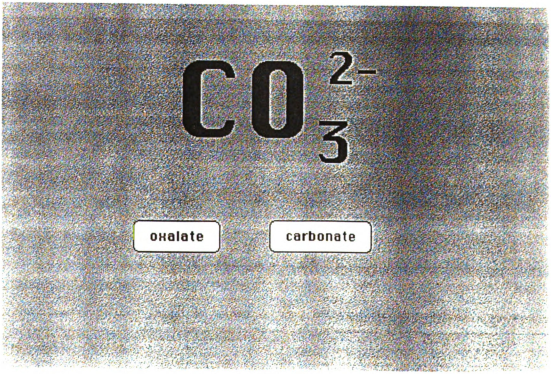




Appendix D3

Quiz Stack Sample Cards





Appendix E1

Pretest and Post-test

Part I: Name the following compounds:

1. $Fe_2(SO_4)_3$ ________________________

2. CO_2 ______________________________

3. $Cu(NO_3)_2$ _________________________

4. NH_4F ____________________________

Part II: Write the formulas for the following compounds:

5. Tin (IV) iodide ________________

6. Mercury (I) fluoride ___________

7. sodium acetate ________________

8. Dinitrogen tetroxide ___________

Part III: Answer the following questions as thoroughly as you can.

9. a) When is a Roman Numeral used in the name of an ionic compound?

   b) What does the Roman Numeral in a name mean?

Appendix E1 (cont'd).

10. Explain (in writing) how you could predict the mass of a product in a chemical reaction, knowing the formulas of all reactants and products involved and knowing the masses of the beginning reactants.

11. What type of chemical reactions are the following:

a. Potassium chlorate ----> potassium chloride + oxygen gas

Type of reaction:______________________

b. copper + oxygen ----> copper (II) oxide

Type of reaction:_____________________

Appendix E2

Polyatomic Ion Quiz 1

Part 1. Matching - Write the correct formula's letter in the blank next to its name.

______1. nitrite	A. HCO_3^{1-}
______2. sulfate	B. SO_3^{2-}
______3. oxalate	C. NO_2^{1-}
______4. bicarbonate	D. ClO_3^{1-}
______5. acetate	E. HSO_4^{1-}
______6. permanganate	F. $C_2H_3O_2^{1-}$
______7. ammonium	G. NH_4^{1+}
______8. carbonate	H. ClO_4^{1-}
______9. chlorate	I. SO_4^{2-}
______10. nitrate	J. NO_3^{1-}
______11. hydroxide	K. CO_3^{2-}
______12. perchlorate	L. $C_2O_4^{2-}$
______13. bisulfate	M. OH^{1-}
______14. sulfite	N. MnO_4^{1-}
______15. phosphate	O. PO_4^{3-}

PART 2: Short answer.

On the computer program, which card:

16. had a donkey (jackass) on it?___________________

17. had a preying mantis on it?____________________

18. on the baseball card, which ion made it to second base?_________________

Types of bonds:

19. What kind of bond forms between sodium and fluorine? ___________________

20. What kind of bond forms between carbon and nitrogen?___________________

Appendix E3

Polyatomic Ion Quiz 2

1. Rubidium Chloride

2. Sulfur (IV) Chloride

3. Nitrogen (IV) Oxide

4. Calcium Sulfite

5. Tin (II) Chloride

6. $Ba(NO_3)_2$

7. HgO

8. K_3PO_4

9. Ni_2S_3

10. Na_2S

Appendix E4

Test 1 and Test 2

Test 1. Part 1. Choose the best answer.

1. What is the mass of 1.0 mole of aluminum phosphate, $AlPO_4$?
   a. 74 g b. 74 kg c. 122 g d. 122kg

2. What is the mass of 1.00 mole of aluminum carbonate, $Al_2(CO_3)_3$?
   a. 234 g b. 279 g c. 138 g d. 210. g

3. The formula for strontium fluoride is SrF_2. The sum of the ionic charges in the formula for the compound is:
   a. 0 b. -2 c. +2 d. none of the above

4. In the compound diantimony pentasulfide, the valence of the antimony is:
   a. 0 b. +7 c. +5 d. +3

5. The simplest formula, $Cu_3(AsO_4)_2$, for copper (II) arsenate can be interpreted as follows:
   a. 4 oxygen atoms b. 2 arsenic atoms
   c. 317.5 g of copper in a mole of this compound
   d. 6 copper ions

6. Among the following ions, the one that has a valence of +1 is: a. hydrogen carbonate b. cuprous
   c. hydroxide d. calcium

