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CAPA

Computer-Assisted Personalized Assignment System

in the High School Setting

By Janet R. Bronson

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
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ABSTRACT

CAPA

(Computer-Assisted Personalized Assignment System)

in the High School Chemistry Classroom

by

Janet R. Bronson

CAPA, Computer-Assisted Personalized Assignment System, software has been used for several years in the college setting at Michigan State University, but never in the high school setting. Instituting the CAPA software in the high school setting involved procuring the hardware, installing the software, and writing individualized homework questions. The program generates a different homework assignment for each student in a class while covering the same concepts. Using the computer system allows students to try to answer the questions correctly as often as was necessary until the due date of the assignment. This system was tested on 100 first year high school chemistry students of differing abilities. Both the teacher and students liked the system and benefited from its use.

CAPA
(Computer-Assisted Personalized Assignment System)
in the High School Chemistry Classroom

Table of Contents

Introduction

Rationale

During the last several years of teaching, I have noticed some disturbing trends among my high school chemistry students. Their grades are, on average, getting worse, although most are still passing. Their attitude is "complete the work as quickly and painlessly as possible". Learning is work that takes time out of their busy social schedule. I have caught my students cheating on homework and tests. And last, most of my students do not know how to prepare themselves for a test.

Many students just do not care about doing well at school. If they can pass their classes and graduate, that is sufficient. They have failed so often in the past that they see no reason to try their best. Most of my students have no idea how to study. They are frustrated by low grades, but when asked to regurgitate the material, they have no idea what they were supposed to learn. I want to teach them the material but even more, I want to teach them how to learn the material. They need to be able to recognize what they don't know and spend time studying that.

My students love the idea of cooperative learning. However, most of them think cooperative learning is simply sharing the workload. They get their homework and split up the questions so each one only does part of the work and only learns part of the lesson. Although their homework is complete, they have learned little of the material. I like the

idea of them working together and using each other as resources, but only if all students learn all the material.

I want my students' attitude toward homework to change. They see school as an endless stream of busy work with no purpose. I want them to see homework as a competition in which everyone can win. I want them to work hard so that they don't get left behind and if I can use a little peer pressure to do this, all the better. I think that often students have a fair argument if their homework is returned after they have taken the test and they didn't realize they were doing the work wrong. They would have worked harder if they had realized and recognized what they didn't know.

Then, in the summer of 1994, I was invited to participate in a program at Michigan State University that brought teachers and high school students together to study nuclear science, Physics of Atomic Nuclei program (PAN). During the workshop, we were introduced to a computer program that gave every student a different homework assignment. For the first time , I saw students working together on homework assignments without giving each other the answers. There was true cooperative learning happening and yet each student was responsible for his own work. The students seemed to like the program and enjoyed helping each other. The program gave them instant feedback on whether they had learned the concept or not by telling them if they were right of wrong. It also allowed them to try the same problem over and over until they got it right or the due date was reached.

I knew instantly that this was the answer to my frustrations. I could give each student in class a separate homework and yet know that they all were learning the same

concepts. They would have to do their own work and yet could study together. For the first time I was sure they were truly learning the information. The students instantly knew if they were right or wrong when doing their CAPA-generated homework. Now that each student could check his current score, a competition developed to see who could get the best score. Now I knew which concepts they were having problems with and which they understood. This helped me to become a better teacher by teaching to the problem areas **before** the test. Before, I had no way of knowing what they did and didn't know until their homework was graded. Often, this was too late since they had already taken the test. I enjoyed using the system and the students enjoyed using the system. Everyone wins.

The CAPA System

The networked Computer-Assisted Personalized Assignment system (**CAPA**) was developed by Michigan State University and was used for the first time in the fall of 1992. At the college level, it is now being used by over 1200 students for classes in physics, chemistry, and mathematics. Computers have long been integrated in experimentation, data acquisition and analysis. The CAPA system does not diminish the need for these computer uses because it represents a very different use of computers.

The CAPA operation relies heavily on modern networking computer technologies. It allows the instructor to produce, for each student, a printed individualized assignment which differs from all others. Each student's answers are unique while the concepts and principles covered on that printed assignment are the same for all students. Because each

printed assignment is unique, students are encouraged to study together and discuss the concepts, yet must complete their own work.

The homework consists of one or more sheets of paper with the individualized homework for a specific student printed on it. This homework has the name of the student and the date that assignment is due on the top left hand corner. See appendix 1 and appendix 2 for examples of the CAPA homework assignments. This printed homework is then given to the students so that they can complete the assignment without the computer. Once the assignment is complete, they check their homework on the computer to see if they have completed the work correctly. If not, they can work the problems that were incorrect again. By having the homework printed out for each student, they are free to do their homework whenever and wherever they like. They only use the computer to check their answers.

Using the computer is optional for the students. The students are allowed to turn in their work on paper but they are only allowed to answer the questions once when using this method. Grading the work by hand, in the traditional sense, does take longer for the instructor but the students are more interested if they are not forced to use the CAPA system on the computer. Most students soon see the advantages of using the computerized system and appreciate the multiple chances they get to answer the questions correctly. Since multiple tries are not penalized, the students are willing to keep trying. Many students will solve <u>all</u> problems if given enough time. Students like not being judged or ranked while learning the concepts. They feel they are truly learning the material.

The CAPA system gives students immediate rewards for the right answers. This is a constant encouragement to the students. This system also allows hints to be inserted on the computer screen when the question has been answered incorrectly. This feature allows the instructor to assign more challenging questions and then instruct the students on how to find the answers. Explanations can also be displayed after the due date of the assignment, allowing students to go back and review problems that they could not complete before the due date. They may then use this information to study for the test.

The system allows many types of questions to be used in the homework assignments. The most common are multiple choice, matching, and those requiring a mathematical solution. This makes the system especially suited to science and math although it could be used for any subject with a little practice. Numerical problems have variables that are randomly distributed across a chosen spectrum. This produces an almost endless number of choices. The *Select N-correct out of M-choices* are especially useful for conceptual questions and in addressing previously held misconceptions. Matching questions are commonly used to review vocabulary. Definitions can be written in several forms and then randomized so students must communicate the meaning of the word, not just the dictionary definition. Assignments can also include essay type answers but these must be turned in to the instructor and graded by hand.

The best part of this system is that the "computer" is the arbitrator of what is correct or incorrect. This changes the role of the instructor from judge to mentor. Valuable dialog is increased between the students and the teacher. There is more time for individualized help during school hours. This adds enjoyment and validation to teaching.

This system can also be used for retesting. Since each student receives their own copy of the questions there is almost no way to cheat. In retesting, partial credit can then be given for all right answers. Students, when given the chance, tend to rework all missed answers thereby increasing their grade as much as possible. I found this a great motivation to get the students to learn the things they did not know at the time of the test.

Scientific Literature

It was very difficult to find any literature on this program in any of the science or educational magazines. The Computer-Assisted Personalized Assignment system was first used in the fall of 1992 for one small college-level physics class by Dr. Ed Kashy at Michigan State University. It is now being used by more than 25 professors at several colleges. As far as I know, I am the only high school teacher using this. Several other local high schools have expressed an interest but are waiting to see the problems I encounter.

The typical college student is very different from the typical high school student. College students choose to go to school and generally spend a large sum of money on their education. This tends to make them more serious about learning and attending class. They understand that they must study a certain amount of time outside of class if they want to receive an education. These attributes are more pronounced in students studying for science careers.

However, in a high school setting, the students are not as committed to making the most of their education. Much of their lives revolve around the typical teenage struggles of self-esteem and self-awareness. The CAPA system should allow them some control over their grade. It should give them the chance to decide how hard they want to work and what grade they will earn. They will have a chance to gain in self-esteem from what they can achieve and how hard they work.

Computers are the tools of the future. Students lacking an opportunity to learn to use computers will be disadvantaged in the job market. Computers must be introduced to students in all areas of education. They can no longer be used as an end in themselves, but as a tool that is a means to an end. In the future, computers will be used for everything from doing your job without leaving your living room to performing surgery on a fetal heart defect from hundreds of miles away. Without the knowledge of computers, students will find their work options diminished. (Karraker, 1991.) The CAPA system will give my students a chance to use a networked computer program in a real-life situation. They will receive firsthand knowledge of the advantages and disadvantages of sharing information through a network of computers.

The first paper published on the CAPA system itself was *CAPA--An integrated computer assisted personalized assignment system* (Kashy, 1993). They reported that the system was a powerful motivator. Students liked not being graded while they were still learning and the opportunity to rework problems with incorrect answers. *CAPA System Update* (Kashy, May 1994) documented the use of the CAPA system in physics, chemistry and math. In each area that the system was used the same results were

reported: students loved it and their grades improved. In all situations, more time was spent on the homework and students felt that the time was well spent. In *Conceptual Questions in Computer-Assisted Assignments* (Kashy, Jan. 1995), E. Kashy explains the correct way to write a conceptual question using the CAPA system and how these questions help students grasp the concepts. If these types of questions are well written, it is nearly impossible to guess the correct answer. CAPA is the only system that allows for this type of question to be individualized for each student. Other articles have been written by the faculty at Michigan State University that point to the same success with college students (Morrissey, 1995) (Kashy, Sept. 1995). These studies indicate that CAPA is well liked by students and staff alike. Students felt that although they spend more time doing their homework, they understand the concepts better and are more confident when taking their tests. The instructors have documented an increase in the test scores of their students. All believe that it has enhanced the student-teacher relationship.

Demographics of the Study Group

Jackson High School is proud and honored to be the first high school in the world to use the CAPA system. It is an urban school with many of the typical urban school problems. These problems include many one-parent families, racial tensions and lack of discipline and motivation among the students. There are close to 2000 students enrolled in the ninth through twelfth grades. About 32% of the student body are minority with black students composing 90% of this group. We have a fairly large "inner-city "

population which adds to our high at-risk student count. The specific racial-ethnic and gender make up of this school is given in the Figure 1. This figure shows that the school is composed of two-thirds white students and one third minority.

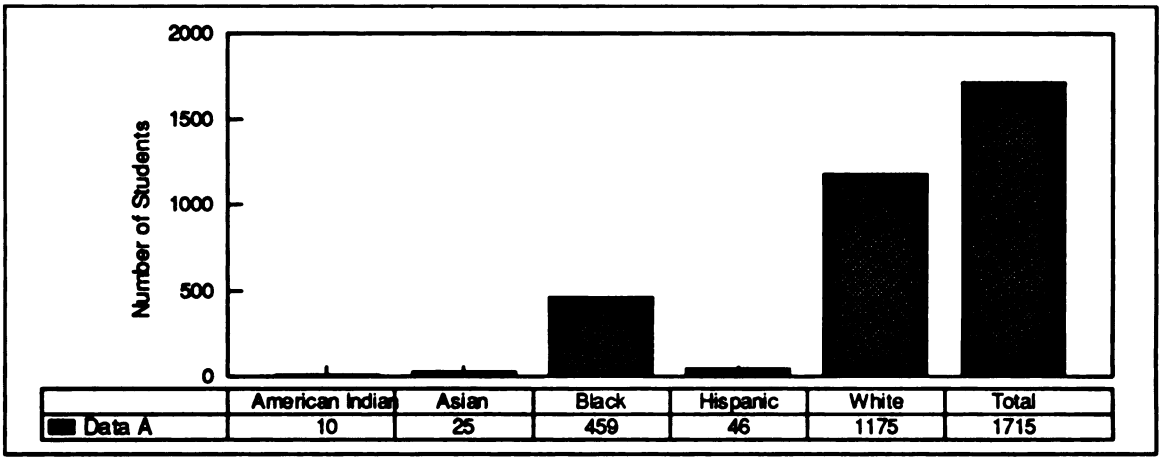


Figure 1. Racial and Ethnic Background of the School at which the Study Took Place

The CAPA program was instituted throughout my chemistry classes which included two different levels of chemistry: a general chemistry class and three practical chemistry classes. There is also a second year chemistry taught at my school. I am not involved in the teaching of this course.

The general chemistry classes are composed primarily of students who intend to study science in college. They are in the top 30% of their class and their grades reflect this, as they achieve A's and B's. They generally come from a two-parent middle to upper-income family. These students expect to spend about two hours or more per night on the homework they receive that day in their classes. The general chemistry class in

which the CAPA system was tested took place in the fall of 1995. This class was composed of 20 students which included 3 from single-parent homes, and 4 students were minorities. Sixteen of the students were in tenth grade, 2 were in eleventh grade, and 2 were in twelfth grade.

The three practical chemistry classes consisted of students who intend to go on to college although most likely will not study science. They generally have poor math skills and often have trouble reading. They would all fall into the middle 50% of their class and their grades generally range from B's to D's. Some of these students care deeply about their grade and will work to maintain a good grade point average. However, some do not care about school at all and do no homework. In fact, many never take their books home or spend more than a two hours per week on the homework in all their subjects. About half of the students in these classes come from single-parent homes. These are difficult classes to teach because the students' abilities and work ethics range widely. The CAPA program was used in all three practical chemistry classes taught during the fall of 1995. Of the 57 students using the program, 26 lived in non-traditional families, and 28 were minorities. These classes are a pretty even mixture of tenth and eleventh grade students.

Implementation and Evaluation

General Operation

CAPA relies heavily on modern networking computer technologies. It allows the instructor to produce, for each student, a printed individualized assignment which differs from that of other students. Each student's answers to the questions are unique while the concepts and principles covered on that printed assignment are the same for all students. Because each printed assignment is unique, students are encouraged to study together and discuss the concepts, yet must complete their own work.

The homework consists of one or more sheets of paper with the individualized homework for a specific student printed on it. This homework has the name of the student and the date that assignment is due on the top left hand corner. See appendices 1 and 2 for samples of the CAPA homework in both general chemistry and practical chemistry. This printed homework is then given to the students so that they can complete the assignment without the computer. Once the assignment is completed, they check their homework on the computer in the classroom to see if they have answered their questions correctly. If not, they can rework the problems that were incorrect. By having individualized homework printed out for each student, they are free to do their homework whenever and wherever they like. They only use the computer to check their answers.

Implementation of the CAPA Program

System Hardware/Software Requirements

The three main parts of this thesis are assembling the hardware and software, writing the questions, and instituting the CAPA program in my chemistry classes. The hardware came from two different sources. Since the student work stations required only a VT100 emulation, these computers need not be up-to-date. Michigan State University, through Dr. Ed Kashy and the warehouse, loaned me 24 old and outdated 8088 computers. Once all of these were checked to be sure they were working, they were shipped to the classroom in which I teach. My classroom had to be altered to accommodate a computer at every desk. These alterations required the removing of four drawers and their supports at each of twenty-four stations. This was a lengthy but ultimately fruitful experience. It took about six months to complete all the alterations and install the computers.

The server required to run the student workstations, the NeXTStep platform software, and the CAPA software had to be reasonably powerful and therefore, reasonably expensive. The server for this system requires one Meg of RAM for each workstation that is operating at the same time. Since RAM can only be installed in a computer in multiples of four, for 24 workstations, 32 Meg of RAM was required. With the support of my

principal and MSU, I was able to convince the central administration to spend just over $4000 on a Gateway2000 pentium computer with the required 32 Meg of RAM.

Once the computer was received, the NeXTStep platform software (Kashy, 1994) required to operate the CAPA software, needed to be loaded. This software is outdated and will load directly on only a few specific hard drives which did not include the hard drive that came in the Gateway2000. However, computer experts at the Cyclotron at Michigan State University were able to help me with this problem. They added the Gateway2000 to their network and downloaded the NeXTStep platform via the internet. Once NeXTStep was installed, the CAPA software could be loaded. This procedure required about a week.

At this point, I found out that I needed a postscript printer since the NeXTStep system only carries drivers for postscript printers. These are generally expensive printers and I had already received more than my share of the school's money for the server. Luckily, I have a postscript printer at home. This meant that whenever I needed to print the homework assignments for my classes I had to take the server home. This was not an easy task, as the Gateway2000 is not a laptop. Since this was my only option, I carried my computer home about once a week for twelve weeks to print out the student assignments.

When everything was finally in my classroom and ready to be setup, Sherry L. Wolfe from the Cyclotron at MSU assisted in getting the system operational. This took us about four days. First, the student computers could not communicate with each other. That took about a day to fix. Next, some of the student computers still needed to have the

network software loaded. This is a rather lengthy job when there are twenty-four computers to consider. Last, we had to automate the login process for each workstation. About a week after school started, everything was ready and the computers were up and running.

Question Writing

For this project I spent a summer writing homework assignments. I completed about twelve weeks of homework for my students both levels of chemistry. The practical chemistry assignments consisted of twelve to twenty questions per assignment. I completed ten practical chemistry assignments and ten practical chemistry retests. An example of these assignments is given in Appendix 1. The general chemistry assignments were longer, usually twenty-five to forty questions. I completed five assignments for general chemistry that covered ten chapters of their book. An example of these assignments is given in Appendix 2.

There are basically four types of questions used for assessment in the CAPA system: multiple choice, mathematical, essay, and matching. The CAPA program does not write the questions or answers, it only rearranges what is written for each student so no two students receive the identical homework assignment. The wording of all questions and options are written by the teacher. Appendices 1 or 2 given two examples of the same homework assignment so that the differences between the assignments can be compared. Also, the computer must be told either the correct answer or how to mathematically find

the correct answer for each question. Most of this programming is done in a type of BASIC computer language.

I had a fair amount of computer knowledge before I started this project, but most of my knowledge was in single-user software applications. I had completed a course in basic programming and Pascal programming in high school. Although this was of some help, I basically had to learn a new computer language. This I did using the user's manual that comes with the CAPA software and much trial and error. With a little tenacity, anyone can learn to use the CAPA software. However, to complete 12 weeks of homework for two different levels of chemistry took me over 300 hours.

The multiple choice questions required the most planning to write. These questions consist of a question with one or more right answers. The student must choose all correct answers to get the question correct. These questions, when written correctly, require a thorough understanding of the concept. It is possible to get these answers correct by guessing, but it could take up to six hours in front of the computer, which is more time and stamina than most students have. The options can also be written in several formats, some of which are false and some true, so students must read carefully when sharing answers. An example of this type of question is:

20. Which of the following are elements? Give all possible answers in alphabetical order using all CAPITALS. (Example: ABD...)

A) E
B) No
C) Co
D) R
E) Z
F) CO
G) NO
H) Y

Each time this question, as well as all others, is printed on a homework assignment for a different student the options are rearranged and/or changed (Appendices 1 and 2). A good multiple choice question must address the common misconceptions that students have. In this example, the misconceptions being addressed are the idea that capital and small letters don't matter in element notation, and that all letters are assigned to elements. Both of these misconceptions must be remedied before the question can be answered correctly. With this type of question the computer must be programmed how to sort the options and the correct answer for each possible way the options are sorted. Appendices 1 and 2 also have examples of the computer coding needed for this type of question.

Mathematical questions are the easiest to write because the computer figures the answer for all students based on math functions. With other questions, all the possible correct solutions must be programmed. Math questions can range from addition or subtraction to advanced story problems. I was able to use this type of question often in my general chemistry class. Following is an example taken from the General Chemistry Homework Set 1, (Unit 1, Chapters 1, 2, and 3).

32. Perform the following calculation, expressing your answer in scientific notation. (Example: 4.56e-8)

$(2.0 \times 10^{-3})/(4.0 \times 10^{-8})$

This is a simple multiplication problem using scientific notation. Here the answer is coded using X/Y and the computer is given parameters within which to assign X and Y.

Then, the computer is simply told to divide X by Y. An example of this type of coding is given in Appendix 2.

Although essay questions can be included on student homework, they cannot be answered on the computer. Thus, they are generally used only on tests and must be graded by hand. Since correct answers must be exact copies of the answer coded into the computer, it is impossible for a student to ever get the answer right using the computer. I tried to keep these questions to a minimum. I felt that if the project was to use the CAPA system, then I should not include homework that did not use the system.

Matching questions were a new type of question that I coded into the CAPA system. Colleges do not spend a lot of time reviewing vocabulary, but I have found that at the high school level this really helps the students understand the concepts better. Thus, this type of question had to be coded without any examples in the CAPA user's manual to refer to. This took me about a week of planing and coding to complete a 12-option matching coding, a 10-option matching coding, a 6-option matching coding, and a 5-option matching coding. Each type of matching-question coding includes twenty-four different sorting options and the correct answer for each option. Each type of matching-question coding had to be checked for answer accuracy in each of the 24 options. This coding is found in Appendix 3. Following is an example of the typical matching question.

2. Match the following words from Water, Part C, with their meanings: solution, concentration, aeration, photosynthesis, aerobic bacteria, biodegradable. (Example: ABC...)

A) splashing to cause more oxygen to dissolve
B) process by which green plants grow
C) dissolved oxygen
D) oxygen consuming single-celled organisms
E) amount of solute / amount of solvent

Matching questions were used on all homework assignments for both classes. Once the general coding for this type of question was done, questions of this type could be quickly planned and compiled. Using these questions in an assignment is similar to using the multiple choice question except that all options given are correct but must be sorted into the order asked for in the question.

For my practical chemistry students, I developed nine assignments and nine retests. Each assignment contained twelve to twenty questions. At least three of the four types of questions previously described were used in each assignment. Each assignment was expected to take my students about a week to complete for a total of twelve weeks of work. Each assignment took me an average of nine hours to plan and program. At the beginning of the summer(1995) when I first began writing CAPA questions, I needed up to sixteen hours per assignment. As I got better at solving problems and writing coding correctly, the time needed to complete each assignment shortened. A sample of these assignments and the coding needed to produce them are found in Appendix 1. A full set of these assignments may be obtained from Janet Bronson (see Appendix 4).

In my general chemistry class, the students had a longer time to work on each assignment, often two or more weeks. Thus, their assignments tended to be longer, usually twenty-five to forty questions. I later found that this was too long. These assignments, because of the objectives of the class, were composed of more mathematical questions than the practical chemistry class assignments, thus making these somewhat

easier to write. However, because of the length of these assignments, they still took me about ten hours apiece to complete. I completed five of these assignments, which covered twelve weeks of class. A sample of these assignments and the coding needed to produce them are found in Appendix 2. A full set of these assignments may be obtained from Janet Bronson (see Appendix 4).

Even though these assignments took many hours to produce, I feel the time was well spent. Once the assignments are coded into the computer they can be used year after year without the worry of students copying the answers from older friends or siblings. The computer generates a new and unique homework assignment for each student whether they are in chemistry together or take the class in different years. This feature allows the teacher to let the students keep their homework and retests if the student wants them.

The CAPA system was instituted in my classroom for the first twelve weeks of school. All students were encouraged, but not forced, to use the computers. The student computers were available before school, after school, during lunch and often at the end of the class period. On Wednesdays, the students were given 38 minutes of computer time. If the student chose to do the homework and turn it in, in hardcopy form, then it was graded by hand. These students were not given the option of reworking their incorrect problems. After twelve weeks, the classes reverted back to the doing book homework in hardcopy form and turning it in. After six more weeks, they were asked to evaluate the CAPA way of doing homework in comparison to the more common way of completing assignments.

Evaluation of the CAPA Program

The evaluation phase of this project was extremely difficult. The way I teach while using the computers is very different from the way I teach without the computers. When using the computers I had to set aside large amounts of class time for my students to check their homework. I tried to give my students the opportunity to use the computers for about ten minutes everyday. This meant that many of my review activities had to be removed from the daily schedule. The types of questions I ask on tests were different with and without the computers. Now instead of the multiple-choice questions having only one answer, I tried to match the types of test questions to the types of questions the students saw on the homework. Last, the students I have this year are different than last year. The type of students and their interest in learning is different from year to year. No two classes have the same personality or character. Thus, I used several methods of evaluation to try to determine the effectiveness of the CAPA system.

First, I had more students asking for help than previously, and the questions asked were more insightful. In class, I could hear the students discussing the problems using the concepts we had covered in class. Students were able to share how they got the answer. Doing the work correctly and having the computer tell you it was correct was the reward for learning the concept. Cooperative groups formed spontaneously during homework time and stayed on task. Everyone knew something and contributed to the group. This

was a great esteem-builder for many of my students who don't often get asked for their ideas.

Next, I compared last year's average test grades to this year's average test grade. The tests from these two years were completely different although they covered the same concepts. The way the questions were asked had to be changed and manipulated so that the computer could be used. In general, my practical chemistry students did better this year on their tests than last year's students. The average scores on these tests increased from 68.6% to 73.4%, a substantial change. The students liked using the computers because they knew what to study. Feedback from the computer informed them of incorrect answers and the need for further study.

I did not see a change in the test scores of my general chemistry class. The average test scores last year were 82.8%. This year the test scores for the general chemistry class were 84.2%. This increase is not statistically significant. Even though there was no change in scores, the student said they felt more comfortable taking the tests in chemistry because of the computer feedback on how to do the problems.

Third, I compared last year's average first semester exam grade to this year's average first semester exam grade. In this case, the questions were exactly the same on the two tests. Although this allowed for a statistical comparison, it was not a good measure of how the CAPA system worked. Last year's students saw these exact questions on their tests during the semester, whereas this year's students were given different tests during the semester. Also, the last six weeks of the first semester of this

year, the CAPA system was not used. I did not have the time needed to create the homework assignments for the last six weeks of the first semester.

Even though the CAPA system was only used during the first two-thirds of the semester, the average number correct on the semester exam for practical chemistry increased by two percent. Although, this is not a large change, I think it is important to note. In many cases, a two percent gain would increase a grade by one step, C+ to B-, or A- to A. At the end of the grading period, I have students who will do almost anything to increase their grade one step.

The standard deviation of the grades on the semester exam for the practical chemistry class also decreased by 4 points, from 22 to 18. This shows that not only did the average score go up, but the students received grades that were closer to the average than the year before. To make this happen, the students who received the lowest scores achieved substantially higher scores than the year before.

I saw little change in my general chemistry exam grades from last year to this year. The average grade last year on the exam was 78.7%, this year it was a 79.2%. These scores are too close to say conclusively that the CAPA system made a difference in the way the students performed. However, it is possible to show that the CAPA system did not, in any way, decrease their learning in general chemistry.

Fourth, I had the students in both my general chemistry and practical chemistry classes evaluate the CAPA program after they had been without the computers for six weeks. This was done using an anonymous response to the question, "Tell me what you thought of the computers that were used earlier in the year now that you have had a

chance to see what this class is like without them. Most of my students responded with a like/dislike comparison. I received fifty-five responses from my students. These is fewer students than the number I originally enrolled in the CAPA program because some students had left school by the time the survey was taken, while other students chose not to respond. A graphical analysis of the student responses is shown in Figure 2.

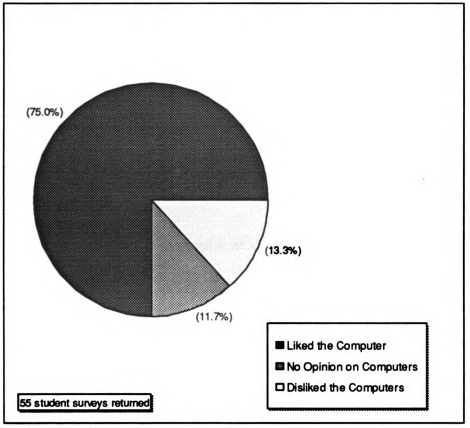


Figure 2. Student Opinions of the Computers

The vast majority of students, seventy-five percent, liked using the computers and felt the computers helped them to learn. They especially liked being able to try questions again if they got them wrong without being marked down. This feature of the program

was mentioned in every opinion that I read from this group. However, even those that liked the computers were frustrated by the problems that were encountered (see the section, Problems I Encountered). This group tended to be composed of students who really wanted to learn.

> ~I liked using the computers because it gave us a chance to see if we did the problem wrong.
> ~I liked the computers better because if you weren't sure of an answer you could try it in the computer. If you were wrong it would tell you and give you a little hint.
> ~...The only thing I didn't like was that some times the computer told you you were wrong but you weren't. You just didn't type it in in the exact form that the computer wanted it in.
> ~I liked it because you had a chance to check to see if it was right or wrong and if it was wrong, you could change it and keep trying until you got it right.
> ~I liked using the computers because it was different. I would rather type my answers into a computer and have it tell me if it is right or wrong so I know what to do next. Also it is nice to have the chance to work with computers because in the work world everything is becoming computerized.

Very few of my students disliked using the computers, only thirteen percent of the fifty-five students interviewed. Most of these students didn't like the extra work of having to correct their wrong answers. They felt that the time spent on the computers was wasted. Many of these students tried the computer once or twice but in general waited until the last minute to do their homework and thus saw no benefit from them.

> ~I hate the computers. I only used it once because it took to much time to correct my answers.
> ~The computers were a waste of my time.
> ~I don't like using the computers because you have to do your work earlier. I never do my homework until the night before it is due.

A small number of students, twelve percent, had no opinion about using the computers. These students used the computers if they completed their homework early enough but then didn't often correct the answers. They liked having control over their grades so they could be sure they were passing . However, once a passing grade was achieved they were done working.

> ~The computers were OK for some kids but I didn't think they helped that much.
> ~If I have time to do my homework early, then I like the computers. But usually by the time I get my homework done, I don't have any time to do the corrections.
> ~I liked knowing I was passing so I didn't have to do any more of the assignment.

Last, I liked using the CAPA system. Although it took a whole summer to prepare twelve weeks of homework, I saw students working together on problems. My students wanted to work in groups. Also, this system made it possible for me to make each student responsible for his own work even though they worked together.

I was asked intelligent and thoughtful questions. This leads me to believe that the students understood the concepts better. They were ready and willing to answer questions from me about how they got their answers. I never heard "I put that cause that's what Steve put." This made my job of correcting their misconceptions much easier. They were willing to share with me and their friends how they answered the questions and solved the problems.

The majority of my students wanted to work on their homework assignments. They would go home the first night that they had their assignment and work until they had an answer for each problem. When they returned to school the next day, they wanted to

check their answers on the computer system. Once they found out which questions were incorrectly answered, they would go home after school and try them again. Every once in a while, a student would show up before school to check his answer. If it was answered correctly, the student would leave with a smile covering their whole face. If the answer was wrong, they would have another answer by the time they arrived for chemistry class. I saw two of my shiest students gain a self-respect from doing their homework, giving them the confidence to help other puzzled students.

Finally, the CAPA system permitted me to be a better teacher. It freed me to do important things, such as spend more time with individual students answering their questions. I knew the concepts that troubled students before the test. I was able to teach to the problem areas, many of which I would not have been aware of without the computer. I was more relaxed because I had more time and the computer validated the job I was doing.

Overall, I liked the CAPA system. It took over 300 hours to prepare for twelve weeks of homework for practical chemistry and twelve weeks of homework for general chemistry, but now that homework can be used year after year. The commitment was enormous but the payoff was worth every minute. My students enjoyed it. I enjoyed it. I would encourage everyone to do whatever possible to get the CAPA system running in their classroom and their school.

Some Problems I Encountered

There were several problems that I encountered. Some of these problems were system malfunctions that I had little or no control over. The other problems simply were caused by my inexperience producing CAPA homework. An understanding of each type of problem may help another CAPA user avoid them in the future. If not, at least they will know they are not the only one to experience these situations.

The system problems were the most frustrating to me because there was little I could do to solve them. Most had to be solved by Sherry L. Wolfe and Ed Kashy at MSU. Although these people were extremely willing, it often took time that I and they couldn't afford to give.

The system runs in the NeXTStep platform. This is extremely frustrating if you need to use a DOS or Windows application while your students are using the CAPA program. The easiest way to solve this is to buy another computer and hook it to the system for your use. Although this sounds easy, if your school is anything like mine, getting money is difficult.

Once the CAPA system was running other problems started to arise. Not all the computer menu systems on the student computers were the same. Some allowed the students to get into the DOS platform and delete and move files, and generally be malicious. Other menu systems allowed students to enter a password which stopped me and other students from using the computer. Since the menu programs were not all the same, I had a difficult time correcting this problem. Each menu program ran in a slightly

different way, and each problem that arose was a little different. I think that this problem can be solved by installing the same menu application on each workstation. Most menus can now be protected so that students with minimal knowledge can not get into the DOS platform.

I also found it a long and tedious job to grade essay questions by hand and enter the grade into the computer. I knew I would need to grade these by hand when I started but I did not realize how long it would take me to enter the grades using the CAPA system. Essay questions are valid and should be used to understand how students are thinking, but I have avoided using them on homework. If your objective questions are written carefully, you can test all learning using this system. Although I dislike the extra time it takes, I do use essay questions on tests.

The CAPA system also failed to inform me that some answers were too long for the software format. While I was programming the questions, CAPA allowed writing of long answers without any indication that there was a problem. Usually, there is some indication that an answer is going to be a problem. However, once the students started logging in to the system, they were only allowed a limited number of characters in their answers. This meant that several of my questions were unanswerable using the system and had to be graded by hand, then entered into the computer.

The other problems were things that I found only by using the system in a high school setting. Some had to do with the type and level of students I was teaching and some were related to the high school setting itself.

The most surprising thing to me was the amount of time the students needed to complete their work. Part of the problem was that some students simply did not do their homework at home. They wanted to do it while in front of the computer. I solved this for the most part, by sending a letter home to parents explaining the system and what I expected the students to do outside of class. Many of my parents, once they understood, started checking their student's work at home to be sure they had at least tried every question. Letters are a great way to get parents on your team.

Using the computers in class also took a large amount of time. Now that my students could get 100% on their work, they wanted the chance to check their work everyday. We compromised on this one. On lecture day they received about ten to fifteen minutes at the end of the hour to use the computers. At my school, we have a two hour common planning time on Wednesdays, so our class periods are only 38 minutes long on this day of the week. I gave the students the full class period on Wednesday to use the computers. Most seemed to feel that this was sufficient amount of time to get their work done by the due date. I also offered lunch time, and before school as computer times. A few students took advantage of this. In the future, the CAPA server will be accessible on the internet to those students with that service at home.

I also found that my practical chemistry students were easily frustrated. I created several questions that involved sorting or matching twelve options. This was too many. Since the computer does not tell the student where they are wrong, only that the problem is wrong, they decided that it wasn't worth the work to try to resort twelve answers. There were too many possibilities. I solved this by dividing most of these questions into

two questions of six. The students seemed to feel that with six possibilities they had a better chance of getting the question right, so it was worth the time to try again. Also, I found that if the first assignment is so easy that everyone does well, the system is seen as more friendly.

Last, some of my assignments were too long. The students didn't have time to complete the homework and rework what they got wrong before the due date. This was especially frustrating to my general chemistry students who wanted to get everything right. I found that 30 or more questions were too many. For my general chemistry students that have about two weeks to do an assignment, 20 to 30 questions worked well. For my practical chemistry class, I found that in a week they could complete between 10 and 22 questions.

Suggestions to Make CAPA Implementation Easier

The following suggestions are offered for those wishing to incorporate the CAPA program into a high school setting. If you follow these suggestions both you and your students will feel better about the CAPA system when you start and fewer catastrophes will happen later.

First, give yourself lots of time to prepare the questions. The CAPA system is unlike any other you have used and often is not very user-friendly for the teacher. It took me 8 hours to write one assignment, about 15 questions, a little less for math-type questions, a little more for concept questions. I spent one whole summer, 10 weeks,

writing questions and completed about 24 weeks of assignments, 12 weeks for each of the two classes. Plan at least this much time to work. Have everything ready to go on Day 1. This will give you peace of mind and the students a sense of organization and planning. When things don't work well at the beginning, the students never forget it. It takes a long time to overcome a bad first impression.

Keep all of your assignments under thirty questions. The students will keep doing the problems until they get them right, so you don't need five of the same type of problem. Long assignments only frustrate the students that are willing to work but need more time to learn. If you find that all the students are having problems with a certain type of problem than supplement with worksheets during class.

Login and do the problems about two weeks after writing them. You will find many mistakes. If the answers are not correct when the students go to use the system they will get frustrated and quit. This also helps you understand what the student is seeing on their screen which may make a difference in how you word the questions.

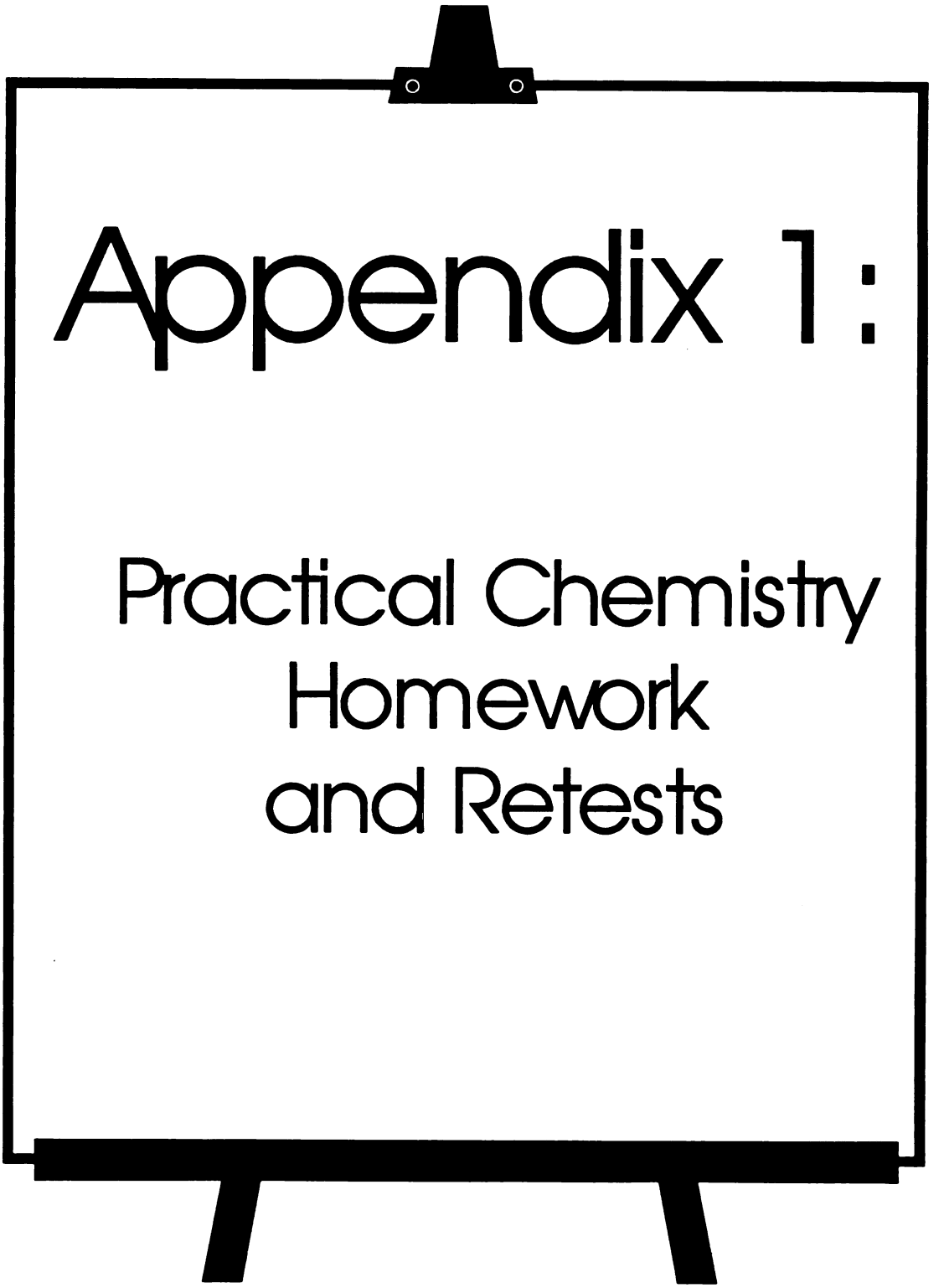
Start with an easy assignment were everyone is successful. This helps the students feel good about themselves, the CAPA system, and the class. This will encourage them to work harder in the future because they have experienced the thrill of getting 100%. My first assignment consists of matching the lab equipment with their names.

Send a note home to parents explaining the CAPA system and what you expect the students to do at home. This will inform the parents and make them feel a part of your classroom. Also, students have a tendency to not always give the complete story about their homework to their parents. Many of my parents thought that the student needed to

be in front of the computer to do their homework. This, of course, was not true but it meant the student didn't have pressure from their parents to do the work at home. By informing parents early, the full responsibility for not completing the work falls on the student.

Last, obtain for yourself a computer separate from the server to run DOS applications. This will make you more productive while the students are using the CAPA system. Place your computer on the network and then you can login to NeXTStep and the CAPA system when you need to. The NeXTStep platform must be running whenever the students are using the system, thus it is much easier if you can simply leave the server on all the time. This is especially true if the server is on the internet and the students login after normal school hours.

I have learned from my experiences, including the problems and am quickly becoming an expert on the CAPA system. Many parts of it are still in their infancy but the idea of giving each student their own individualized homework is great. I think that the students who chose to use the system found it a helpful and useful tool. They felt better about doing their homework and taking tests.