7. The symbol of an element stands for one atom of the element. It, in quantitative terms, can also stand for:
   a. one molecule of a diatomic element
   b. 12 grams of the element
   c. one mole of atoms of the element

8. A formula which represents the actual number of atoms found in a molecule of a covalent compound is a(n):
   a. polar dot formula b. molecular formula
   c. empirical formula d. ionic formula

9. In the formula, $Cr_2(SO_4)_3$, the total number of electrons transferred from the chromium atoms to the sulfate ion is: a. 6 b. 2 c. 3 d. 5

10. The formula, $HNO3$, represents all of the following EXCEPT
    a. 1 mole of hydrogen nitrate
    b. 1 gram of the compound
    c. the composition of the compound

Appendix E4 (cont'd).

11. What is the empirical formula for silver fluoride, which is 85% silver?
    a. AgF_2 b. Ag_2F c. AgF d. Ag_3F

12. Which of these compounds contains the highest percentage of nitrogen?
    a. $Ca(NO_3)_2$ b. $Ca(CN)_2$ c. $(NH_4)_2SO_4$

Part 2: Name the following compounds:

1. $Fe_2(SO_4)_3$______________
2. CO_2____________________
3. $Cu(NO_3)_2$______________
4. NH_4F___________________
5. SO_3____________________
6. SnO_________________
7. SnO_2________________
8. Ni_2S_3_______________
9. PCl_3________________
10. $AsCl_5$_______________

Part II: Write the formulas for the following compounds:

11. Tin (IV) iodide ___________

12. Mercury (I) fluoride ___________

13. Dinitrogen tetroxide ___________

14. hydrogen phosphate _____________

15. sodium acetate ________________

16. lithium carbonate _______________

Part 3: Percentage composition, empirical and molecular formulas:

17.a. Determine the mass of 1.00 mole of $Sn(SO_4)_2 \cdot 2H_2O$.

b. Determine the mass percentage of Sn in this compound.

18. Determine the mass percentage of silver in the compound, Ag_2Se.

19. The simplest formula for a compound is SN. Its molecular weight is 184 amu. Determine the molecular formula for this compound.

20. A compound upon analysis gave the composition:
$C = 40\%$, $H = 6.7\%$, $O = 53.3\ \%$.
Its molecular weight is 180.amu. Determine the:

empirical formula ____________

molecular formula ___________

Extra Credit: Design an original mnemonic device to help remember one of the polyatomic ions.

Test 2. Part 1. Balance the following equations and show all set ups to receive full credit.

1. 25.0 g of lead (II) oxide is to be decomposed by heating.

_____PbO ---> _____Pb + _____O_2

(a) How many moles of lead (II) oxide are given?

(b) How many moles of oxygen can be prepared?

(c) How many grams of oxygen can be prepared?

(d) How many moles of lead can be prepared?

2. A quantity of magnesium reacts with hydrochloric acid and produces 0.10 g of hydrogen.

$$\_\_\_\_\_\_Mg + \_\_\_\_\_HCl \longrightarrow \_\_\_\_\_H_2 + \_\_\_\_\_MgCl_2$$

(a) How many moles of hydrogen are produced?

(b) How many moles of HCl are produced?

(c) How many moles of magnesium are required?

(d) How many grams of Mg are required?

3. Potassium hydroxide reacted with 10.0 g of Copper (II) nitrate in water solution.

$$\_\_\_\_KOH + \_\_\_\_\_Cu(NO_3)_2 \longrightarrow \_\_\_\_\_Cu(OH)_2 + KNO_3$$

(a) How many moles of $Cu(NO_3)_2$ react?

(b) How many moles of KOH are required?

(c) How many grams of KOH are required?

4. What mass of copper (II) oxide in grams is formed by oxidizing 1.00 kg of copper?

$$\_\_\_\_\_Cu + \_\_\_\_O_2 \longrightarrow \_\_\_\_\_CuO$$

Appendix E4 (cont'd).

Part 2. For the following reactions - write out the correct formulas, balance the equation, and identify the type of reaction taking place. You must complete 5 out of the 6. If you do all 6, you may earn extra credit.