Appendix 1:

Practical Chemistry Homework and Retests

BRONSON, JANET

Practical Chemistry *1996-97*

pchem Set 3, (Water, Part A Homework). Due 07/15/96 07:40 Give 3 digits for numerical answers. PIN is 1337

---

1. Match the following words from Water, Part A, with their meanings: meter, liter, filtration, filtrate, distillation. Use all CAPITAL letters in your answer. (Example: ADE.....)

A) separation of two substances using differences in boiling point
B) liquid collected after filtration
C) separation of a solid from a liquid by passing it through a porous paper
D) SI unit of length
E) SI unit of volume

2. Match the following words from Water, Part A, with their meanings: electrical conductivity, hydrologic cycle, surface water, groundwater, aquifers. Use all CAPITAL letters in your answer. (Example: DBC...)

A) water on the surface of the planet
B) porous rocks that hold water
C) water that collects underground
D) ability to carry a current
E) nature's water purification system

---

3. Which SI unit would most likely be used to measure each of the following things: meter(m), millimeter(mm), liter(L), milliliter(mL), kilogram(kg), gram(g)? Use each answer only once and place a comma and a space between each answer. NO COMMA AT THE END. (Example: m,mm,L, ...)

A) Thickness of a dime
B) Volume of thimble
C) Milk
D) Mass of a staple
E) Height of room
F) Meat

4. Complete the following metric conversion. (Example: 234.5)

279.2 cm = ...km

5. Complete the following metric conversion. (Example: 234.5)

176.2 L = ...mL

6. Complete the following metric conversion. (Example: 234.5)

1.8 kg = ...g

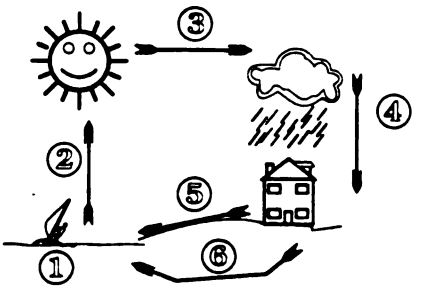
---

7. Using Figure 6 on page 13 of your ChemCom book, answer the following questions. The answers that are possible are: irrigation(I), other agriculture(A), homes and offices (H), manufacturing(F), steam-electric generation(E), mining(M). In the United States, what is the greatest single water use in each of the following? Use all CAPITAL letters in your answer. (Example: HHF...)

A) the West?
B) the South?
C) the Midwest?
D) Hawaii?
E) the East?
F) Alaska?

---

8. Place the following words in their correct location on the diagram. (Example: MDNF...)



A) suface water
B) condensation
C) runoff
D) evaporation
E) groundwater
F) precipitation

---

9. Place the following in order of **increasing** water storage (smallest to largest). Place the options in the correct order. (Example: BDH...)

A) glaciers and ice caps
B) rivers
C) atmospheric moisture
D) oceans
E) lakes
F) groundwater

---

10. Which of the following uses would **produce** "gray water"? Give all possible answers in alphabetical order using all CAPITAL letters. (Example: ABD...)

A) watering the lawn
B) cooking rice

C) shaving
D) washing hands
E) bathing
F) washing dishes

---

11. Which of the following are indirect water uses for preparing an egg for breakfast? Give all possible answers in alphabetical order using all CAPITAL letters. (Example: ABD...)

A) poaching the egg
B) washing the pan
C) drinking a glass of water
D) watering the plants for chicken feed
E) cleaning the farm equipment
F) watering the chickens

Doe, John

Practical Chemistry *1996-97*

pchem Set 3. (Water, Part A Homework). Due 07/15/96 07:40 Give 3 digits for numerical answers. PIN is 5208

---

1. Match the following words from Water, Part A, with their meanings: meter, liter, filtration, filtrate, distillation. Use all CAPITAL letters in your answer. (Example: ADE.....)

A) separation of a solid from a liquid by passing it through a porous paper
B) SI unit of volume
C) liquid collected after filtration
D) SI unit of length
E) separation of two substances using differences in boiling point

2. Match the following words from Water, Part A, with their meanings: electrical conductivity, hydrologic cycle, surface water, groundwater, aquifers. Use all CAPITAL letters in your answer. (Example: DBC...)

A) water that collects underground
B) ability to carry a current
C) nature's water purification system
D) porous rocks that hold water
E) water on the surface of the planet

---

3. Which SI unit would most likely be used to measure each of the following things: meter(m), millimeter(mm), liter(L), milliliter(mL), kilogram(kg), gram(g)? Use each answer only once and place a comma and a space between each answer. NO COMMA AT THE END. (Example: m,mm,L, ...)

A) Thickness of a dime
B) Volume of aspirin tablet
C) Pop
D) Mass of a staple
E) Height of room
F) Bulk foods

4. Complete the following metric conversion. (Example: 234.5)

260.4 cm = ...km

5. Complete the following metric conversion. (Example: 234.5)

170.0 L = ...mL

6. Complete the following metric conversion. (Example: 234.5)

2.6 kg = ...g

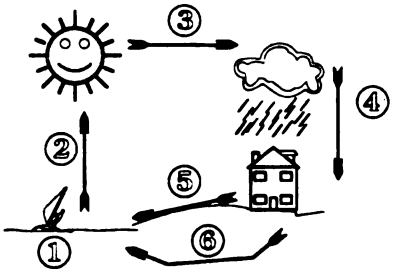
---

7. Using Figure 6 on page 13 of your ChemCom book, answer the following questions. The answers that are possible are: irrigation(I), other agriculture(A), homes and offices (H), manufacturing(F), steam-electric generation(E), mining(M). In the United States, what is the greatest single water use in each of the following? Use all CAPITAL letters in your answer. (Example: HHF...)

A) Hawaii?
B) Alaska?
C) the East?
D) the West?
E) the South?
F) the Midwest?

---

8. Place the following words in their correct location on the diagram. (Example: MDNF...)



A) groundwater
B) precipitation
C) suface water
D) evaporation
E) runoff
F) condensation

---

9. Place the following in order of **increasing** water storage (smallest to largest). Place the options in the correct order. (Example: BDH...)

A) lakes
B) oceans
C) atmospheric moisture
D) groundwater
E) rivers
F) glaciers and ice caps

---

10. Which of the following uses would **produce** "gray water"? Give all possible answers in alphabetical order using all CAPITAL letters. (Example: ABD...)

A) washing hands
B) bathing

C) washing dishes
D) watering the lawn
E) cooking rice
F) shaving

---

11. Which of the following are indirect water uses for preparing an egg for breakfast? Give all possible answers in alphabetical order using all CAPITAL letters. (Example: ABD...)

A) watering the chickens
B) poaching the egg
C) watering the plants for chicken feed
D) cleaning the farm equipment
E) drinking a glass of water
F) washing the pan

```
// Practical Chemistry
// Water, Part A Homework
//
{tex("\noindent {\large \bf ","")}{name()} {tex("}\\","")} {tex("\vskip
-.1in","")} {tex("\noindent {\large \it Practical Chemistry \hfill 1996-97\\ }
","")} {tex("\vskip -.1in","")}{tex("{\noindent \bf pchem}","pchem")}
{tex("\noindent Set ","No.")}{set()}, (Water, Part A Homework). Due
{due_date()} {tex("Give 3 digits for numerical answers.","")} PIN is
{tex("{\footnotesize  ","")}{pin()}{tex("}","")} {tex("\vskip .1in","")}
{tex("\hrule width2.0in height0.8pt
\hfill","----------------------------------------------------")}{tex("\vskip
.15in","")}
//
//
// Bold Word Matching-1
//
#m1="SI unit of length"
#m2="SI unit of volume"
#m3="separation of a solid from a liquid by passing it through a porous paper"
#m4="liquid collected after filtration"
#m5="separation of two substances using differences in boiling point"
{tex("{\bf ","")}{question()}{tex(".}","")}  Match the following words from
Water, Part A, with their meanings:  meter, liter, filtration, filtrate,
distillation.  Use all CAPITAL letters in your answer.  (Example:  ADE.....)
{tex("\begin{quote}","")}
#colzwy1=random(1,24,1)
A)
{choose(colzwy1,m5,m2,m1,m4,m3,m5,m2,m1,m4,m3,m3,m5,m2,m1,m4,m5,m2,m1,m4,m3,m5,m
2,m1,m4)}{tex("\\","")}
B)
{choose(colzwy1,m3,m5,m2,m1,m4,m4,m3,m5,m2,m1,m5,m2,m1,m4,m3,m1,m4,m3,m5,m2,m1,m
4,m3,m5)}{tex("\\","")}
C)
{choose(colzwy1,m4,m3,m5,m2,m1,m3,m5,m2,m1,m4,m4,m3,m5,m2,m1,m3,m5,m2,m1,m4,m4,m
3,m5,m2)}{tex("\\","")}
D)
{choose(colzwy1,m1,m4,m3,m5,m2,m1,m4,m3,m5,m2,m1,m4,m3,m5,m2,m4,m3,m5,m2,m1,m3,m
5,m2,m1)}{tex("\\","")}
E)
{choose(colzwy1,m2,m1,m4,m3,m5,m2,m1,m4,m3,m5,m2,m1,m4,m3,m5,m2,m1,m4,m3,m5,m2,m
1,m4,m3)}{tex("\\","")}
{tex("\end{quote}","")}

#ans=choose(colzwy1,"DEBCA","EACDB","ABDEC","BCEAD","CDABE","DECBA","EABDC","ACD
EB","CBEAD","BDACE","DEACB","EBCDA","BADEC","ACEBD","CDBAE","BECDA","EADBC","ACB
ED","CDEAB","DBACE","BECDA","EACBD","ADBEC","DCEAB")
```

```
[ans]
//
//
// Bold Word Matching-2
//
#m1="ability to carry a current"
#m2="nature's water purification system"
#m3="water on the surface of the planet"
#m4="water that collects underground"
#m5="poreous rocks that hold water"
{tex("{\bf ","")}{question()}{tex(".}","")}  Match the following words from
Water, Part A, with their meanings:  electrical conductivity, hydrologic cycle,
surface water, groundwater, aquifers.  Use all CAPITAL letters in your answer.
(Example:  DBC...)
{tex("\begin{quote}","")}
#colzwy1=random(1,24,1)
A)
{choose(colzwy1,m5,m2,m1,m4,m3,m5,m2,m1,m4,m3,m3,m5,m2,m1,m4,m5,m2,m1,m4,m3,m5,m
2,m1,m4)}{tex("\\","")}
B)
{choose(colzwy1,m3,m5,m2,m1,m4,m4,m3,m5,m2,m1,m5,m2,m1,m4,m3,m1,m4,m3,m5,m2,m1,m
4,m3,m5)}{tex("\\","")}
C)
{choose(colzwy1,m4,m3,m5,m2,m1,m3,m5,m2,m1,m4,m4,m3,m5,m2,m1,m3,m5,m2,m1,m4,m4,m
3,m5,m2)}{tex("\\","")}
D)
{choose(colzwy1,m1,m4,m3,m5,m2,m1,m4,m3,m5,m2,m1,m4,m3,m5,m2,m4,m3,m5,m2,m1,m3,m
5,m2,m1)}{tex("\\","")}
E)
{choose(colzwy1,m2,m1,m4,m3,m5,m2,m1,m4,m3,m5,m2,m1,m4,m3,m5,m2,m1,m4,m3,m5,m2,m
1,m4,m3)}{tex("\\","")}
{tex("\end{quote}","")}

#ans=choose(colzwy1,"DEBCA","EACDB","ABDEC","BCEAD","CDABE","DECBA","EABDC","ACD
EB","CBEAD","BDACE","DEACB","EBCDA","BADEC","ACEBD","CDBAE","BECDA","EADBC","ACB
ED","CDEAB","DBACE","BECDA","EACBD","ADBEC","DCEAB")
[ans]

{tex("\hrule width2.0in height0.8pt
\hfill","----------------------------------------------------")}{tex("\vskip
.15in","")}
//
//
//
//SI units choices (Water A, Hmwk)
//
```

```
#ranA=random(1,3,1)
#ranB=random(1,3,1)
#ranC=random(1,4,1)
#ranD=random(1,3,1)
#ranE=random(1,3,1)
#ranF=random(1,3,1)
{tex("{\bf ","")}{question()}{tex(".}","")} Which SI unit would most likely be
used to measure each of the following things: meter(m), millimeter(mm),
liter(L), milliliter(mL), kilogram(kg), gram(g)? Use each answer only once and
place a comma and a space between each answer. NO COMMA AT THE END. (Example:
m,mm,L, ...)
{tex("\begin{quote}","")}
A) Thickness of a {choose(ranA,"dime","quarter","penny")}{tex("\\","")}
B) Volume of {choose(ranB,"aspirin tablet","thimble","teaspoon")}{tex("\\","")}
C) {choose(ranC,"Milk","Pop","Distilled water","Liquid drain
cleaner")}{tex("\\","")}
D) Mass of a {choose(ranD,"staple","paper clip","pencil lead")}{tex("\\","")}
E) Height of {choose(ranE,"table","person","room")}{tex("\\","")}
F) {choose(ranF,"Oranges","Bulk foods","Meat")}{tex("\\","")}
{tex("\end{quote}","")}
#ans="mm,mL,L,mg,m,kg"
[ans]
//
//
//Metric conversions (Water A, Hmwk)
//
#mc=random(255.0,293.0,0.2)
{tex("{\bf ","")}{question()}{tex(".}","")} Complete the following metric
conversion. (Example: 234.5)
{tex("\begin{quote}","")}
{mc:".1f"} cm = ......km{tex("\end{quote}","")}
[mc/100000:4]
//
//
//Metric conversions (Water A, Hmwk)
//
#mc=random(113.0,196.0,0.2)
{tex("{\bf ","")}{question()}{tex(".}","")} Complete the following metric
conversion. (Example: 234.5)
{tex("\begin{quote}","")}
{mc:".1f"} L = ......mL{tex("\end{quote}","")}
[mc*1000:4]
//
//
//Metric conversions (Water A, Hmwk)
//
```

```
#mc=random(1.0,3.0,0.2)
{tex("{\bf ","")}{question()}{tex(".}","")}  Complete the following metric
conversion.  (Example:  234.5)
{tex("\begin{quote}","")}
{mc:".1f"} kg = ......g{tex("\end{quote}","")}
[mc*1000:2]
//
{tex("\hrule width2.0in height0.8pt
\hfill","----------------------------------------------------")}{tex("\vskip
.15in","")}
//
//
//Figure 6, Page 13 (Water A, Hmwk)
//
#m1="Hawaii?"
#a1="I"
#m2="the East?"
#a2="F"
#m3="the South?"
#a3="I"
#m4="the Midwest?"
#a4="I"
#m5="the West?"
#a5="I"
#m6="Alaska?"
#a6="M"
{tex("{\bf ","")}{question()}{tex(".}","")}  Using Figure 6 on page 13 of your
ChemCom book, answer the following questions.  The answers that are possible
are:  irrigation(I), other agriculture(A), homes and offices (H),
manufacturing(F), steam-electric generation(E), mining(M).   In the United
States, what is the greatest single water use in each of the following?  Use
all CAPITAL letters in your answer.  (Example:  HHF...)
{tex("\begin{quote}","")}
#colzwy1=random(1,24,1)
A)
{choose(colzwy1,m5,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m1,m4,m3,m5,m6,m2,m1,m4,m3,m
5,m6,m2)}{tex("\\","")}
B)
{choose(colzwy1,m3,m5,m6,m2,m1,m4,m4,m3,m5,m6,m2,m1,m5,m6,m2,m1,m4,m3,m3,m5,m6,m
2,m1,m4)}{tex("\\","")}
C)
{choose(colzwy1,m4,m3,m5,m6,m2,m1,m3,m5,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m5,m6,m2,m
1,m4,m3)}{tex("\\","")}
D)
{choose(colzwy1,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m6,m2,m4,m3,m5,m6,m2,m1,m2,m1,m4,m
3,m5,m6)}{tex("\\","")}
```

```
E)
{choose(colzwy1,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m6,m6,m2,m1,m
4,m3,m5)}{tex("\\","")}
F)
{choose(colzwy1,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m4,m3,m5,m
6,m2,m1)}{tex("\\","")}
{tex("\end{quote}","")}

!Recheck your answers.
#ans1=choose(colzwy1,a5,a6,a2,a1,a4,a3,a5,a6,a2,a1,a4,a3,a1,a4,a3,a5,a6,a2,a1,a4
,a3,a5,a6,a2)
#ans2=choose(colzwy1,a3,a5,a6,a2,a1,a4,a4,a3,a5,a6,a2,a1,a5,a6,a2,a1,a4,a3,a3,a5
,a6,a2,a1,a4)
#ans3=choose(colzwy1,a4,a3,a5,a6,a2,a1,a3,a5,a6,a2,a1,a4,a3,a5,a6,a2,a1,a4,a5,a6
,a2,a1,a4,a3)
#ans4=choose(colzwy1,a1,a4,a3,a5,a6,a2,a1,a4,a3,a5,a6,a2,a4,a3,a5,a6,a2,a1,a2,a1
,a4,a3,a5,a6)
#ans5=choose(colzwy1,a2,a1,a4,a3,a5,a6,a2,a1,a4,a3,a5,a6,a2,a1,a4,a3,a5,a6,a6,a2
,a1,a4,a3,a5)
#ans6=choose(colzwy1,a6,a2,a1,a4,a3,a5,a6,a2,a1,a4,a3,a5,a6,a2,a1,a4,a3,a5,a4,a3
,a5,a6,a2,a1)
[ans1+ans2+ans3+ans4+ans5+ans6]
//
{tex("\hrule width2.0in height0.8pt
\hfill","----------------------------------------------------")}{tex("\vskip
.15in","")}
//
//
//Hydrologic Cycle (graphic)
//
#r1="suface water"
#r2="evaporation"
#r3="condensation"
#r4="precipitation"
#r5="runoff"
#r6="groundwater"
{tex("{\bf ","")}{question()}{tex(".}","")}  Place the following words in their
correct location on the diagram.  (Example:  MDNF...){tex("\\","")}
{tex("\\","")}
{tex("\centerline{ \epsfxsize=2.8 in \hskip .15in
\epsffile{/teacher/CAPA/graphics/h2o-cyc1.eps}}"," ")}
{tex("\\","")}
#colzwy1=random(1,24,1)
{tex("\begin{quote}","")}
A)
{choose(colzwy1,r5,r6,r2,r1,r4,r3,r5,r6,r2,r1,r4,r3,r1,r4,r3,r5,r6,r2,r1,r4,r3,r
```

```
5,r6,r2)}{tex("\\","")}
B)
{choose(colzwy1,r3,r5,r6,r2,r1,r4,r4,r3,r5,r6,r2,r1,r5,r6,r2,r1,r4,r3,r3,r5,r6,r
2,r1,r4)}{tex("\\","")}
C)
{choose(colzwy1,r4,r3,r5,r6,r2,r1,r3,r5,r6,r2,r1,r4,r3,r5,r6,r2,r1,r4,r5,r6,r2,r
1,r4,r3)}{tex("\\","")}
D)
{choose(colzwy1,r1,r4,r3,r5,r6,r2,r1,r4,r3,r5,r6,r2,r4,r3,r5,r6,r2,r1,r2,r1,r4,r
3,r5,r6)}{tex("\\","")}
E)
{choose(colzwy1,r2,r1,r4,r3,r5,r6,r2,r1,r4,r3,r5,r6,r2,r1,r4,r3,r5,r6,r6,r2,r1,r
4,r3,r5)}{tex("\\","")}
F)
{choose(colzwy1,r6,r2,r1,r4,r3,r5,r6,r2,r1,r4,r3,r5,r6,r2,r1,r4,r3,r5,r4,r3,r5,r
6,r2,r1)}{tex("\\","")}
{tex("\end{quote}","")}

!The hydrologic cycle is covered on page 16 in your Chemcom book.
#ans=choose(colzwy1,"DEBCAF","EFCDBA","FADECB","ABEFDC","BCFAED","CDABFE","DECBA
F","EFBDCA","FADEBC","ACEFDB","CBFAED","BDACFE","AECDBF","EFDACB","FBAEDC","BCEF
AD","CDFBEA","DABCFE","ADBFCE","DEFABC","ECADFB","CBDEAF","BFECDA","FACBED")
[ans]
//
{tex("\hrule width2.0in height0.8pt
\hfill","----------------------------------------------------------")}{tex("\vskip
.15in","")}
//
//
// Water Storage Systems (Water A, Hmwk)
//
#r1="rivers"
#r2="atmospheric moisture"
#r3="lakes"
#r4="groundwater"
#r5="glaciers and ice caps"
#r6="oceans"
{tex("{\bf ","")}{question()}{tex(".}","")}  Place the following in order of
{tex("{\bf increasing}","increasing")} water storage (smallest to largest).
Place the options in the correct order.  (Example:  BDH...)
{tex("\begin{quote}","")}
#colzwy1=random(1,24,1)
A)
{choose(colzwy1,r5,r6,r2,r1,r4,r3,r5,r6,r2,r1,r4,r3,r1,r4,r3,r5,r6,r2,r1,r4,r3,r
5,r6,r2)}{tex("\\","")}
B)
```

```
{choose(colzwy1,r3,r5,r6,r2,r1,r4,r4,r3,r5,r6,r2,r1,r5,r6,r2,r1,r4,r3,r3,r5,r6,r
2,r1,r4)}{tex("\\","")}
C)
{choose(colzwy1,r4,r3,r5,r6,r2,r1,r3,r5,r6,r2,r1,r4,r3,r5,r6,r2,r1,r4,r5,r6,r2,r
1,r4,r3)}{tex("\\","")}
D)
{choose(colzwy1,r1,r4,r3,r5,r6,r2,r1,r4,r3,r5,r6,r2,r4,r3,r5,r6,r2,r1,r2,r1,r4,r
3,r5,r6)}{tex("\\","")}
E)
{choose(colzwy1,r2,r1,r4,r3,r5,r6,r2,r1,r4,r3,r5,r6,r2,r1,r4,r3,r5,r6,r6,r2,r1,r
4,r3,r5)}{tex("\\","")}
F)
{choose(colzwy1,r6,r2,r1,r4,r3,r5,r6,r2,r1,r4,r3,r5,r6,r2,r1,r4,r3,r5,r4,r3,r5,r
6,r2,r1)}{tex("\\","")}
{tex("\end{quote}","")}
#ans=choose(colzwy1,"DEBCAF","EFCDBA","FADECB","ABEFDC","BCFAED","CDABFE","DECBA
F","EFBDCA","FADEBC","ACEFDB","CBFAED","BDACFE","AECDBF","EFDACB","FBAEDC","BCEF
AD","CDFBEA","DABCFE","ADBFCE","DEFABC","ECADFB","CBDEAF","BFECDA","FACBED")
[ans]
//
{tex("\hrule width2.0in height0.8pt
\hfill","------------------------------------------------------")}{tex("\vskip
.15in","")}
//
//
//Gray Water (Water A, Hmwk)
//
#r1="bathing"
#r2="washing dishes"
#r3="shaving"
#r4="washing hands"
#w5="cooking rice"
#w6="watering the lawn"
{tex("{\bf ","")}{question()}{tex(".}","")} Which of the following uses would
{tex("{\bf produce}","produce")} "gray water"? Give all possible answers in
alphabetical order using all CAPITAL letters. (Example: ABD...)
{tex("\begin{quote}","")}
#colzwy1=random(1,24,1)
A)
{choose(colzwy1,w5,w6,r2,r1,r4,r3,w5,w6,r2,r1,r4,r3,r1,r4,r3,w5,w6,r2,r1,r4,r3,w
5,w6,r2)}{tex("\\","")}
B)
{choose(colzwy1,r3,w5,w6,r2,r1,r4,r4,r3,w5,w6,r2,r1,w5,w6,r2,r1,r4,r3,r3,w5,w6,r
2,r1,r4)}{tex("\\","")}
C)
{choose(colzwy1,r4,r3,w5,w6,r2,r1,r3,w5,w6,r2,r1,r4,r3,w5,w6,r2,r1,r4,w5,w6,r2,r
```

```
1,r4,r3)}{tex("\\","")}
D)
{choose(colzwy1,r1,r4,r3,w5,w6,r2,r1,r4,r3,w5,w6,r2,r4,r3,w5,w6,r2,r1,r2,r1,r4,r
3,w5,w6)}{tex("\\","")}
E)
{choose(colzwy1,r2,r1,r4,r3,w5,w6,r2,r1,r4,r3,w5,w6,r2,r1,r4,r3,w5,w6,w6,r2,r1,r
4,r3,w5)}{tex("\\","")}
F)
{choose(colzwy1,w6,r2,r1,r4,r3,w5,w6,r2,r1,r4,r3,w5,w6,r2,r1,r4,r3,w5,r4,r3,w5,w
6,r2,r1)}{tex("\\","")}
{tex("\end{quote}","")}
#ans=choose(colzwy1,"BCDE","CDEF","ADEF","ABEF","ABCF","ABCD","BCDE","BDEF","ADE
F","ACEF","ABCF","ABCD","ACDE","ADEF","ABEF","BCEF","BCDF","ABCD","ABDF","ADEF",
"ACDE","BCDE","BCEF","ABCF")
[ans]
//
{tex("\hrule width2.0in height0.8pt
\hfill","----------------------------------------------------")}{tex("\vskip
.15in","")}
//
//
//Indirect Water Uses (Water A, Hmwk)
//
#r1="watering the plants for chicken feed"
#r2="cleaning the farm equipment"
#r3="watering the chickens"
#w4="poaching the egg"
#w5="washing the pan"
#w6="drinking a glass of water"
{tex("{\bf ","")}{question()}{tex(".}","")} Which of the following are
indirect water uses for preparing an egg for breakfast? Give all possible
answers in alphabetical order using all CAPITAL letters. (Example: ABD...)
{tex("\begin{quote}","")}
#colzwy1=random(1,24,1)
A)
{choose(colzwy1,w5,w6,r2,r1,w4,r3,w5,w6,r2,r1,w4,r3,r1,w4,r3,w5,w6,r2,r1,w4,r3,w
5,w6,r2)}{tex("\\"," ")}
B)
{choose(colzwy1,r3,w5,w6,r2,r1,w4,w4,r3,w5,w6,r2,r1,w5,w6,r2,r1,w4,r3,r3,w5,w6,r
2,r1,w4)}{tex("\\"," ")}
C)
{choose(colzwy1,w4,r3,w5,w6,r2,r1,r3,w5,w6,r2,r1,w4,r3,w5,w6,r2,r1,w4,w5,w6,r2,r
1,w4,r3)}{tex("\\"," ")}
D)
{choose(colzwy1,r1,w4,r3,w5,w6,r2,r1,w4,r3,w5,w6,r2,w4,r3,w5,w6,r2,r1,r2,r1,w4,r
3,w5,w6)}{tex("\\"," ")}
```

```
E)
{choose(colzwyl,r2,r1,w4,r3,w5,w6,r2,r1,w4,r3,w5,w6,r2,r1,w4,r3,w5,w6,w6,r2,r1,w
4,r3,w5)}{tex("\\"," ")}
F)
{choose(colzwyl,w6,r2,r1,w4,r3,w5,w6,r2,r1,w4,r3,w5,w6,r2,r1,w4,r3,w5,w4,r3,w5,w
6,r2,r1)}{tex("\\"," ")}
{tex("\end{quote}","")}

!An indirect water use in one where you, personally, do not see the water used.
#ans=choose(colzwyl,"BDE","CEF","ADF","ABE","BCF","ACD","CDE","BEF","ADF","ACE",
"BCF","ABD","ACE","DEF","ABF","BCE","CDF","ABD","ABD","DEF","ACE","BCD","BEF","A
CF")
[ans]
```

BRONSON, JANET

Practical Chemistry *Fall 1995*

pchem Set 4. (Water, Part A Retest). Due 10/04/95 14:30
Give 3 digits for numerical answers. PIN is 8919

---

1. Match the following words with their meanings: aquifer, distillation, filtration, hydrologic cycle, liter, meter. Use all CAPITAL letters in your answer. (Example: ABCD...)

A) nature's water purification system
B) separation of two liquids by boiling point
C) porous rocks that hold water
D) SI unit of length
E) SI unit of volume
F) separation of a solid from a liquid

---

2. Complete the following metric conversion. (Example: 345)

288.2 cm = ...km

3. Place a greater than (>), less than (<), or equal to (=) sign in each of the following situations. (Example: ==<)

A) 1 L ..... 1000 mL
B) 26.8 cm ..... 26800 mm
C) 36 g ..... 3600 kg

---

4. Place the following in order of **decreasing** water storage (largest to smallest). Use all CAPITAL letters in your answer. (Example: ABCD...)

A) glaciers and ice caps
B) atmospheric moisture
C) rivers
D) groundwater
E) lakes
F) oceans

---

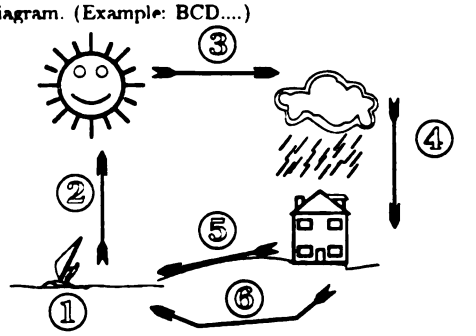
5. Which of the following could be formed from runoff? Give all possible answers in alphabetical order using all capitals. (Example: BCD....)

A) lakes
B) rain
C) rivers
D) glaciers
E) snow
F) oceans
G) clouds
H) fog

6. Which of the following could be considered precipitation? Give all possible answers in alphabetical order using all capitals. (Example: ABCDE.....) (Example: BCD....)

A) humidity
B) sleet
C) rain
D) groundwater
E) rivers
F) snow

7. Place the following words in their correct location on the diagram. (Example: BCD....)



A) precipitation
B) suface water
C) evaporation
D) groundwater
E) runoff
F) condensation

ESSAY QUESTION

8. Give 3 direct and 3 indirect water uses involved in placing a steak on your plate for supper. Please write your answer on a separate piece of paper and turn it in.

ESSAY QUESTION

9. Explain the difference between "clean" and "gray" water. Please write your answer on a separate piece of paper and turn it in.

Doe, John

Practical Chemistry *Fall 1995*

pchem Set 4. (Water, Part A Retest). Due 10/04/95 14:30
Give 3 digits for numerical answers. PIN is 7499

---

1. Match the following words with their meanings: aquifer, distillation, filtration, hydrologic cycle, liter, meter. Use all CAPITAL letters in your answer. (Example: ABCD...)

A) porous rocks that hold water
B) separation of two liquids by boiling point
C) SI unit of length
D) SI unit of volume
E) separation of a solid from a liquid
F) nature's water purification system

---

2. Complete the following metric conversion. (Example: 345)

260.6 cm = ...km

3. Place a greater than (>), less than (<), or equal to (=) sign in each of the following situations. (Example: ==<)

A) 1 L ..... 100 mL
B) 26.8 cm ..... 26800 mm
C) 36 g ..... 3600 kg

---

4. Place the following in order of **decreasing** water storage (largest to smallest). Use all CAPITAL letters in your answer. (Example: ABCD...)

A) groundwater
B) oceans
C) lakes
D) glaciers and ice caps
E) rivers
F) atmospheric moisture

---

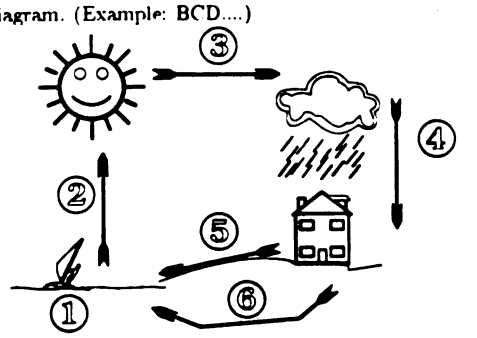
5. Which of the following could be formed from runoff? Give all possible answers in alphabetical order using all capitals. (Example: BCD....)

A) lakes
B) glaciers
C) oceans
D) rivers
E) rain
F) snow
G) fog
H) clouds

6. Which of the following could be considered precipitation? Give all possible answers in alphabetical order using all capitals. (Example: ABCDE.....) (Example: BCD....)

A) humidity
B) groundwater
C) rivers
D) snow
E) rain
F) sleet

7. Place the following words in their correct location on the diagram. (Example: BCD....)



A) precipitation
B) groundwater
C) runoff
D) condensation
E) suface water
F) evaporation

ESSAY QUESTION

8. Give 3 direct and 3 indirect water uses involved in placing a steak on your plate for supper. Please write your answer on a separate piece of paper and turn it in.

ESSAY QUESTION

9. Explain the difference between "clean" and "gray" water. Please write your answer on a separate piece of paper and turn it in.

```
//Practical Chemistry
//Water, Part A Retest
//
{tex("\noindent {\large \bf ","")}{name()} {tex("}\\","")} {tex("\vskip
-.1in","")} {tex("\noindent {\large \it Practical Chemistry \hfill Fall 1995\\
} ","")} {tex("\vskip -.1in","")}{tex("{\noindent \bf pchem}","pchem")}
{tex("\noindent Set ","No.")}{set()}, (Water, Part A Retest). Due {due_date()}
{tex("Give 3 digits for numerical answers.","")} PIN is {tex("{\footnotesize
","")}{pin()}{tex("}","")} {tex("\vskip .1in \pagestyle{plain} ","")}

{tex("\hrule width3.5in height0.6pt
\hfill","----------------------------------------------------------")}{tex("\vskip
.15in","")}
//
//
//Water(A Quiz), Matching(6) bold words from Part A
//
#r1="porous rocks that hold water"
#r2="separation of two liquids by boiling point"
#r3="separation of a solid from a liquid"
#r4="nature's water purification system"
#r5="SI unit of volume"
#r6="SI unit of length"
{tex("{\bf ","")}{question()}{tex(".}","")} Match the following words with
their meanings: aquifer, distillation, filtration, hydrologic cycle, liter,
meter. Use all CAPITAL letters in your answer. (Example: ABCD...)
#colzwy1=random(1,24,1)
{tex("\begin{quote}","")}
A)
{choose(colzwy1,r5,r6,r2,r1,r4,r3,r5,r6,r2,r1,r4,r3,r1,r4,r3,r5,r6,r2,r1,r4,r3,r
5,r6,r2)}{tex("\\","")}
B)
{choose(colzwy1,r3,r5,r6,r2,r1,r4,r4,r3,r5,r6,r2,r1,r5,r6,r2,r1,r4,r3,r3,r5,r6,r
2,r1,r4)}{tex("\\","")}
C)
{choose(colzwy1,r4,r3,r5,r6,r2,r1,r3,r5,r6,r2,r1,r4,r3,r5,r6,r2,r1,r4,r5,r6,r2,r
1,r4,r3)}{tex("\\","")}
D)
{choose(colzwy1,r1,r4,r3,r5,r6,r2,r1,r4,r3,r5,r6,r2,r4,r3,r5,r6,r2,r1,r2,r1,r4,r
3,r5,r6)}{tex("\\","")}
E)
{choose(colzwy1,r2,r1,r4,r3,r5,r6,r2,r1,r4,r3,r5,r6,r2,r1,r4,r3,r5,r6,r6,r2,r1,r
4,r3,r5)}{tex("\\","")}
F)
{choose(colzwy1,r6,r2,r1,r4,r3,r5,r6,r2,r1,r4,r3,r5,r6,r2,r1,r4,r3,r5,r4,r3,r5,r
6,r2,r1)}{tex("\\","")}
```

```
{tex("\end{quote}","")}

#ans=choose(colzwy1,"DEBCAF","EFCDBA","FADECB","ABEFDC","BCFAED","CDABFE","DECBA
F","EFBDCA","FADEBC","ACEFDB","CBFAED","BDACFE","AECDBF","EFDACB","FBAEDC","BCEF
AD","CDFBEA","DABCFE","ADBFCE","DEFABC","ECADFB","CBDEAF","BFECDA","FACBED")
[ans]
//
{tex("\hrule width3.5in height0.6pt
\hfill","----------------------------------------------------")}{tex("\vskip
.15in","")}
//
//
//Water(A Quiz), Metric Conversion
//
#mc=random(255.0,293.0,0.2)
{tex("{\bf ","")}{question()}{tex(".}","")}  Complete the following metric
conversion.  (Example:  345)
{tex("\begin{quote}","")}
{mc:".1f"} cm = ......km {tex("\\","")}
{tex("\end{quote}","")}

#mcans=mc/100000.0
[mcans:4]
//
//
//
//Water(A Quiz), Logic Question about Metric Conversions
//
#ran1=random(1,3,1)
#ran2=random(1,3,1)
#ran3=random(1,3,1)
{tex("{\bf ","")}{question()}{tex(".}","")}  Place a greater than
({tex("$>$",">")}), less than ({tex("$<$","<")}), or equal to
({tex("$=$","=")}) sign in each of the following situations.  (Example:
=={tex("$<$","<")}){tex("\\","")}
{tex("\begin{quote}","")}
A)  1 L ........ {choose(ran1,"100","1000","10")} mL{tex("\\","")}
B)  26.8 cm  ........ {choose(ran2,"2.68","268","26800")} mm{tex("\\","")}
C)  36 g ........ {choose(ran3,"3600","0.036","0.0036")} kg{tex("\\","")}
{tex("\end{quote}","")}

#ans1=choose(ran1,">","=",">")
#ans2=choose(ran2,">","=","<")
#ans3=choose(ran3,"<","=",">")
[ans1+ans2+ans3]
//
```