1. potassium chloride + aluminum hydroxide --->
potassium hydroxide + aluminum chloride

____

Reaction type = ________________

2. sodium chloride + hydrogen sulfate --->
sodium sulfate + hydrogen chloride

____

Reaction type = _______________

3. hydrogen + fluorine ---> hydrogen fluoride

____

Reaction type = _______________

4. potassium chlorate ---> potassium chloride + oxygen

____

Reaction type = ________________

5. aluminum + copper (II) nitrate --->
aluminum nitrate + copper

____

Reaction type = _________________

6. iron (II) sulfide + hydrogen chloride --->
hydrogen sulfide + iron (II) chloride

____

Reaction type = ________________

Appendix F1

Oreo^R Cookie Lab

Percent composition of cream filled cookies.

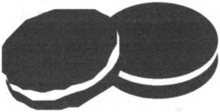
Materials - cream filled cookie
- balance
- milk? (for later)

Procedure - you figure it out :)

Write up must include the following:

- title
- material list
- brief outline of procedure
- calculations with data table which should include % composition of cream and % composition of wafer.
- conclusion

Have fun & enjoy!



Appendix F2

Empirical Formula Lab

Purposes: *To help students obtain a better understanding of the Law of Definite Composition.
*To have experience in synthesizing a compound.
*To determine the empirical (simplest) formula for an ionic compound.

Introduction: The Law of Definite Composition states that compounds have a definite mass proportion. This concept is applied in calculating empirical formulas. In this experiment you will react a given metal with a given acid to produce a compound called a salt and hydrogen gas. The reaction occurs in a water solution with the gas escaping. The salt can be obtained as an ionic solid thru evaporation of the water. You will find the mass of the metal and the mass of the resulting solid. This information will allow you to determine the mass of the element that combines with the metal and the empirical formula of the resulting compound (salt).

Procedure:

1. Wash, rinse, and dry your 150 mL beaker. Mark your drawer number on it with your wax pencil, then determine the beaker's mass (on the digital balance) to the nearest 0.01 g.
   Record. Balance # ________
2. Obtain, using a weigh paper, approximately 1g of Zinc metal from the main supply table using the "large" balance. (Note: the large balance should be preset to about 2 g to approximately account for the mass of the weigh paper which is about 1 g).
3. Add the Zn metal to your beaker. Mass your beaker (on the digital balance) with the zinc metal. Record. Use the same balance you used in step 1.
4. At your lab table, SLOWLY add 15 mL o f 6 M hydrochloric acid, to the beaker and metal.
5. After observing the reaction, and making a note of your observations, place the beaker under the hood on the hot plate provided. Any remaining, unreacted acid and water will be evaporated leaving the other product of the reaction, a salt, in your beaker.

Procedure Day 2:

1. You will find your beaker and salt in the oven indicated by your instructor. Mass your beaker and its contents using the same balance you did yesterday. Record.
2. After recording your mass rinse out your beaker and dissolve the contents with tap water.

Appendix F2 (cont'd).

Data table:

Mass of beaker and metal______g
Mass of beaker ________g
Mass of metal used ________g

Mass of beaker and solid product _______g
Mass of beaker _______g
Mass of salt (product) _______g

Calculations and Conclusions:

The first thing you need to know is what chemical change took place. So, write the chemical equation for the reaction. (Hint: single replacement reaction).

____

1. From the mass of the metal use, calculate the moles of metal used.

_____moles

2. Using subtraction, determine the mass of the second element in your salt product (the metal used being the first element).

_____g

3. Determine the moles of the second element in the salt.

_____moles

4. Now you need to determine a ratio of moles. To do this, look at the moles of metal used (_____ moles of metal) and look at the moles of the second element used (_____moles of second element). Which is smaller?
Now: Take your #moles of metal and **divide** by this "smaller #" = _______
Take your # moles of second element and **divide** by this same "smaller #" = _______

(By doing this you have now determined a ratio of first element to second element in your product the salt. This gives you a formula). Write your experimentally determined formula for the salt.

____

Can this formula be considered a **molecular** formula? ____
why or why not?

What is the stock system name for this compound? ___

Appendix F3

Smore Lab

Background: Using graham crackers, marshmallows, and mini chocolate bars, you will discover the stoichiometry of smores. What is Stoichiometry? Well, it is going to be your job to find out.

Materials: Two graham crackers, one marshmallow, and one mini chocolate bar per person

Procedure: Study the balanced equation below:

2 Gc + 1 M + 1 Cb ----> 1 Smore

Obtain all of the materials needed and <u>mass</u> the reactants and products. Consume your finished product when all of the masses have been recorded in the following data table. YUM.