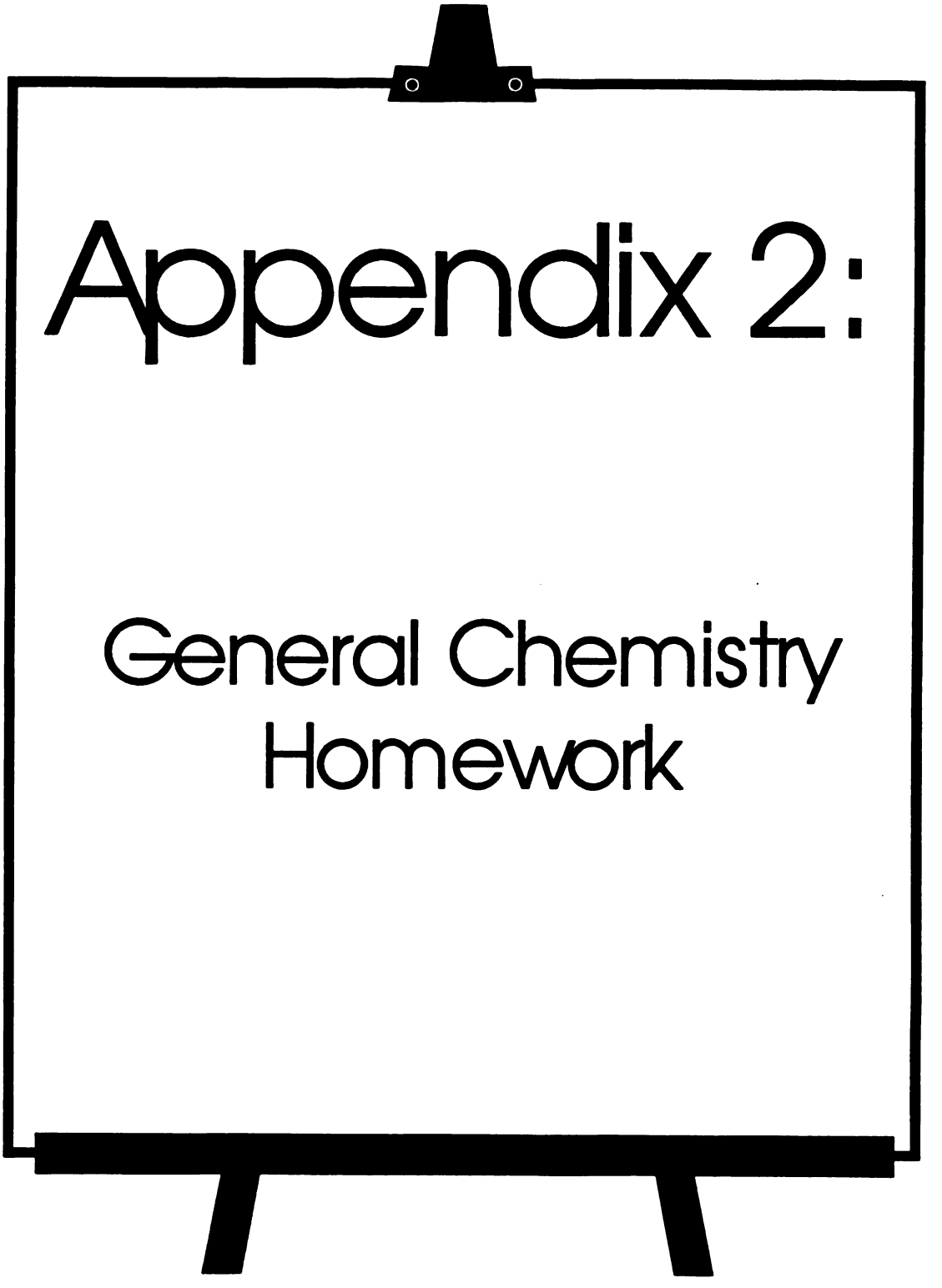
```
{tex("\hrule width3.5in height0.6pt
\hfill","-----------------------------------------------------")}{tex("\vskip
.15in","")}
//
//
//Water(A Quiz), Water Storage
//
#r1="oceans"
#r2="glaciers and ice caps"
#r3="groundwater"
#r4="lakes"
#r5="atmospheric moisture"
#r6="rivers"
{tex("{\bf ","")}{question()}{tex(".}","")}  Place the following in order of
{tex("{\bf decreasing}","decreasing")} water storage (largest to smallest).
Use all CAPITAL letters in your answer.  (Example:  ABCD...)
#colzwy1=random(1,24,1)
{tex("\begin{quote}","")}
A)
{choose(colzwy1,r5,r6,r2,r1,r4,r3,r5,r6,r2,r1,r4,r3,r1,r4,r3,r5,r6,r2,r1,r4,r3,r
5,r6,r2)}{tex("\\","")}
B)
{choose(colzwy1,r3,r5,r6,r2,r1,r4,r4,r3,r5,r6,r2,r1,r5,r6,r2,r1,r4,r3,r3,r5,r6,r
2,r1,r4)}{tex("\\","")}
C)
{choose(colzwy1,r4,r3,r5,r6,r2,r1,r3,r5,r6,r2,r1,r4,r3,r5,r6,r2,r1,r4,r5,r6,r2,r
1,r4,r3)}{tex("\\","")}
D)
{choose(colzwy1,r1,r4,r3,r5,r6,r2,r1,r4,r3,r5,r6,r2,r4,r3,r5,r6,r2,r1,r2,r1,r4,r
3,r5,r6)}{tex("\\","")}
E)
{choose(colzwy1,r2,r1,r4,r3,r5,r6,r2,r1,r4,r3,r5,r6,r2,r1,r4,r3,r5,r6,r6,r2,r1,r
4,r3,r5)}{tex("\\","")}
F)
{choose(colzwy1,r6,r2,r1,r4,r3,r5,r6,r2,r1,r4,r3,r5,r6,r2,r1,r4,r3,r5,r4,r3,r5,r
6,r2,r1)}{tex("\\","")}
{tex("\end{quote}","")}

#ans3=choose(colzwy1,"DEBCAF","EFCDBA","FADECB","ABEFDC","BCFAED","CDABFE","DECB
AF","EFBDCA","FADEBC","ACEFDB","CBFAED","BDACFE","AECDBF","EFDACB","FBAEDC","BCE
FAD","CDFBEA","DABCFE","ADBFCE","DEFABC","ECADFB","CBDEAF","BFECDA","FACBED")
[ans3]
//
{tex("\hrule width3.5in height0.6pt
\hfill","-----------------------------------------------------")}{tex("\vskip
.15in","")}
```

```
//
//
//Water(A Quiz), Definition of Runoff
//
#r1="lakes"
#r2="rivers"
#r3="oceans"
#w4="fog"
#w5="snow"
#w6="glaciers"
#w7="rain"
#w8="clouds"
{tex("{\bf ","")}{question()}{tex(".}","")} Which of the following could be
formed from runoff? Give all possible answers in alphabetical order using all
capitals. (Example: BCD....)
#colzwy1=random(1,24,1)
{tex("\begin{quote}","")}
A)
{choose(colzwy1,w5,w8,w6,r2,w7,r1,w4,r3,w5,w8,w6,r2,w7,r1,w4,r3,w5,w8,w6,r2,w7,r
1,w4,r3)}{tex("\\","")}
B)
{choose(colzwy1,r3,w5,w8,w6,r2,w7,r1,w4,r1,w4,r3,w5,w8,w6,r2,w7,w8,w6,r2,w7,r1,w
4,r3,w5)}{tex("\\","")}
C)
{choose(colzwy1,w4,r3,w5,w8,w6,r2,w7,r1,w6,r2,w7,r1,w4,r3,w5,w8,r2,w7,r1,w4,r3,w
5,w8,w6)}{tex("\\","")}
D)
{choose(colzwy1,r1,w4,r3,w5,w8,w6,r2,w7,w4,r3,w5,w8,w6,r2,w7,r1,w6,r2,w7,r1,w4,r
3,w5,w8)}{tex("\\","")}
E)
{choose(colzwy1,r2,w7,r1,w4,r3,w5,w8,w6,r3,w5,w8,w6,r2,w7,r1,w4,r3,w5,w8,w6,r2,w
7,r1,w4)}{tex("\\","")}
F)
{choose(colzwy1,w6,r2,w7,r1,w4,r3,w5,w8,r2,w7,r1,w4,r3,w5,w8,w6,w7,r1,w4,r3,w5,w
8,w6,r2)}{tex("\\","")}
G)
{choose(colzwy1,w7,r1,w4,r3,w5,w8,w6,r2,w8,w6,r2,w7,r1,w4,r3,w5,w4,r3,w5,w8,w6,r
2,w7,r1)}{tex("\\","")}
H)
{choose(colzwy1,w8,w6,r2,w7,r1,w4,r3,w5,w7,r1,w4,r3,w5,w8,w6,r2,r1,w4,r3,w5,w8,w
6,r2,w7)}{tex("\\","")}
{tex("\end{quote}","")}

#ans4=choose(colzwy1,"BDE","CFG","DEH","AFG","BEH","ACF","BDH","ACG","BEF","CDH"
,"BFG","ACH","EFG","ACD","BEG","ADH","CEH","DFG","BCH","ADF","BCE","ADG","BEH","
AFG")
```

```
[ans4]
//
//
//Water (A Quiz), Definition of Precipitation
//
#r1="rain"
#r2="sleet"
#r3="snow"
#w4="humidity"
#w5="rivers"
#w6="groundwater"
{tex("{\bf ","")}{question()}{tex(".}","")} Which of the following could be
considered precipitation? Give all possible answers in alphabetical order
using all capitals. (Example: ABCDE.....)
 (Example: BCD....)
#colzwy1=random(1,24,1)
{tex("\begin{quote}","")}
A)
{choose(colzwy1,w5,w6,r2,r1,w4,r3,w5,w6,r2,r1,w4,r3,r1,w4,r3,w5,w6,r2,r1,w4,r3,w
5,w6,r2)}{tex("\\","")}
B)
{choose(colzwy1,r3,w5,w6,r2,r1,w4,w4,r3,w5,w6,r2,r1,w5,w6,r2,r1,w4,r3,r3,w5,w6,r
2,r1,w4)}{tex("\\","")}
C)
{choose(colzwy1,w4,r3,w5,w6,r2,r1,r3,w5,w6,r2,r1,w4,r3,w5,w6,r2,r1,w4,w5,w6,r2,r
1,w4,r3)}{tex("\\","")}
D)
{choose(colzwy1,r1,w4,r3,w5,w6,r2,r1,w4,r3,w5,w6,r2,w4,r3,w5,w6,r2,r1,r2,r1,w4,r
3,w5,w6)}{tex("\\","")}
E)
{choose(colzwy1,r2,r1,w4,r3,w5,w6,r2,r1,w4,r3,w5,w6,r2,r1,w4,r3,w5,w6,w6,r2,r1,w
4,r3,w5)}{tex("\\","")}
F)
{choose(colzwy1,w6,r2,r1,w4,r3,w5,w6,r2,r1,w4,r3,w5,w6,r2,r1,w4,r3,w5,w4,r3,w5,w
6,r2,r1)}{tex("\\","")}
{tex("\end{quote}","")}

#ans=choose(colzwy1,"BDE","CEF","ADF","ABE","BCF","ACD","CDE","BEF","ADF","ACE",
"BCF","ABD","ACE","DEF","ABF","BCE","CDF","ABD","ABD","DEF","ACE","BCD","BEF","A
CF")
[ans]
//
//
//Water(A Quiz), Hydrologic Cycle
//
#r1="suface water"
```

```
#r2="evaporation"
#r3="condensation"
#r4="precipitation"
#r5="runoff"
#r6="groundwater"
{tex("{\bf ","")}{question()}{tex(".}","")}  Place the following words in their
correct location on the diagram.  (Example:  BCD....){tex("\\","")}
{tex("\centerline{ \epsfxsize=3.0in \hskip .15in
\epsffile{/teacher/CAPA/graphics/h2o-cyc1.eps}}"," ")}
{tex("\\","")}
#colzwy1=random(1,24,1)
{tex("\begin{quote}","")}
A)
{choose(colzwy1,r5,r6,r2,r1,r4,r3,r5,r6,r2,r1,r4,r3,r1,r4,r3,r5,r6,r2,r1,r4,r3,r
5,r6,r2)}{tex("\\","")}
B)
{choose(colzwy1,r3,r5,r6,r2,r1,r4,r4,r3,r5,r6,r2,r1,r5,r6,r2,r1,r4,r3,r3,r5,r6,r
2,r1,r4)}{tex("\\","")}
C)
{choose(colzwy1,r4,r3,r5,r6,r2,r1,r3,r5,r6,r2,r1,r4,r3,r5,r6,r2,r1,r4,r5,r6,r2,r
1,r4,r3)}{tex("\\","")}
D)
{choose(colzwy1,r1,r4,r3,r5,r6,r2,r1,r4,r3,r5,r6,r2,r4,r3,r5,r6,r2,r1,r2,r1,r4,r
3,r5,r6)}{tex("\\","")}
E)
{choose(colzwy1,r2,r1,r4,r3,r5,r6,r2,r1,r4,r3,r5,r6,r2,r1,r4,r3,r5,r6,r6,r2,r1,r
4,r3,r5)}{tex("\\","")}
F)
{choose(colzwy1,r6,r2,r1,r4,r3,r5,r6,r2,r1,r4,r3,r5,r6,r2,r1,r4,r3,r5,r4,r3,r5,r
6,r2,r1)}{tex("\\","")}
{tex("\end{quote}","")}

#ans=choose(colzwy1,"DEBCAF","EFCDBA","FADECB","ABEFDC","BCFAED","CDABFE","DECBA
F","EFBDCA","FADEBC","ACEFDB","CBFAED","BDACFE","AECDBF","EFDACB","FBAEDC","BCEF
AD","CDFBEA","DABCFE","ADBFCE","DEFABC","ECADFB","CBDEAF","BFECDA","FACBED")
[ans]
//
{tex("\hrule width3.5in height0.6pt
\hfill","----------------------------------------------------")}{tex("\vskip
.15in","")}
//
//
//Water(A Quiz) Direct and Indirect Water Uses Essay
//
{tex("{\noindent \bf ESSAY QUESTION}","ESSAY QUESTION")}{tex("\\","")}
{tex("\vskip .05in","")}
```

```
{tex("{\bf ","")}{question()}{tex(".}","")} Give 3 direct and 3 indirect water
uses involved in placing a steak on your plate for supper. Please write your
answer on a separate piece of paper and turn it in.{tex("\\","")}

["3 direct and 3 indirect water uses"]
//
{tex("\hrule width3.5in height0.6pt
\hfill","----------------------------------------------------")}{tex("\vskip
.15in","")}
//
//
//Water(A Quiz) Clean and Pure Water Uses Essay
//
{tex("{\noindent \bf ESSAY QUESTION}","ESSAY QUESTION")}{tex("\\","")}
{tex("\vskip .05in","")}
{tex("{\bf ","")}{question()}{tex(".}","")} Explain the difference between
"clean" and "gray" water. Please write your answer on a separate piece of
paper and turn it in.{tex("\\","")}

["clean water vs. gray water"]
```



Appendix 2:

General Chemistry Homework

BRONSON, JANET

General Chemistry *Fall 1995*

pchem Set 1, (Unit1, Chapter 1, 2, and 3). Due 09/19/95 14:30 Give 3 digits for numerical answers. PIN is 8595

---

1. March the following bold words from chapters 1, 2, and 3 with their definitions: pure science, applied science, chemistry, scientific method, experiments, scientific law, hypothesis, theory, controlled experiment, data. (Example: AJD...)

A) putting science discovery to work
B) general explanation for observations
C) procedures that enable scientists to gather facts
D) statement of a relationship between facts
E) search for a better understanding of our world
F) study of matter and the changes it undergoes
G) way scientists go about solving problems
H) changing variables one at a time
I) results of an experiment
J) educated guess

2. March the following bold words from chapters 1, 2, and 3 with their definitions: quantity, base units, derived units, precision, accuracy, significant figures, absolute error, scientific notation, conversion factors, dimentional analysis. (Example: AJD...)

A) difference between observed and true values
B) factor-label method of problem solving
C) numbers used to convert from one unit to another
D) reproducability of a series of measurements
E) combinations of SI base units
F) things that can be measured
G) parts of a number we are sure are correct
H) how close the a measurement is to the true value
I) a number times 10 to a power
J) fundamental units of the SI system

---

3. Occasionally we will have to find areas and volumes of very small objects. For practice, calculate the area of a rectangle with a length of 1.22×10^{-9} centimeters and a width of 3.71×10^{-8} centimeters. Give your answer in units of cm^2. (Example: 4653)

4. We will need to find the square-roots of small numbers. Use your calculator to evaluate the square root of 2.38×10^{-23}. (Example: 4.653)

5. Test your calculator skills by verifying that $(8.380)^2$ equals 70.22 and that $(8.380)^3$ equals 588.5. Now, the challenge, find the value of $(8.380)^{2.550}$. (Example: 4653)

6. We will use many linear equations later in the term with the form y = a + bx where "a" and "b" are numbers determined in experiments and "x" is known. What is the value of "y" for the case in which a=20.67 , b=0.592, and x=59.58? (Example: 4653)

7. Some linear equations will have to be solved for "x" because "y" can be measured. What is the value of "x" in the linear equation, y=a+bx, for the case in which a=62.15, b=0.529, and y=74.66? (Example: 4653)

8. You probably could use some more practice solving for "x." What is the value of "x" in the linear equation, y=a+bx, for the case in which a=66.75 , b=0.535, and y=80.16? (Example: 4653)

9. Very often we will use equations with exponential or logarithmic functions. What is the value of "y" in the equation y = a log(x), when a = 9.65 and x = 4.91? Note that 'log' represent the logarithm function to the base ten. (Example: 4653)

10. Now let's try a more challenging equation using logarithms. What is the value of "y" in the equation log(y) = 3.810 x, when x = 8.00? (Example: 4653)

---

11. Place the following steps of the scientific method in the correct order. (Exapmle: BDC...)

A) Forming hypothesis
B) Collecting observations
C) Stating the problem
D) Modifying theories
E) Forming theories
F) Searching for scientific laws

---

12. You are asked to do an experiment to determine the mass of detergent necessary to removeoil from different kinds of fabrics. You set up the experiment by taking five strips of cotton fabric, each the same size and placing 0.1 gram of a certain kind of black oil on each. Each strip is placed in an identical test tube containing 10 mL of water. In the first test tube, 0.1 gram of detergent is added. In the second, 0.2 grams of detergent is added. This is repeated so that the five test tubes contain 0.1 to0.5 grams of detergent. The tubes are shaken 10 times each, and the cotton strips are examined for signs of oil. The experiment is repeated with other kinds of cloth. Give all the controlled variables.

A) kind of oil
B) amount of detergent
C) kind of cloth
D) amount of water
E) time in detergent
F) number of shakes

---

13. The numbers following show the ocean water temperature in a cove in Gloucester, Massachusetts, on the first day of the month for a period of one year. Prepare a graph to illustrate this data. Then, estimate the temperature of the water in the cove on April 15. Jan. (3.8), Feb. (0.9), March

(1.1), April (2.5), May (5.2), June (10.1), July (15.5), Aug. (19.0), Sept. (18.5), Oct. (15.5), Nov. (9.2), Dec. (5.8)

14. Turn in your graph with your name on it to be graded by hand. Remeber to use the steps for building a good graph.

---

15. Identify the metric units represented by the following names. (Example: cs, mm, ...)

A) millisecond
B) second
C) kilogram
D) meter
E) centimeter
F) gram

16. Which SI unit is most closely equivalent to the following quantities. (Example: mg, cl, ...)

A) the mass of a paper clip
B) the diameter of a beach umbrella
C) the mass of a head of cabbage
D) the thickness of a dime
E) the volume of a 1/4-teaspoon measuring spoon
F) the volume of a big glup

17. Give the appropriate SI derived unit. (Example: mm3, cg*m2/s, ...)

A) 8.1 kg/(0.45 cm x 4.0 cm)
B) 18 grams/4.5 kelvins

---

18. Which of the following can be measured? (Example: ADF...)

A) personallity
B) volume
C) thickness
D) density
E) area
F) beauty
G) color
H) speed

---

19. Determine the number of significant figures in each of the following measurements. (Example: 6, 8, 4, ...)

A) 250 g
B) 4050. mL
C) 3.05 cm
D) 0.0620 g
E) 0.505 cm
F) 1.0 cm

20. Perform the following calculations and report each answer to the correct number of significant figures. (Example: 354 mm2, ...)

A) 5.22 m x 82.7 m
B) 4.08 g / 0.061 g

21. Perform the following calculations and report each answer to the correct number of significant figures. (Example: 354 mm2, ...)

A) 4.375 g + 14.62 g + 327.9 g
B) 16.748 s - 1.512 s

---

22. Three scientists measure the standard meter bar at the International Bureau of Standards. Their measurements are 1.08 m, 1.07 m and 1.07 m. Are the measurements accurate, precise, or both?

---

23. A standard 20.00-g mass is used to check the accuracy of a laboratory balance. The balance indicates a mass of 19.77 g when the standard mass is measured. What is the percent error of this measurement?

24. At a track meet, you time a friend running 100-m at 11.14 seconds. The officials time her at 20.00 seconds. What is your percent error?

---

25. How many millimeters are equal to 6.40 meters? (Example: 1000 g = 1 kg, 1000 g / 1 kg)

A) What equality is the basis for solving this problem?
B) What is conversion factor that must be used?

26. Calculate the number of centimeters in 7.00 yards. For reference, there are exactly 36 inch/yard and exactly 25.4 mm/inch. (Exapmle: 345)

27. A chemistry department is hiring students to prepare chemical solutions for a freshman chemistry class. The wage offered is (only) $5.90 per hour. What is the yearly wage in thousands of dollars if the student were to work 40 hours a week for 49 weeks per year?

28. The density of a certain cut-rate gasoline is 0.707 grams/mL. What is the mass in **kilograms** of 9 gallons of this gasoline?

29. People tend to buy a certain number of dollars-worth of gasoline and not certain volumes (gallons) and not certain masses (pounds?). What is the mass in kilograms of $23 worth of the same cut-rate gasoline if it costs $1.529 per gallon.

---

30. Express the following in scientific notation. (Example: 5.342e-2)

404

31. Express the following as whole numbers or decimals. (Example: 23 455.342 534)

$6.6x10$

32. Preform the following calculation, expressing your answer in scientific notation:. (Example: 4.56e-8)

$(2.5x10^{4})(4.0x10^{3})$

33. Preform the following calculation, expressing your answer in scientific notation. (Example: 4.56e-8)

$(3.0x10^{4})/(6.0x10^{-2})$

34. How many significant figures are there in the following measurement. (Example: 4)

$5.0x10^{-4}$

---

35. Place the following steps of problem solving in the correct order. (Example: CGD...)

A) Work out a plan.
B) Look up needed information.
C) Turn in your work and answer.
D) Check your work.
E) Obtain an answer by doing the math.
F) Read the problem and make a list of 'knowns' and 'unknowns'.

Doe, John

General Chemistry *Fall 1995*

pchem Set 1, (Unit1, Chapter 1, 2, and 3). Due 09/19/95 14:30 Give 3 digits for numerical answers. PIN is 5238

---

1. Match the following bold words from chapters 1, 2, and 3 with their definitions: pure science, applied science, chemistry, scientific method, experiments, scientific law, hypothesis, theory, controlled experiment, data. (Example: AJD...)

A) putting science discovery to work
B) educated guess
C) procedures that enable scientists to gather facts
D) statement of a relationship between facts
E) way scientists go about solving problems
F) general explanation for observations
G) study of matter and the changes it undergoes
H) search for a better understanding of our world
I) changing variables one at a time
J) results of an experiment

2. Match the following bold words from chapters 1, 2, and 3 with their definitions: quantity, base units, derived units, precision, accuracy, significant figures, absolute error, scientific notation, conversion factors, dimentional analysis. (Example: AJD...)

A) parts of a number we are sure are correct
B) fundamental units of the SI system
C) a number times 10 to a power
D) factor-label method of problem solving
E) difference between observed and true values
F) combinations of SI base units
G) reproducibility of a series of measurements
H) numbers used to convert from one unit to another
I) things that can be measured
J) how close the a measurement is to the true value

---

3. Occasionally we will have to find areas and volumes of very small objects. For practice, calculate the area of a rectangle with a length of 1.31×10^{-6} centimeters and a width of 3.62×10^{-6} centimeters. Give your answer in units of cm^2. (Example: 4653)

4. We will need to find the square-roots of small numbers. Use your calculator to evaluate the square root of 5.17×10^{-22}. (Example: 4.653)

5. Test your calculator skills by verifying that $(5.100)^2$ equals 26.01 and that $(5.100)^3$ equals 132.7. Now, the challenge, find the value of $(5.100)^{2.150}$. (Example: 4653)

6. We will use many linear equations later in the term with the form y = a + bx where "a" and "b" are numbers determined in experiments and "x" is known. What is the value of "y" for the case in which a=80.52 , b=0.568, and x=15.19? (Example: 4653)

7. Some linear equations will have to be solved for "x" because "y" can be measured. What is the value of "x" in the linear equation, y=a+bx, for the case in which a=49.13, b=0.519, and y=31.60? (Example: 4653)

8. You probably could use some more practice solving for "x." What is the value of "x" in the linear equation, y=a+bx, for the case in which a=44.49 , b=0.564, and y=55.17? (Example: 4653)

9. Very often we will use equations with exponential or logarithmic functions. What is the value of "y" in the equation y = a log(x), when a = 8.15 and x = 6.70? Note that 'log' represent the logarithm function to the base ten. (Example: 4653)

10. Now let's try a more challenging equation using logarithms. What is the value of "y" in the equation log(y) = 6.710 x, when x = 7.50? (Example: 4653)

---

11. Place the following steps of the scientific method in the correct order. (Exapmle: BDC...)

A) Searching for scientific laws
B) Forming hyporhesis
C) Stating the problem
D) Collecting observations
E) Modifying theories
F) Forming theories

---

12. You are asked to do an experiment to determine the mass of detergent necessary to removeoil from different kinds of fabrics. You set up the experiment by taking five strips of cotton fabric, each the same size and placing 0.1 gram of a certain kind of black oil on each. Each strip is placed in an identical test tube containing 10 mL of water. In the first test tube, 0.1 gram of detergent is added. In the second, 0.2 grams of detergent is added. This is repeated so that the five test tubes contain 0.1 to0.5 grams of detergent. The tubes are shaken 10 times each, and the cotton strips are examined for signs of oil. The experiment is repeated with other kinds of cloth. Give all the controlled variables.

A) kind of cloth
B) time in detergent
C) amount of water
D) number of shakes
E) kind of oil
F) amount of detergent

---

13. The numbers following show the ocean water temperature in a cove in Gloucester, Massachusetts, on the first day of the month for a period of one year. Prepare a graph to illustrate this data. Then, estimate the temperature of the water in the cove on Aug. 15. Jan. (3.8), Feb. (0.9), March (1.1), April (2.5), May (5.2), June (10.1), July (15.5), Aug.

(19.0), Sept. (18.5), Oct. (15.5), Nov. (9.2), Dec. (5.8)

14. Turn in your graph with your name on it to be graded by hand. Remeber to use the steps for building a good graph.

---

15. Identify the metric units represented by the following names. (Example: cs, mm, ...)

A) second
B) gram
C) millisecond
D) kilogram
E) meter
F) centimeter

16. Which SI unit is most closely equivalent to the following quantities. (Example: mg, cl, ...)

A) the thickness of a dime
B) the mass of a head of cabbage
C) the volume of a 1/4-teaspoon measuring spoon
D) the diameter of a beach umbrella
E) the volume of a big glup
F) the mass of a paper clip

17. Give the appropriate SI derived unit. (Example: mm3, cg*m2/s, ...)

A) 6.2 g / 3.1 s
B) 2.33 m x 5.15 m

---

18. Which of the following can be measured? (Example: ADF...)

A) beauty
B) speed
C) density
D) volume
E) thickness
F) area
G) color
H) personallity

---

19. Determine the number of significant figures in each of the following measurements. (Example: 6, 8, 4, ...)

A) 1.0 cm
B) 3.05 cm
C) 0.505 cm
D) 250 g
E) 0.0620 g
F) 4050. mL

20. Perform the following calculations and report each answer to the correct number of significant figures. (Example: 354 mm2, ...)

A) 5.22 m x 82.7 m
B) 9.475 g / 12.05 mL

21. Perform the following calculations and report each answer to the correct number of significant figures. (Example: 354 mm2, ...)

A) 162.1 g + 38.73 g + 1.554 g
B) 16.748 s - 1.512 s

---

22. Three scientists measure the standard meter bar at the International Bureau of Standards. Their measurements are 1.09 m, 1.06 m and 1.05 m. Are the measurements accurate, precise, or both?

---

23. A standard 20.00-g mass is used to check the accuracy of a laboratory balance. The balance indicates a mass of 19.08 g when the standard mass is measured. What is the percent error of this measurement?

24. At a track meet, you time a friend running 100-m at 11.47 seconds. The officials time her at 20.00 seconds. What is your percent error?

---

25. How many millimeters are equal to 6.33 meters? (Example: 1000 g = 1 kg, 1000 g / 1 kg)

A) What equality is the basis for solving this problem?
B) What is conversion factor that must be used?

26. Calculate the number of centimeters in 7.70 yards. For reference, there are exactly 36 inch/yard and exactly 25.4 mm/inch. (Exapmle: 345)

27. A chemistry department is hiring students to prepare chemical solutions for a freshman chemistry class. The wage offered is (only) $5.60 per hour. What is the yearly wage in thousands of dollars if the student were to work 40 hours a week for 48 weeks per year?

28. The density of a certain cut-rate gasoline is 0.687 grams/mL. What is the mass in **kilograms** of 10 gallons of this gasoline?

29. People tend to buy a certain number of dollars-worth of gasoline and not certain volumes (gallons) and not certain masses (pounds?). What is the mass in kilograms of $11 worth of the same cut-rate gasoline if it costs $1.239 per gallon.