Mass of 1 graham cracker	__________g
Mass of 2 graham crackers	__________g
Mass of marshmallow	__________g
Mass of chocolate bar	__________g
Mass of Smore	__________g

Use the above balanced equation **AND** your data to answer the following questions:

1. If you add your three individual masses together, do they equal the mass of your product?____Should they?____What law have you just observed?_______________

2. What mass of Gc would be needed to react with 5.0 g of M?

3. What mass of Smores could you make using 15.0 g of Gc and excess M and Cb?

Appendix F3 (cont'd).

By using the masses that you obtained in your data table as "mole masses" you can do the above problems. You just learned Stoichiometry! Stoichiometry is the relationship between the masses and quantities of reactants and products.

PART 2

Examine the following equation and answer the following ?'s

$$2\ H_2 \quad + \quad 1\ O_2 \quad \text{----->} \quad 2\ H_2O$$

1.A. What is the mass of 1 mole of H_2?

B. What is the mass of 1 mole of O_2?

C. What is the mass of 1 mole of H_2O?

(Since we do not have a mole of these sitting in front of you just use your periodic table to figure them out)

2. If you had 2.0 moles of H_2:
   A. how many moles of O_2 would you need?

   B. how many moles of water could you produce (assuming enough O_2 is around)?

3. A. What mass of water could you make using 42.0 g of O_2 and excess H_2?

4.A. What mass of O_2 would you need to react with 22.0 g of H_2?

HAVE A VERY MERRY CHRISTMAS AND A HAPPY NEW YEAR!!!

Appendix F4

Chemical Reactions!!!Lab

Background Information and Purpose: There are many different ways to categorize chemical reactions. If you take a look at your goal sheet you should have noticed that you are required to recognize the following types: composition reactions, decomposition reactions, single replacement reactions and double replacement reactions. This lab will give you some practice in recognizing such reactions and writing such reactions.

Reactions involving chemical changes will produce new and different substances. Most of the chemical changes which will occur in this lab are easily recognized either through a definite color change, a solid forming, or maybe even a gas given off. Or a special substance, known as an indicator may be used so that a change may be noticed.

For each step (each chemical reaction) that occurs you will need to write a balanced chemical equation. The reactants and products will either be apparent or you will be given their names or formulas. Some of the reactions will occur in water solutions and will actually involve ions from the salt, acid, or base that is dissolved in that water, but that knowledge will be explored (in great depth) in a later chapter. For now, just know that if a salt, base, or an acid is dissolved in water it is considered aqueous and its symbol should be followed with this: (aq); a solid should be followed with (s); a gas with a (g); and a pure liquid with a (l).

Materials: test tubes, copper wool, crucible, clay triangle, ring and stand, forceps, 150 mL beaker, 3 M sulfuric acid, funnel, filter paper, 250 mL beaker, 3 M sodium hydroxide, stirring rod, Bunsen burner, iron nail, copper sulfate pentahydrate(s), 0.5 M copper sulfate (aq), NaOH pipette, H_2SO_4 pipette

Procedure:

1a. Make a loose wad of **copper wool** and place it in a crucible. Place the crucible, uncovered, on a clay triangle on an iron ring and heat strongly for a five minutes. The black product is **copper(II) oxide.** The reactants are **copper metal** and **oxygen gas** from the air.

Appendix F4 (cont'd).

1b. Using forceps, place the product from 1a into a 150 mL beaker. Add about 5 mL of dilute **sulfuric acid**(H_2SO_4) and stir the mixture. Set up a funnel(using a second clay triangle since the first will still be quite warm) and filter the mixture into a 250 mL beaker (this will separate out the excess, unreacted Cu). Note the characteristic color of Cu^{2+} ions in the filtrate (coming from the soluble **copper (II) sulfate** that is formed). **Water** is also formed in this reaction.

1c. Add 5 mL dilute **sodium hydroxide** to the filtrate while stirring. A precipitate will form. Add additional sodium hydroxide (using a pipette) until precipitation appears to be complete. The precipitate is **copper (II) hydroxide.** What is the soluble salt that is formed?

1d. Pour off about 1 mL of the above mixture into a small test tube. Add dilute **sulfuric acid** drop by drop (using a pipette) until the precipitate is dissolved. Identify the colored product. The other product is **water.**

1e. Gently boil the remaining mixture from (c) in the beaker until a reaction takes place. One of the products is **copper(II) oxide. Water** is also formed.

2a. Add about 1g of **solid copper sulfate pentahydrate** to a small test tube and heat strongly for a few minutes. Note any substances forming on the side of the tube. Note what you can hear also. Identify the products (hint: dehydration).