---

30. Express the following in scientific notation. (Example: 5.342e-2)

4400

31. Express the following as whole numbers or decimals. (Example: 23 455.342 534)

$6.01x10^{-4}$

32. Preform the following calculation, expressing your answer in scientific notation:. (Example: 4.56e-8)

$(2.5x10^{4})(4.0x10^{3})$

33. Preform the following calculation, expressing your answer in scientific notation. (Example: 4.56e-8)

$(7.0x10^{7})/(3.5x10^{5})$

34. How many significant figures are there in the following measurement. (Example: 4)

$5.01x10^{7}$

---

35. Place the following steps of problem solving in the correct order. (Example: CGD...)

A) Obtain an answer by doing the math.
B) Look up needed information.
C) Read the problem and make a list of 'knowns' and 'unknowns'.
D) Turn in your work and answer.
E) Check your work.
F) Work out a plan.

```
// General Chemistry
// Unit 1, Chapter 1,2,&3
//
{tex("\noindent {\large \bf ","")}{name()} {tex("}\\","")} {tex("\vskip
-.1in","")} {tex("\noindent {\large \it General Chemistry \hfill Fall 1995\\ }
","")} {tex("\vskip -.1in","")}{tex("{\noindent \bf pchem}","pchem")}
{tex("\noindent Set ","No.")}{set()}, (Unit1, Chapter 1, 2, and 3). Due
{due_date()} {tex("Give 3 digits for numerical answers.","")} PIN is
{tex("{\footnotesize  ","")}{pin()}{tex("}","")} {tex("\vskip .1in
\pagestyle{plain} ","")}
{tex("\hrule width2.0in height0.8pt
\hfill","--------------------------------------------------")}{tex("\vskip
.15in","")}
//
//Bold Word Matching
//
#m1="search for a better understanding of our world"
#m2="putting science discovery to work"
#m3="study of matter and the changes it undergoes"
#m4="way scientists go about solving problems"
#m5="procedures that enable scientists to gather facts"
#m6="statement of a relationship between facts"
#m7="educated guess"
#m8="general explanation for observations"
#m9="changing variables one at a time"
#m10="results of an experiment"
{tex("{\bf ","")}{question()}{tex(".}","")}  Match the following bold words
from chapters 1, 2, and 3 with their definitions:  pure science, applied
science, chemistry, scientific method, experiments, scientific law, hypothesis,
theory, controlled experiment, data.  (Example:  AJD...)
{tex("\begin{quote}","")}
#colzwy1=random(1,24,1)
A)
{choose(colzwy1,m2,m3,m5,m7,m10,m6,m6,m2,m6,m9,m2,m1,m7,m1,m2,m1,m2,m3,m3,m10,m5
,m2,m7,m10)}{tex("\\","")}
B)
{choose(colzwy1,m8,m9,m10,m4,m9,m4,m4,m1,m2,m1,m1,m2,m10,m6,m8,m3,m7,m7,m7,m8,m1
,m5,m10,m6)}{tex("\\","")}
C)
{choose(colzwy1,m5,m7,m4,m2,m1,m1,m2,m9,m8,m4,m4,m4,m9,m5,m7,m9,m5,m2,m8,m3,m9,m
10,m5,m3)}{tex("\\","")}
D)
{choose(colzwy1,m6,m10,m6,m5,m3,m9,m1,m6,m10,m3,m8,m9,m4,m2,m9,m6,m6,m8,m5,m4,m4
,m8,m6,m8)}{tex("\\","")}
E)
{choose(colzwy1,m1,m4,m3,m10,m8,m10,m9,m5,m7,m7,m9,m7,m3,m8,m1,m8,m4,m5,m10,m7,m
```

```
3,m6,m3,m5)}{tex("\\","")}
F)
{choose(colzwy1,m3,m8,m1,m8,m4,m5,m10,m7,m3,m6,m3,m5,m1,m4,m3,m10,m8,m10,m9,m5,m
7,m7,m9,m7)}{tex("\\","")}
G)
{choose(colzwy1,m4,m2,m9,m6,m6,m8,m5,m4,m4,m8,m6,m8,m6,m10,m6,m5,m3,m9,m1,m6,m10
,m3,m8,m9)}{tex("\\","")}
H)
{choose(colzwy1,m9,m5,m7,m9,m5,m2,m8,m3,m9,m10,m5,m3,m5,m7,m4,m2,m1,m1,m2,m9,m8,
m4,m4,m4)}{tex("\\","")}
I)
{choose(colzwy1,m10,m6,m8,m3,m7,m7,m7,m8,m1,m5,m10,m6,m8,m9,m10,m4,m9,m4,m4,m1,m
2,m1,m1,m2)}{tex("\\","")}
J)
{choose(colzwy1,m7,m1,m2,m1,m2,m3,m3,m10,m5,m2,m7,m10,m2,m3,m5,m7,m10,m6,m6,m2,m
6,m9,m2,m1)}{tex("\\","")}
{tex("\end{quote}","")}

#ans=choose(colzwy1,"EAFGCDJBHI","JGAEHICFBD","FJECADHIGB","JCIBDGAFHE","CJEFHGI
EBA","CHJBFAIGDE","DCJBGAIHEF","BAHGEDFICJ","IBFGJAECHD","BJDCIFEGAH","BAFCHGJDE
I","ABHCFIEGDJ","FJEDHGAICB","ADJFCBHEIG","EAFHJGCBDI","AHBIGDJECF","HAGECDBFIJ"
,"HCAIEJBDGF","GHAIDJBCFE","IJCDFGEBHA","BIEDAJFHCG","IAGHBEFDJC","IJEHCDAGFB","
JICHEBFDGA")
{ans}
//
//
//Bold Word Matching
//
#m1="things that can be measured"
#m2="fundamental units of the SI system"
#m3="combinations of SI base units"
#m4="reproducability of a series of measurements"
#m5="how close the a measurement is to the true value"
#m6="parts of a number we are sure are correct"
#m7="difference between observed and true values"
#m8="a number times 10 to a power"
#m9="numbers used to convert from one unit to another"
#m10="factor-label method of problem solving"
{tex("{\bf ","")}{question()}{tex(".}","")} Match the following bold words
from chapters 1, 2, and 3 with their definitions: quantity, base units,
derived units, precision, accuracy, significant figures, absolute error,
scientific notation, conversion factors, dimentional analysis. (Example:
AJD...)
{tex("\begin{quote}","")}
#colzwy1=random(1,24,1)
A)
```

```
{choose(colzwyl,m2,m3,m5,m7,m10,m6,m6,m2,m6,m9,m2,m1,m7,m1,m2,m1,m2,m3,m3,m10,m5
,m2,m7,m10)}{tex("\\","")}
B)
{choose(colzwyl,m8,m9,m10,m4,m9,m4,m4,m1,m2,m1,m1,m2,m10,m6,m8,m3,m7,m7,m7,m8,m1
,m5,m10,m6)}{tex("\\","")}
C)
{choose(colzwyl,m5,m7,m4,m2,m1,m1,m2,m9,m8,m4,m4,m4,m9,m5,m7,m9,m5,m2,m8,m3,m9,m
10,m5,m3)}{tex("\\","")}
D)
{choose(colzwyl,m6,m10,m6,m5,m3,m9,m1,m6,m10,m3,m8,m9,m4,m2,m9,m6,m6,m8,m5,m4,m4
,m8,m6,m8)}{tex("\\","")}
E)
{choose(colzwyl,m1,m4,m3,m10,m8,m10,m9,m5,m7,m7,m9,m7,m3,m8,m1,m8,m4,m5,m10,m7,m
3,m6,m3,m5)}{tex("\\","")}
F)
{choose(colzwyl,m3,m8,m1,m8,m4,m5,m10,m7,m3,m6,m3,m5,m1,m4,m3,m10,m8,m10,m9,m5,m
7,m7,m9,m7)}{tex("\\","")}
G)
{choose(colzwyl,m4,m2,m9,m6,m6,m8,m5,m4,m4,m8,m6,m8,m6,m10,m6,m5,m3,m9,m1,m6,m10
,m3,m8,m9)}{tex("\\","")}
H)
{choose(colzwyl,m9,m5,m7,m9,m5,m2,m8,m3,m9,m10,m5,m3,m5,m7,m4,m2,m1,m1,m2,m9,m8,
m4,m4,m4)}{tex("\\","")}
I)
{choose(colzwyl,m10,m6,m8,m3,m7,m7,m7,m8,m1,m5,m10,m6,m8,m9,m10,m4,m9,m4,m4,m1,m
2,m1,m1,m2)}{tex("\\","")}
J)
{choose(colzwyl,m7,m1,m2,m1,m2,m3,m3,m10,m5,m2,m7,m10,m2,m3,m5,m7,m10,m6,m6,m2,m
6,m9,m2,m1)}{tex("\\","")}
{tex("\end{quote}","")}

#ans=choose(colzwyl,"EAFGCDJBHI","JGAEHICFBD","FJECADHIGB","JCIBDGAFHE","CJEFHGI
EBA","CHJBFAIGDE","DCJBGAIHEF","BAHGEDFICJ","IBFGJAECHD","BJDCIFEGAH","BAFCHGJDE
I","ABHCFIEGDJ","FJEDHGAICB","ADJFCBHEIG","EAFHJGCBDI","AHBIGDJECF","HAGECDBFIJ"
,"HCAIEJBDGF","GHAIDJBCFE","IJCDFGEBHA","BIEDAJFHCG","IAGHBEFDJC","IJEHCDAGFB","
JICHEBFDGA")
[ans]
//
{tex("\hrule width2.0in height0.8pt
\hfill","----------------------------------------------------------")}{tex("\vskip
.15in","")}
//
//Simple math problems derived from the CAPA sampler: 1,2,3, and 4
//    djm, Chem 141, Fall/94
//
#len=random(1.100, 9.900, 0.030 )
```

```
#len_exp=random( -9, -6, 1)
#wid=random(1.100, 9.900, 0.030 )
#wid_exp=random( -9, -6, 1)
{tex("{\bf ","")}{question()}{tex(".}","")}  Occasionally we will have to find
areas and volumes of very small objects.  For practice, calculate the area of a
rectangle with a length of {len:".2f"}x10{tex("$^{","
"")}{len_exp}{tex("}$","")} centimeters and a width of
{wid:".2f"}x10{tex("$^{"," ")}{wid_exp}{tex("}$","")} centimeters. Give your
answer in units of {tex("$cm^2$","cm^2")}.  (Example:  4653){tex("\\","")}

#ans1=len*wid * pow( 10, (wid_exp+len_exp) )
!The area of a rectangle is the width times the length.
!  Use a calculator but use the notation 1.00e-03 for computer input.
/E Multiply the width times the length, use scientific notation.
[ans1:3,2%]
//
//
//    djm, Chem 141, Fall/94
//
#arg3=random( 1.140, 8.990, 0.310 )
#arg_exp=random( -26, -10, 1 )
#num3=arg3 * pow( 10, arg_exp )
{tex("{\bf ","")}{question()}{tex(".}","")}  We will need to find the
square-roots of small numbers.  Use your calculator to evaluate the square root
of {arg3:".2f"}x10{tex("$^{"," ")}{arg_exp}{tex("}$","")}.  (Example:
4.653){tex("\\","")}

!  Use a calculator but use the notation 1.00e-03 for computer input.
/E Be sure the number is entered properly into your calculator.
#ans2=pow( num3, 0.5 )
[ans2:3,3%]
//
//
//    djm, Chem 141, Fall/94
//
#H4=random(2.20, 9.00, 0.010 )
#D4=random(2.10, 2.98, 0.010 )
#square=pow(H4,2.0)
#cube=pow(H4,3.0)
{tex("{\bf ","")}{question()}{tex(".}","")}  Test  your calculator skills by
verifying that ({H4:".3f"}){tex("$^{ ","^")}2{tex("}$","")} equals
{square:".2f"} and that   ({H4:".3f"}){tex("$^{ ","^")}3{tex("}$","")} equals
{cube:".1f"}. Now, the challenge, find the value of
({H4:".3f"}){tex("$^{","^")}{D4:".3f"}{tex("}$","")}.  (Example:
4653){tex("\\","")}
```

```
!Check the calculator manual or with a friend or the Instructor,
!   for help in raising a number to an arbitrary power.
/E Scientific calculators have a function to raise X to the Y-th power.
/E This can be done -long-hand- with log tables but that is not recommended.
#ans4=pow(H4,D4)
[ans4:3,2%]
//
//  A trivial tests of linear algebra
//  djm, Chem141 Fall/94
//
#r6a=random(10.30, 99.10, 0.010 )
#r6b=random(0.501, 0.599, 0.001 )
#r6x=random(10.30, 99.10, 0.010 )
{tex("{\bf ","")}{question()}{tex(".}","")} We will use many linear equations
later in the term with the form y = a + bx where ''a'' and ''b'' are numbers
determined in experiments and ''x'' is known.  What is the value of ''y'' for
the case in which a={r6a:".2f"} , b={r6b:".3f"}, and x={r6x:".2f"}?  (Example:
4653){tex("\\","")}

#ans6=r6a + (r6b*r6x)
!You should plug in the values of a, b, and x;
!  evaluate the right hand side of the equation; done.
/E Multiply b times x, then add a.
[ans6:3,3%]
//
//
//  djm, Chem141 Fall/94
#r7a=random(10.30, 69.10, 0.01 )
#r7b=random(0.501, 0.599, 0.001 )
#r7y=random(10.30, 99.10, 0.010 )
{tex("{\bf ","")}{question()}{tex(".}","")}  Some linear equations will have to
be solved for ''x'' because ''y'' can be measured.  What is the value of ''x''
in the linear equation, y=a+bx, for the case in which a={r7a:".2f"},
b={r7b:".3f"}, and y={r7y:".2f"}?  (Example:  4653){tex("\\","")}

#ans7= (r7y - r7a) / r7b
!You should plug in the values of a, b, and y;
!  rearrange the equation so that x is by itself on the right-hand side.
/E Subtract b from y, then divide by b.
[ans7:3,3%]
//
//
//  djm, Chem141 Fall/94
#r8a=random(10.30, 69.10, 0.010 )
#r8b=random(0.501, 0.599, 0.001 )
#r8y=random(10.30, 99.10, 0.010 )
```

```
{tex("{\bf ","")}{question()}{tex(".}","")} You probably could use some more
practice solving for ''x.'' What is the value of ''x'' in the linear equation,
y=a+bx, for the case in which a={r8a:".2f"} , b={r8b:".3f"}, and y={r8y:".2f"}?
(Example: 4653){tex("\\","")}

#ans8= (r8y - r8a) / r8b
!You should plug in the values of a, b, and y;
! rearrange the equation so that x is by itself on the right-hand side.
/E Subtract b from y, then divide by b.
[ans8:3,3%]
//
// A simple test of ln key on calculator
// djm, Chem141 Fall/94
//
#r9=random(3.11, 9.91, 0.010)
#r9a=random(3.31, 9.91, 0.010)
{tex("{\bf ","")}{question()}{tex(".}","")} Very often we will use equations
with exponential or logarithmic functions. What is the value of ''y'' in the
equation y = a log(x), when a = {r9a:".2f"} and x = {r9:".2f"}? Note that
'log' represent the logarithm function to the base ten. (Example:
4653){tex("\\","")}

#ans9=r9a * log10( r9 )
! Try the -log- key on your calculation.
/E Take the log of x then multiply by a.
[ans9:3,1%]
//
// djm, from Chem152 Spring/93
//
#r10a=random(3.31, 9.91, 0.010)
#r10b=random(3.31, 9.91, 0.010)
{tex("{\bf ","")}{question()}{tex(".}","")} Now let's try a more challenging
equation using logarithms. What is the value of ''y'' in the equation log(y)
= {r10a:".3f"} x, when x = {r10b:".2f"}? (Example: 4653){tex("\\","")}

!The exponential and logarithmic functions are inverses of one-another.
! First, multiply the right hand side. Then use exponentiation of both sides
! of the equation to remove or "cancel" the "ln" function.
#arg10= r10a * r10b
#ans10=pow(10, arg10 )
/E Evaluate the right-side of the equation, then use the exponential function.
[ans10:3,1%]
//
{tex("\hrule width2.0in height0.8pt
\hfill","----------------------------------------------------")}{tex("\vskip
.15in","")}
```

```
//
//
//Scientific Method
//
#m1="Stating the problem"
#m2="Collecting observations"
#m3="Searching for scientific laws"
#m4="Forming hypothesis"
#m5="Forming theories"
#m6="Modifying theories"
{tex("{\bf ","")}{question()}{tex(".}","")}  Place the following steps of the
scientific method in the correct order.  (Exapmle:  BDC...)
{tex("\begin{quote}","")}
#colzwyl=random(1,24,1)
A)
{choose(colzwyl,m5,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m1,m4,m3,m5,m6,m2,m1,m4,m3,m
5,m6,m2)}{tex("\\","")}
B)
{choose(colzwyl,m3,m5,m6,m2,m1,m4,m4,m3,m5,m6,m2,m1,m5,m6,m2,m1,m4,m3,m3,m5,m6,m
2,m1,m4)}{tex("\\","")}
C)
{choose(colzwyl,m4,m3,m5,m6,m2,m1,m3,m5,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m5,m6,m2,m
1,m4,m3)}{tex("\\","")}
D)
{choose(colzwyl,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m6,m2,m4,m3,m5,m6,m2,m1,m2,m1,m4,m
3,m5,m6)}{tex("\\","")}
E)
{choose(colzwyl,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m6,m6,m2,m1,m
4,m3,m5)}{tex("\\","")}
F)
{choose(colzwyl,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m4,m3,m5,m
6,m2,m1)}{tex("\\","")}{tex("\end{quote}","")}

#ans=choose(colzwyl,"DEBCAF","EFCDBA","FADECB","ABEFDC","BCFAED","CDABFE","DECBA
F","EFBDCA","FADEBC","ACEFDB","CBFAED","BDACFE","AECDBF","EFDACB","FBAEDC","BCEF
AD","CDFBEA","DABCFE","ADBFCE","DEFABC","ECADFB","CBDEAF","BFECDA","FACBED")
[ans]
//
{tex("\hrule width2.0in height0.8pt
\hfill","----------------------------------------------------")}{tex("\vskip
.15in","")}
//
//
//Controlled Experiment
//
#r1="amount of detergent"
```

```
#r2="kind of cloth"
#w3="number of shakes"
#w4="kind of oil"
#w5="time in detergent"
#w6="amount of water"
{tex("{\bf ","")}{question()}{tex(".}","")} You are asked to do an experiment
to determine the mass of detergent necessary to removeoil from different kinds
of fabrics. You set up the experiment by taking five strips of cotton fabric,
each the same size and placing 0.1 gram of a certain kind of black oil on each.
Each strip is placed in an identical test tube containing 10 mL of water. In
the first test tube, 0.1 gram of detergent is added. In the second, 0.2 grams
of detergent is added. This is repeated so that the five test tubes contain
0.1 to0.5 grams of detergent. The tubes are shaken 10 times each, and the
cotton strips are examined for signs of oil. The experiment is repeated with
other kinds of cloth. Give all the controlled variables.
{tex("\begin{quote}","")}
#colzwyl=random(1,24,1)
A)
{choose(colzwyl,w5,w6,r2,r1,w4,w3,w5,w6,r2,r1,w4,w3,r1,w4,w3,w5,w6,r2,r1,w4,w3,w
5,w6,r2)}{tex("\\","")}
B)
{choose(colzwyl,w3,w5,w6,r2,r1,w4,w4,w3,w5,w6,r2,r1,w5,w6,r2,r1,w4,w3,w3,w5,w6,r
2,r1,w4)}{tex("\\","")}
C)
{choose(colzwyl,w4,w3,w5,w6,r2,r1,w3,w5,w6,r2,r1,w4,w3,w5,w6,r2,r1,w4,w5,w6,r2,r
1,w4,w3)}{tex("\\","")}
D)
{choose(colzwyl,r1,w4,w3,w5,w6,r2,r1,w4,w3,w5,w6,r2,w4,w3,w5,w6,r2,r1,r2,r1,w4,w
3,w5,w6)}{tex("\\","")}
E)
{choose(colzwyl,r2,r1,w4,w3,w5,w6,r2,r1,w4,w3,w5,w6,r2,r1,w4,w3,w5,w6,w6,r2,r1,w
4,w3,w5)}{tex("\\","")}
F)
{choose(colzwyl,w6,r2,r1,w4,w3,w5,w6,r2,r1,w4,w3,w5,w6,r2,r1,w4,w3,w5,w4,w3,w5,w
6,r2,r1)}{tex("\\","")}
{tex("\end{quote}","")}

[choose(colzwyl,"DE","EF","AF","AB","BC","CD","DE","EF","AF","AC","BC","BD","AE"
,"EF","BF","BC","CD","AD","AD","DE","CE","BC","BF","AF")]
//
{tex("\hrule width2.0in height0.8pt
\hfill","----------------------------------------------------")}{tex("\vskip
.15in","")}
//
//
//Graphing
```

```
//
#r1=random(1,11,1)
#m1=choose(r1,"Jan.","Feb.","March","April","May","June","July","Aug.","Sept.","
Oct.","Nov.")
{tex("{\bf ","")}{question()}{tex(".}","")} The numbers following show the
ocean water temperature in a cove in Gloucester, Massachusetts, on the first
day of the month for a period of one year. Prepare a graph to illustrate this
data. Then, estimate the temperature of the water in the cove on {m1} 15.
Jan. (3.8), Feb. (0.9), March (1.1), April (2.5), May (5.2), June (10.1), July
(15.5), Aug. (19.0), Sept. (18.5), Oct. (15.5), Nov. (9.2), Dec.
(5.8){tex("\\","")}

#ans1=choose(r1, 2.4, 1.0, 1.8, 3.8, 7.7, 12.8, 17.3, 18.8, 17.0, 12.3, 7.5)
[ans1:3, 10%]
//
//
//Graph
//
{tex("{\bf ","")}{question()}{tex(".}","")} Turn in your graph with your name
on it to be graded by hand. Remeber to use the steps for building a good
graph.{tex("\\","")}

["JRB"]
//
{tex("\hrule width2.0in height0.8pt
\hfill","----------------------------------------------------")}{tex("\vskip
.15in","")}
//
//
//Metric Units
//
#m1="centimeter"
#a1="cm"
#m2="gram"
#a2="g"
#m3="second"
#a3="s"
#m4="meter"
#a4="m"
#m5="kilogram"
#a5="kg"
#m6="millisecond"
#a6="ms"
{tex("{\bf ","")}{question()}{tex(".}","")} Identify the metric units
represented by the following names. (Example: cs, mm, ...)
{tex("\begin{quote}","")}
```

```
#colzwy1=random(1,24,1)
A)
{choose(colzwy1,m5,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m1,m4,m3,m5,m6,m2,m1,m4,m3,m
5,m6,m2)}{tex("\\","")}
B)
{choose(colzwy1,m3,m5,m6,m2,m1,m4,m4,m3,m5,m6,m2,m1,m5,m6,m2,m1,m4,m3,m3,m5,m6,m
2,m1,m4)}{tex("\\","")}
C)
{choose(colzwy1,m4,m3,m5,m6,m2,m1,m3,m5,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m5,m6,m2,m
1,m4,m3)}{tex("\\","")}
D)
{choose(colzwy1,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m6,m2,m4,m3,m5,m6,m2,m1,m2,m1,m4,m
3,m5,m6)}{tex("\\","")}
E)
{choose(colzwy1,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m6,m6,m2,m1,m
4,m3,m5)}{tex("\\","")}
F)
{choose(colzwy1,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m4,m3,m5,m
6,m2,m1)}{tex("\\","")}{tex("\end{quote}","")}

#ans1=choose(colzwy1,a5,a6,a2,a1,a4,a3,a5,a6,a2,a1,a4,a3,a1,a4,a3,a5,a6,a2,a1,a4
,a3,a5,a6,a2)
#ans2=choose(colzwy1,a3,a5,a6,a2,a1,a4,a4,a3,a5,a6,a2,a1,a5,a6,a2,a1,a4,a3,a3,a5
,a6,a2,a1,a4)
#ans3=choose(colzwy1,a4,a3,a5,a6,a2,a1,a3,a5,a6,a2,a1,a4,a3,a5,a6,a2,a1,a4,a5,a6
,a2,a1,a4,a3)
#ans4=choose(colzwy1,a1,a4,a3,a5,a6,a2,a1,a4,a3,a5,a6,a2,a4,a3,a5,a6,a2,a1,a2,a1
,a4,a3,a5,a6)
#ans5=choose(colzwy1,a2,a1,a4,a3,a5,a6,a2,a1,a4,a3,a5,a6,a2,a1,a4,a3,a5,a6,a6,a2
,a1,a4,a3,a5)
#ans6=choose(colzwy1,a6,a2,a1,a4,a3,a5,a6,a2,a1,a4,a3,a5,a6,a2,a1,a4,a3,a5,a4,a3
,a5,a6,a2,a1)
[ans1+", "+ans2+", "+ans3+", "+ans4+", "+ans5+", "+ans6]
//
//
//SI Unit Equivalent
//
#m1="the mass of a paper clip"
#a1="g"
#m2="the thickness of a dime"
#a2="mm"
#m3="the diameter of a beach umbrella"
#a3="m"
#m4="the volume of a big glup"
#a4="l"
#m5="the mass of a head of cabbage"
```

```
#a5="kg"
#m6="the volume of a 1/4-teaspoon measuring spoon"
#a6="ml"
{tex("{\bf ","")}{question()}{tex(".}","")} Which SI unit is most closely
equivalent to the following quantities. (Example: mg, cl, ...)
{tex("\begin{quote}","")}
#colzwy1=random(1,24,1)
A)
{choose(colzwy1,m5,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m1,m4,m3,m5,m6,m2,m1,m4,m3,m
5,m6,m2)}{tex("\\","")}
B)
{choose(colzwy1,m3,m5,m6,m2,m1,m4,m4,m3,m5,m6,m2,m1,m5,m6,m2,m1,m4,m3,m3,m5,m6,m
2,m1,m4)}{tex("\\","")}
C)
{choose(colzwy1,m4,m3,m5,m6,m2,m1,m3,m5,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m5,m6,m2,m
1,m4,m3)}{tex("\\","")}
D)
{choose(colzwy1,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m6,m2,m4,m3,m5,m6,m2,m1,m2,m1,m4,m
3,m5,m6)}{tex("\\","")}
E)
{choose(colzwy1,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m6,m6,m2,m1,m
4,m3,m5)}{tex("\\","")}
F)
{choose(colzwy1,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m4,m3,m5,m
6,m2,m1)}{tex("\\","")}{tex("\end{quote}","")}

#ans1=choose(colzwy1,a5,a6,a2,a1,a4,a3,a5,a6,a2,a1,a4,a3,a1,a4,a3,a5,a6,a2,a1,a4
,a3,a5,a6,a2)
#ans2=choose(colzwy1,a3,a5,a6,a2,a1,a4,a4,a3,a5,a6,a2,a1,a5,a6,a2,a1,a4,a3,a3,a5
,a6,a2,a1,a4)
#ans3=choose(colzwy1,a4,a3,a5,a6,a2,a1,a3,a5,a6,a2,a1,a4,a3,a5,a6,a2,a1,a4,a5,a6
,a2,a1,a4,a3)
#ans4=choose(colzwy1,a1,a4,a3,a5,a6,a2,a1,a4,a3,a5,a6,a2,a4,a3,a5,a6,a2,a1,a2,a1
,a4,a3,a5,a6)
#ans5=choose(colzwy1,a2,a1,a4,a3,a5,a6,a2,a1,a4,a3,a5,a6,a2,a1,a4,a3,a5,a6,a6,a2
,a1,a4,a3,a5)
#ans6=choose(colzwy1,a6,a2,a1,a4,a3,a5,a6,a2,a1,a4,a3,a5,a6,a2,a1,a4,a3,a5,a4,a3
,a5,a6,a2,a1)
[ans1+", "+ans2+", "+ans3+", "+ans4+", "+ans5+", "+ans6]
//
//
//Derived Units
//
#r1=random(1,4,1)
#s1=choose(r1,"2.0 m x 3.5 m","6.2 g / 3.1 s","8.1 kg/(0.45 cm x 4.0 cm)","(75
kg x 5.0 m)/(2.5 s x 6.0 s)")
```

```
#a1=choose(r1,"m2","g/s","kg/cm2","kg*m/s2")
#r2=random(1,4,1)
#s2=choose(r2,"6.5 cm x 2.1 cm","2.33 m x 5.15 m","62 g / 1.62 cm","18
grams/4.5 kelvins")
#a2=choose(r2,"cm2","m2","g/cm","g/K")
{tex("{\bf ","")}{question()}{tex(".}","")} Give the appropriate SI derived
unit. (Example: mm3, cg*m2/s, ...)
{tex("\begin{quote}","")}
A) {s1}{tex("\\","")}
B) {s2}{tex("\\","")}
{tex("\end{quote}","")}

[a1+", "+a2]
//
{tex("\hrule width2.0in height0.8pt
\hfill","------------------------------------------------------")}{tex("\vskip
.15in","")}
//
//
//Can be measured
//
#r1="speed"
#r2="thickness"
#r3="density"
#r4="volume"
#r5="area"
#w6="color"
#w7="beauty"
#w8="personallity"
{tex("{\bf ","")}{question()}{tex(".}","")} Which of the following can be
measured? (Example: ADF...)
{tex("\begin{quote}","")}
#colzwy1=random(1,24,1)
A)
{choose(colzwy1,r5,w8,w6,r2,w7,r1,r4,r3,r5,w8,w6,r2,w7,r1,r4,r3,r5,w8,w6,r2,w7,r
1,r4,r3)}{tex("\\","")}
B)
{choose(colzwy1,r3,r5,w8,w6,r2,w7,r1,r4,r1,r4,r3,r5,w8,w6,r2,w7,w8,w6,r2,w7,r1,r
4,r3,r5)}{tex("\\","")}
C)
{choose(colzwy1,r4,r3,r5,w8,w6,r2,w7,r1,w6,r2,w7,r1,r4,r3,r5,w8,r2,w7,r1,r4,r3,r
5,w8,w6)}{tex("\\","")}
D)
{choose(colzwy1,r1,r4,r3,r5,w8,w6,r2,w7,r4,r3,r5,w8,w6,r2,w7,r1,w6,r2,w7,r1,r4,r
3,r5,w8)}{tex("\\","")}
E)
```

```
{choose(colzwy1,r2,w7,r1,r4,r3,r5,w8,w6,r3,r5,w8,w6,r2,w7,r1,r4,r3,r5,w8,w6,r2,w
7,r1,r4)}{tex("\\","")}
F)
{choose(colzwy1,w6,r2,w7,r1,r4,r3,r5,w8,r2,w7,r1,r4,r3,r5,w8,w6,w7,r1,r4,r3,r5,w
8,w6,r2)}{tex("\\","")}
G)
{choose(colzwy1,w7,r1,r4,r3,r5,w8,w6,r2,w8,w6,r2,w7,r1,r4,r3,r5,r4,r3,r5,w8,w6,r
2,w7,r1)}{tex("\\","")}
H)
{choose(colzwy1,w8,w6,r2,w7,r1,r4,r3,r5,w7,r1,r4,r3,r5,w8,w6,r2,r1,r4,r3,r5,w8,w
6,r2,w7)}{tex("\\","")}
{tex("\end{quote}","")}

[choose(colzwy1,"ABCDE","BCDFG","CDEGH","ADEFG","BEFGH","ACEFH","ABDFH","ABCGH",
"ABDEF","BCDEH","BDFGH","ABCFH","CEFGH","ACDFG","ABCEG","ADEGH","ACEGH","DEFGH",
"BCFGH","ACDFH","BCDEF","ABCDG","ABDEH","ABEFG")]
//
{tex("\hrule width2.0in height0.8pt
\hfill","------------------------------------------------------")}{tex("\vskip
.15in","")}
//
//
//Significant Figures
//
#m1="1.0 cm"
#a1="2"
#m2="250 g"
#a2="2"
#m3="3.05 cm"
#a3="3"
#m4="4050. mL"
#a4="4"
#m5="0.505 cm"
#a5="3"
#m6="0.0620 g"
#a6="3"
{tex("{\bf ","")}{question()}{tex(".}","")} Determine the number of
significant figures in each of the following measurements. (Example: 6, 8, 4,
...)
{tex("\begin{quote}","")}
#colzwy1=random(1,24,1)
A)
{choose(colzwy1,m5,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m1,m4,m3,m5,m6,m2,m1,m4,m3,m
5,m6,m2)}{tex("\\","")}
B)
{choose(colzwy1,m3,m5,m6,m2,m1,m4,m4,m3,m5,m6,m2,m1,m5,m6,m2,m1,m4,m3,m3,m5,m6,m
```

```
2,m1,m4)}{tex("\\","")}
C)
{choose(colzwy1,m4,m3,m5,m6,m2,m1,m3,m5,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m5,m6,m2,m
1,m4,m3)}{tex("\\","")}
D)
{choose(colzwy1,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m6,m2,m4,m3,m5,m6,m2,m1,m2,m1,m4,m
3,m5,m6)}{tex("\\","")}
E)
{choose(colzwy1,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m6,m6,m2,m1,m
4,m3,m5)}{tex("\\","")}
F)
{choose(colzwy1,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m4,m3,m5,m
6,m2,m1)}{tex("\\","")}{tex("\end{quote}","")}

#ans1=choose(colzwy1,a5,a6,a2,a1,a4,a3,a5,a6,a2,a1,a4,a3,a1,a4,a3,a5,a6,a2,a1,a4
,a3,a5,a6,a2)
#ans2=choose(colzwy1,a3,a5,a6,a2,a1,a4,a4,a3,a5,a6,a2,a1,a5,a6,a2,a1,a4,a3,a3,a5
,a6,a2,a1,a4)
#ans3=choose(colzwy1,a4,a3,a5,a6,a2,a1,a3,a5,a6,a2,a1,a4,a3,a5,a6,a2,a1,a4,a5,a6
,a2,a1,a4,a3)
#ans4=choose(colzwy1,a1,a4,a3,a5,a6,a2,a1,a4,a3,a5,a6,a2,a4,a3,a5,a6,a2,a1,a2,a1
,a4,a3,a5,a6)
#ans5=choose(colzwy1,a2,a1,a4,a3,a5,a6,a2,a1,a4,a3,a5,a6,a2,a1,a4,a3,a5,a6,a6,a2
,a1,a4,a3,a5)
#ans6=choose(colzwy1,a6,a2,a1,a4,a3,a5,a6,a2,a1,a4,a3,a5,a6,a2,a1,a4,a3,a5,a4,a3
,a5,a6,a2,a1)
[ans1+", "+ans2+", "+ans3+", "+ans4+", "+ans5+", "+ans6]
//
//
//Significant Figure Multiply & Divide
//
#r1=random(1,4,1)
#s1=choose(r1,"6.5 cm x 2.1 cm","2.33 m x 5.15 m","5.22 m x 82.7 m","0.0322 cm
x 6.5 cm")
#a1=choose(r1,"14 cm2","12.0 m2","432 m2","0.21 cm2")
#r2=random(1,4,1)
#s2=choose(r2,"62 g / 1.62 cm","9.6781 g / 10.0 mL","4.08 g / 0.061 g","9.475 g
/ 12.05 mL")
#a2=choose(r2,"38 g/cm","0.968 g/mL","67","0.7863 g/mL")
{tex("{\bf ","")}{question()}{tex(".}","")}  Perform the following calculations
and report each answer to the correct number of significant figures.  (Example:
354 mm2, ...)
{tex("\begin{quote}","")}
A)  {s1}{tex("\\","")}
B)  {s2}{tex("\\","")}
{tex("\end{quote}","")}
```

```
[a1+", "+a2]
//
//
//Significant Figure Adding & Subtracting
//
#r1=random(1,4,1)
#s1=choose(r1,"4.375 g + 14.62 g + 327.9 g","2.5725 m + 14.55 m + 0.035 m +
4.88 m","162.1 g + 38.73 g + 1.554 g","21.9 m + 6.34 m + 157 m")
#a1=choose(r1,"346.9 g","22.04 m","202.4 g","185 m")
#r2=random(1,4,1)
#s2=choose(r2,"9.88 s - 7.2 s","44.7 kg - 2.7 kg","16.748 s - 1.512 s","6.0098
cm - 2.51 cm")
#a2=choose(r2,"2.7 s","42.0 kg","15.236 s","3.50 cm")
{tex("{\bf ","")}{question()}{tex(".}","")} Perform the following calculations
and report each answer to the correct number of significant figures. (Example:
354 mm2, ...)
{tex("\begin{quote}","")}
A) {s1}{tex("\\","")}
B) {s2}{tex("\\","")}
{tex("\end{quote}","")}

[a1+", "+a2]
//
{tex("\hrule width2.0in height0.8pt
\hfill","----------------------------------------------------")}{tex("\vskip
.15in","")}
//
//
//Precision/Accuracy
//
#r1=random(5,9,1)
#r2=random(5,9,1)
#r3=random(5,9,1)
{tex("{\bf ","")}{question()}{tex(".}","")} Three scientists measure the
standard meter bar at the International Bureau of Standards. Their
measurements are 1.0{r1} m, 1.0{r2} m and 1.0{r3} m. Are the measurements
accurate, precise, or both?{tex("\\","")}

["precise"]
//
{tex("\hrule width2.0in height0.8pt
\hfill","----------------------------------------------------")}{tex("\vskip
.15in","")}
//
//
```

```
//Percent Error
//
#r1=random(19.00,19.99,0.01)
#r2= 20.00
{tex("{\bf ","")}{question()}{tex(".}","")} A standard 20.00-g mass is used to
check the accuracy of a laboratory balance. The balance indicates a mass of
{r1:".2f"} g when the standard mass is measured. What is the percent error of
this measurement?{tex("\\","")}

#a1=r2-r1
#ans=a1/r2*100
[ans:4,3%]
//
//
//Percent Error
//
#r1=random(10.00,10.99,0.01)
#r1=random(11.00,11.99,0.01)
{tex("{\bf ","")}{question()}{tex(".}","")} At a track meet, you time a friend
running 100-m at {r1:".2f"} seconds. The officials time her at {r2:".2f"}
seconds. What is your percent error?{tex("\\","")}

#a1=r2-r1
#ans=a1/r2*100
[ans:4,3%]
//
{tex("\hrule width2.0in height0.8pt
\hfill","----------------------------------------------------")}{tex("\vskip
.15in","")}
//
//Conversion Factors
//
#r1=random(5.00,8.00,0.01)
{tex("{\bf ","")}{question()}{tex(".}","")} How many millimeters are equal to
{r1:".2f"} meters? (Example: 1000 g = 1 kg, 1000 g / 1 kg)
{tex("\begin{quote}","")}
A) What equality is the basis for solving this problem?{tex("\\","")}
B) What is conversion factor that must be used?{tex("\\","")}
{tex("\end{quote}","")}

["1 m = 1000 mm, 1000 mm / 1 m"]
//
//
// A simple test of dimensional analysis
// djm, Chem152 Spring/93
//
```

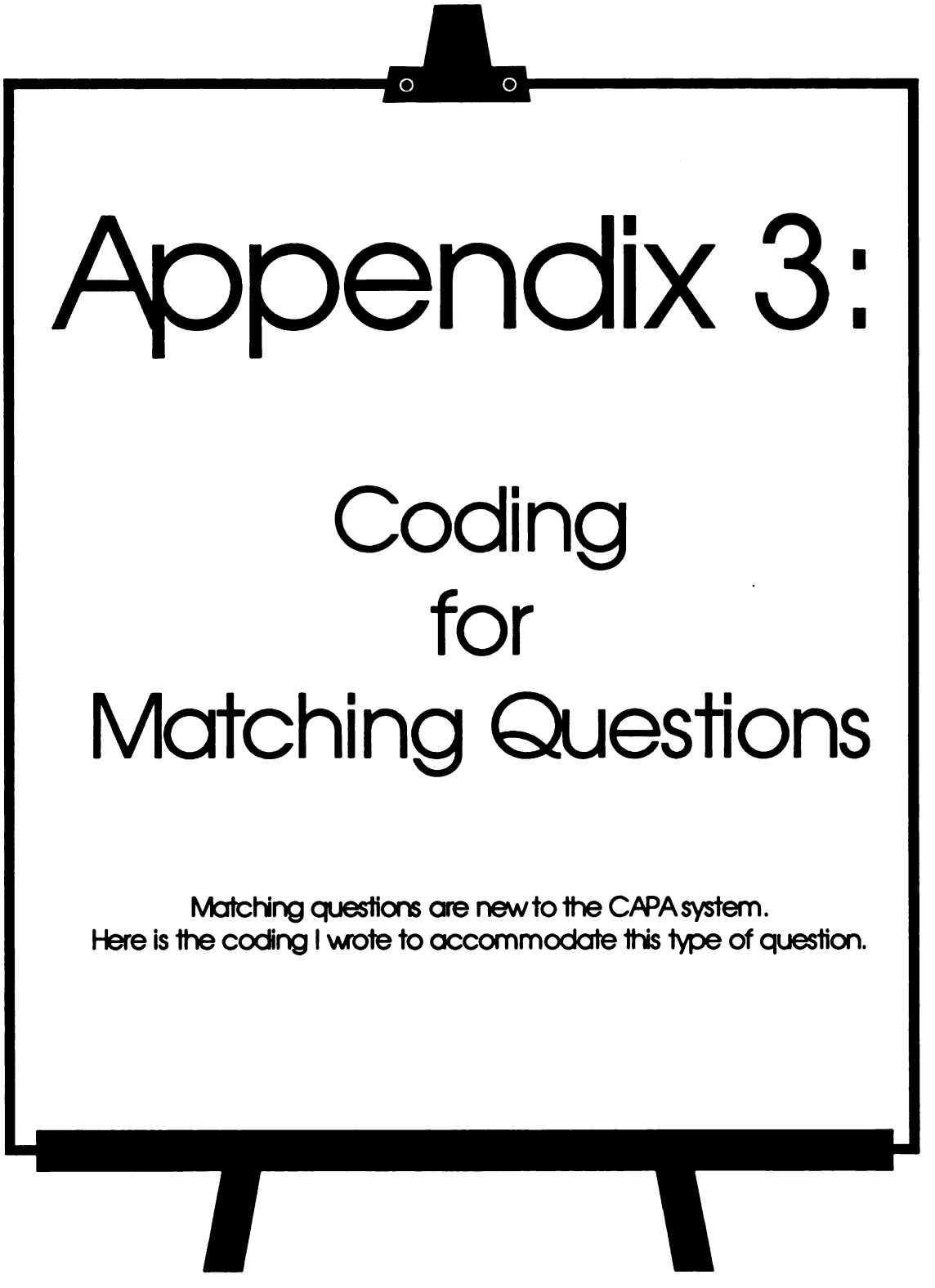
```
#r5=random(1.050, 9.050, 0.010)
{tex("{\bf ","")}{question()}{tex(".}","")} Calculate the number of centimeters
in {r5:".2f"} yards.  For reference, there are exactly 36 inch/yard and exactly
25.4 mm/inch.   (Exapmle:  345){tex("\\","")}

!Because these conversion factors are exact, the number of significant
!figures is determined by the value of the yards.
#ans5=r5 * 36.0 * 2.54
/E Multiply the number of yards times the number of inches per yard and
/E  that times the number of centimeters per inch.
[ans5:3,1%]
//
//  Dimensional Analysis use common example
//  djm, from Chem141 Fall/94
//
#r11a=random(3.01, 5.91, 0.010)
#r11b=random(38, 50, 1)
{tex("{\bf ","")}{question()}{tex(".}","")}  A chemistry department is hiring
students to prepare  chemical solutions for a freshman chemistry class.  The
wage offered is (only) {tex("\$","$")}{r11a:".2f"} per hour. What is the yearly
wage in thousands of dollars if the student were to work 40 hours a week for
{r11b} weeks per year?{tex("\\","")}

#ans11=r11a * r11b * 40.0 / 1000.0
! Simply convert dollars/hour to thousand-dollars/year.
/E Multiply by the wage by the number of weeks/yr and the number of hours/week
/E  Be sure to divide by a thousand...
[ans11:3,2%]
//
//  Dimensional Analysis use Tables in the TextBook, two parts
//  djm, Chem141 Fall/94
//
#r12a=random(0.6100, 0.7100, 0.0010)
#r12b=random(8., 15., 1.)
{tex("{\bf ","")}{question()}{tex(".}","")}  The density of a certain cut-rate
gasoline is {r12a:".3f"} grams/mL.  What is the mass in {tex("{\bf
kilograms}","kilograms")} of {r12b:".0f"} gallons of this gasoline?
{tex("\\","")}

#ans12=r12a * r12b * 3.785411784
! Use the conversions (in the textbook) from milliLiters to Liters,
!  from grams to kilograms, and also from Liters to Gallons
/E Multiply by the volume by the density by the number of liters/gallon
/E  Be sure to covert from grams to kilograms ...
[ans12:3,2%]
//
```

```
//  djm, Chem141 Fall/94
//
#r13a=random(8., 25., 1.)
#r13b=random(1.0190, 1.5990, 0.0100)
{tex("{\bf ","")}{question()}{tex(".}","")}  People tend to buy a certain
number of dollars-worth of gasoline and not certain volumes (gallons) and not
certain masses (pounds?).  What is the mass in kilograms of
{tex("\$","$")}{r13a:".0f"} worth of the same cut-rate gasoline if it costs
{tex("\$","$")}{r13b:".3f"} per gallon.{tex("\\","")}

#ans13=(r13a / r13b) * r12a * 3.785411784
! Use the conversions (in the textbook) from milliLiters to Liters,
!  from grams to kilograms, and also from Liters to Gallons
/E First, divide the dollars by the dollars/gallon, then this problem
/E becomes similar to the previous problem...
[ans13:3,2%]
//
{tex("\hrule width2.0in height0.8pt
\hfill","----------------------------------------------------------")}{tex("\vskip
.15in","")}
//
//
//Scientific Notation
//
#r1=random(1,8,1)
#s1=choose(r1,"40.","400.","0.4","404","4004","4400","0.004","0.0404")
{tex("{\bf ","")}{question()}{tex(".}","")}  Express the following in
scientific notation.  (Example:  5.342e-2)
{tex("\begin{quote}","")}
{s1}{tex("\\","")}
{tex("\end{quote}","")}

#ans=choose(r1,"4.0e1","4.00e2","4e-1","4.04e2","4.004e3","4.4e3","4e-3","4.04e-
2")
[ans]
//
//
//Scientific Notation
//
#r1=random(1,6,1)
#n1=tex("$6.1 x 10^2$","6.1e2")
#n2=tex("$6.01 x 10^3$","6.01e3")
#n3=tex("$6.0 x 10^{-2}$","6.0e-2")
#n4=tex("$6.6 x 10$","6.6e1")
#n5=tex("$6.01 x 10^{-4}$","6.01e-4")
#n6=tex("$6.01 x 10^4$","6.01e4")
```

```
#s1=choose(r1,n1,n2,n3,n4,n5,n6)
{tex("{\bf ","")}{question()}{tex(".}","")}  Express the following as whole
numbers or decimals.  (Example:  23 455.342 534)
{tex("\begin{quote}","")}
{s1}{tex("\\","")}
{tex("\end{quote}","")}

#ans=choose(r1,"610","6010","0.060","66","0.000 601","60 100")
[ans]
//
//
//Scientific Notation
//
#r1=random(1,6,1)
#n1=tex("$(6.0 x 10^4)(2.0 x 10^5)$","(6.0e4)(2.0e5)")
#n2=tex("$(6.0 x 10^{-3})(3.0 x 10^5)$","(6.0e-3)(3.0e5)")
#n3=tex("$(4.0 x 10^4)(2.0 x 10^{-6})$","(4.0e4)(2.0e-6)")
#n4=tex("$(2.5 x 10^{-4})(4.0 x 10^{-3})$","(2.5e-4)(4.0e-3)")
#n5=tex("$(2.5 x 10^4)(4.0 x 10^3)$","(2.5e4)(4.0e3)")
#n6=tex("$(5.0 x 10^{-1})(1.2 x 10^3)$","(5.0e-1)(1.2e3)")
#s1=choose(r1,n1,n2,n3,n4,n5,n6)
{tex("{\bf ","")}{question()}{tex(".}","")}  Preform the following calculation,
expressing your answer in scientific notation:.  (Example:  4.56e-8)
{tex("\begin{quote}","")}
{s1}{tex("\\","")}
{tex("\end{quote}","")}

#ans=choose(r1,"1.2e10","1.8e3","8.0e-2","1.0e-6","1.0e8","6.0e2")
[ans]
//
//
//Scientific Notation
//
#r1=random(1,6,1)
#n1=tex("$(6.0 x 10^6)/(2.0 x 10^4)$","(6.0e6)/(2.0e4)")
#n2=tex("$(8.0 x 10^3)/(2.0 x 10^6)$","(8.0e3)/(2.0e6)")
#n3=tex("$(3.0 x 10^4)/(6.0 x 10^{-2})$","(3.0e4)/(6.0e-2)")
#n4=tex("$(2.0 x 10^{-3})/(4.0 x 10^{-8})$","(2.e-3)/(4.0e-8)")
#n5=tex("$(7.0 x 10^7)/(3.5 x 10^5)$","(7.0e7)/(3.5e5)")
#n6=tex("$(9.0 x 10^2)/(3.0 x 10^{-3})$","(9.0e2)/(3.0e-3)")
#s1=choose(r1,n1,n2,n3,n4,n5,n6)
{tex("{\bf ","")}{question()}{tex(".}","")}  Preform the following calculation,
expressing your answer in scientific notation.  (Example:  4.56e-8)
{tex("\begin{quote}","")}
{s1}{tex("\\","")}
{tex("\end{quote}","")}
```

```
#ans=choose(r1,"3.0e-2","4.0e-3","5.0e5","5.0e4","2.0e2","3.0e5")
[ans]
//
//
//Scientific Notation & Significant Figures
//
#r1=random(1,6,1)
#n1=tex("$5 x 10^{-3}$","5e-3")
#n2=tex("$5.0 x 10^{-4}$","5.0e-4")
#n3=tex("$5.01 x 10^7$","5.01e7")
#n4=tex("$7.0010 x 10^9$","7.0010e9")
#s1=choose(r1,n1,n2,n3,n4)
{tex("{\bf ","")}{question()}{tex(".}","")}  How many significant figures are
there in the following measurement.  (Example:  4)
{tex("\begin{quote}","")}
{s1}{tex("\\","")}
{tex("\end{quote}","")}

#ans=choose(r1,"1","2","3","5")
[ans]
//
{tex("\hrule width2.0in height0.8pt
\hfill","----------------------------------------------------------")}{tex("\vskip
.15in","")}
//
//
//Problem Solving
//
#m1="Read the problem and make a list of 'knowns' and 'unknowns'."
#m2="Look up needed information."
#m3="Work out a plan."
#m4="Obtain an answer by doing the math."
#m5="Check your work."
#m6="Turn in your work and answer."
{tex("{\bf ","")}{question()}{tex(".}","")}  Place the following steps of
problem solving in the correct order.  (Example: CGD...)
{tex("\begin{quote}","")}
#colzwy1=random(1,24,1)
A)
{choose(colzwy1,m5,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m1,m4,m3,m5,m6,m2,m1,m4,m3,m
5,m6,m2)}{tex("\\","")}
B)
{choose(colzwy1,m3,m5,m6,m2,m1,m4,m4,m3,m5,m6,m2,m1,m5,m6,m2,m1,m4,m3,m3,m5,m6,m
2,m1,m4)}{tex("\\","")}
C)
```

```
{choose(colzwyl,m4,m3,m5,m6,m2,m1,m3,m5,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m5,m6,m2,m
1,m4,m3)}{tex("\\","")}
D)
{choose(colzwyl,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m6,m2,m4,m3,m5,m6,m2,m1,m2,m1,m4,m
3,m5,m6)}{tex("\\","")}
E)
{choose(colzwyl,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m6,m6,m2,m1,m
4,m3,m5)}{tex("\\","")}
F)
{choose(colzwyl,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m4,m3,m5,m
6,m2,m1)}{tex("\\","")}{tex("\end{quote}","")}

#ans=choose(colzwyl,"DEBCAF","EFCDBA","FADECB","ABEFDC","BCFAED","CDABFE","DECBA
F","EFBDCA","FADEBC","ACEFDB","CBFAED","BDACFE","AECDBF","EFDACB","FBAEDC","BCEF
AD","CDFBEA","DABCFE","ADBFCE","DEFABC","ECADFB","CBDEAF","BFECDA","FACBED")
[ans]
```



Appendix 3:

Coding for Matching Questions

Matching questions are new to the CAPA system.
Here is the coding I wrote to accommodate this type of question.

Sorting 5

```
#r1="correct statement"
#a1="correct answer"
#r2="correct statement"
#a2="correct answer"
#r3="correct statement"
#a3="correct answer"
#r4="correct statement"
#a4="correct answer"
#r5="correct statement"
#a5="correct answer"
{tex("{\bf ","")}{question()}{tex(".}","")}
{tex("\begin{quote}","")}
#colzwy1=random(1,24,1)
A)
{choose(colzwy1,r5,r2,r1,r4,r3,r5,r2,r1,r4,r3,r3,r5,r2,r1,r4,r5,r2,r1,r4,r3,r5,r
2,r1,r4)}{tex("\\","")}
B)
{choose(colzwy1,r3,r5,r2,r1,r4,r4,r3,r5,r2,r1,r5,r2,r1,r4,r3,r1,r4,r3,r5,r2,r1,r
4,r3,r5)}{tex("\\","")}
C)
{choose(colzwy1,r4,r3,r5,r2,r1,r3,r5,r2,r1,r4,r4,r3,r5,r2,r1,r3,r5,r2,r1,r4,r4,r
3,r5,r2)}{tex("\\","")}
D)
{choose(colzwy1,r1,r4,r3,r5,r2,r1,r4,r3,r5,r2,r1,r4,r3,r5,r2,r4,r3,r5,r2,r1,r3,r
5,r2,r1)}{tex("\\","")}
E)
{choose(colzwy1,r2,r1,r4,r3,r5,r2,r1,r4,r3,r5,r2,r1,r4,r3,r5,r2,r1,r4,r3,r5,r2,r
1,r4,r3)}{tex("\\","")}
{tex("\end{quote}","")}

#ans1=choose(colzwy1,a5,a2,a1,a4,a3,a5,a2,a1,a4,a3,a3,a5,a2,a1,a4,a5,a2,a1,a4,a3
,a5,a2,a1,a4)
#ans2=choose(colzwy1,a3,a5,a2,a1,a4,a4,a3,a5,a2,a1,a5,a2,a1,a4,a3,a1,a4,a3,a5,a2
,a1,a4,a3,a5)
#ans3=choose(colzwy1,a4,a3,a5,a2,a1,a3,a5,a2,a1,a4,a4,a3,a5,a2,a1,a3,a5,a2,a1,a4
,a4,a3,a5,a2)
#ans4=choose(colzwy1,a1,a4,a3,a5,a2,a1,a4,a3,a5,a2,a1,a4,a3,a5,a2,a4,a3,a5,a2,a1
,a3,a5,a2,a1)
#ans5=choose(colzwy1,a2,a1,a4,a3,a5,a2,a1,a4,a3,a5,a2,a1,a4,a3,a5,a2,a1,a4,a3,a5
,a2,a1,a4,a3)
[ans1+", "+ans2+", "+ans3+", "+ans4+", "+ans5]
```

Sorting 6

```
#m1="correct statement"
#a1="correct answer"
#m2="correct statement"
#a2="correct answer"
#m3="correct statement"
#a3="correct answer"
#m4="correct statement"
#a4="correct answer"
#m5="correct statement"
#a5="correct answer"
#m6="correct statement"
#a6="correct answer"
{tex("{\bf ","")}{question()}{tex(".}","")}