2b. After the tube has cooled to room temperature, add about 5 drops of **water** to the product. At the same time note any temperature change be feeling the tube. The reaction which occurs is very simply related to the one in 2a. Can you see how?

3. Add a clean **iron nail** to about 2 mL of a **copper(II) sulfate** solution. Allow to stand for a few minutes, and note any changes that occur. One of the reaction products is a soluble salt, **iron(II) sulfate.** The other product is a **metal.**

Appendix F4 (cont'd).

Data table:

STEP	reactants	products	observations
1a			
1b			
1c			
1d			
1e			
2a			
2b			
3			

Using the reactants and products you have recorded, write a balanced chemical equation for each reaction. Make sure you identify the state of each species, with the symbols (g), (l), (s), or (aq), appropriately. Also, label each reaction according to its type: Double replacement (DR), single replacement (SR), Decomposition (D), or Composition (C).

_____1a: ____

_____1b: ____

_____1c: ____

_____1d: ____

_____1e: ____

_____2a: ____

_____2b: ____

_____3: ____

Appendix F5

A Mole? Lab

Lab!!!

Introduction: During a chemical reaction, reactants combine with each other in definite proportions by mass. The amounts of reactants can be expressed in a variety of ways -- grams, pounds, tons, etc. However, no matter what the units, they are all related in the ratio of moles of one species reacting with a certain number of moles of another species (hence the need and use of a balanced chemical equation (coefficients).

Purpose: In this experiment, you will investigate a reaction between sodium bicarbonate, $NaHCO_3$ and hydrochloric acid (HCl). This reaction produces a salt, water, and a gas. You will try to determine the ratio of the number of moles of sodium bicarbonate, that reacts with an excess of hydrochloric acid, to the number of moles of sodium chloride (the salt that is produced). This experimentally determined ratio will give you the ratio of the coefficients between this reactant and product in the balanced equation.

Materials and Equipment:

four test tubes
3 M HCl
small beaker
pipette (HCl)
sodium bicarbonate
Bunsen burner
balance

Procedure:

1. Label three test tubes A,B, and C. Put the labels near the top of the tubes.
2. Mass each of the labeled test tubes to the nearest hundredth of a gram and record.

Appendix F5 (cont'd).

3. To each test tube add just enough sodium bicarbonate to fill the curved bottom of the tube.

4. Mass each test tube and its contents and record. (The masses of the three solid samples do not need to be identical).
5. To test tube A, add 3 M HCl drop wise from a pipette. Let the liquid run down the wall of the test tube and gently "tap" the tube after each drop reaches the bottom. Continue to add acid until there is no evidence of further reaction. Save the tube and its contents for further work.
6. Repeat step 5 with each of the remaining test tubes (B and C).
7. Gently heat test tube A and its contents in a Bunsen burner flame, holding the tube at an angle when doing so. The idea is to evaporate the water in the tube without spattering anything out of the tube. <u>Caution</u>: Too rapid heating of the tube, especially if it is held in an upright position, will cause spattering to occur.
8. Remove the tube from the flame, test for the evolution of water vapor from tube A, by inverting a clean, dry test tube over the upright mouth of test tube A. If condensation occurs, continue the drying and testing process until no condensation occurs. Set test tube A and its dried contents aside in a beaker to cool.
9. Repeat the procedures in steps 7 and 8 with test tubes B and C.
10. Allow the three test tubes to cool (at least 5 minutes) and then mass each with its contents. Record the masses in the data table.
11. Clean up your work space by rinsing out your test tubes in the sink and returning all of the equipment.

Data Table:

	Tube A	Tube B	Tube C
Mass tube + $NaHCO_3$	_____	_____	_____
Mass of empty tube	_____	_____	_____
Mass of $NaHCO_3$	_____	_____	_____

~~~~~~

	Tube A	Tube B	Tube C
Mass of tube + NaCl	_____	_____	_____
Mass of empty tube	_____	_____	_____
Mass of NaCl	_____	_____	_____
~~~~~~

Appendix F5 (cont'd).

Calculations:

1. Determine the number of moles of $NaHCO_3$ used in each test tube:

Test tube A:
_____moles

Test tube B:
_____moles

Test tube C:
_____moles

2. Determine the number of moles of NaCl produced in each of the test tubes:

Test tube A:
_____moles

Test tube B:
_____moles

Test tube C:
_____moles

3. Determine the ratio of moles of $NaHCO_3$ used to moles of NaCl produced:

Test tube A: ___/___

Test tube B: ___/___

Test tube C: ___/___

AVERAGE RATIO: ___/___

4. Write a balanced chemical equation to represent the reaction:

____

5. Name two sources of error in this experiment.
   a.
   b.

6. Estimate whether as a result of each error stated above, the experimental value would be higher or lower than the actual value and explain your reasoning.
   a.

   b.

Appendix F6

Double Displacement Lab

Introduction: Stoichiometry is a lot like cooking or baking. (If you don't do either you may want to learn. :-) For example, if a recipe for cookies is doubled to make a larger batch, how does that change affect the number of cookies that can be made? Or, if a cookie recipe asks for 4 eggs and you only have 2 (and desperately need cookies) what could you do to get by with only 2 eggs? Now think about a chemical reaction, what do the coefficients in an equation represent?

In this lab you are about to put two chemicals together and create something completely different and new. Your job is to predict (beforehand), knowing the amount of reactants you are going to use, the <u>type</u> of products you are about to produce and the <u>amount</u> that you **should** get of those products. Have fun, good luck and of course be careful.

Materials:

100 ml graduated cylinder	filter paper
two - 150 ml beakers	iron ring and stand
250 ml beaker	funnel
labeled weighing boat	stirring rod
~3 g zinc acetate	~4 g sodium phosphate
deionized water	evaporating dish

Procedure:

1. Obtain a clean, dry 150 mL beaker and label it "zinc acetate". Determine the mass of this beaker to the nearest 0.01 g and record its value in the data table.
2. Add approximately 3 g of zinc acetate to the beaker and determine the mass of the beaker and its contents to the nearest 0.01 g. Record to your data table. Add 10.0 mL of deionized water and stir until completely dissolved. Don't forget your procedure of cleaning off the stirring rod before setting it down.
3. Obtain a second clean, dry 150 mL beaker and label it "sodium phosphate". Determine the mass of this beaker (no two beakers are the same) as you did with the first and record its value in the data table.
4. Add approximately 4 g of sodium phosphate to this beaker and determine the mass of the beaker and its contents. Record in the data table. Then, add 10.0 mL deionized water and stir until completely dissolved.
5. Obtain a clean, dry 250 mL beaker and label "filtrate"and also write your drawer number on it. Determine its mass and record it in the data table.

Appendix F6 (cont'd).

6. Obtain a piece of filter paper, mass it, and record. Also, obtain a clean dry evaporating dish, label it with your drawer number, mass it, and record.

7. Now take your two solutions and pour them together into one of the beakers. Stir.
8. Now you are ready to filter. Set up you filtering apparatus the same as you did in your previous filtering lab. Also, follow the same procedures using your 250 beaker to catch the filtrate and your evaporating dish to hold your filter paper.
9. Once you are done filtering, place your filtrate under the hood on the hot plate so that the water may evaporate and place your evaporating dish holding your solid residue in the brown oven.

Procedure Day 2: Before you will be allowed into lab you must show your answers to Calculations/Questions from day 1.
1. Mass both your evaporating dish containing the solid residue and your beaker containing its solid on the balance. Record.
2. Cleanup - throw the filter paper and solid in the waste container. Rinse out the beaker with water and pour down the sink.

Data Table #1:

Mass of 150 mL beaker and zinc acetate	________
Mass of 150 mL beaker #1	________
Mass of zinc acetate used	________
Mass of 150 mL beaker and sodium phosphate	________
Mass of 150 mL beaker #2	________
Mass of sodium phosphate used	________

Calculations/Questions (Day 1):
What evidence for a chemical reaction was present when you poured the two solutions together?
Write the balanced chemical equation for the reaction that occurred.

Appendix F6 (cont'd).

Using the mass of the zinc acetate that you used, show the theoretical amount of zinc phosphate you should produce?

" " show the theoretical amount of sodium acetate you should produce?

Using the mass of the sodium phosphate that you used, show the theoretical amount of zinc phosphate you should produce?

" " show the theoretical amount of sodium acetate you should produce?

Which reactant appears to be the limiting reagent?___________

Data Table #2:

Mass of dry solid and 250 mL beaker (day2)	________g
Mass of empty 250 mL beaker (day 1)	________g
Mass of dry solid	________g
Mass of evaporating dish, filter paper, and solid	________g
Mass of evaporating dish (day 1)	________g
Mass of filter paper (day 1)	________g
Mass of dry solid	________g

Using your data from your limiting reagent calculations from day 1, determine the percentage error for:

mass of zinc phosphate collected _________%

mass of sodium acetate collected _________%

Name at least two sources of error: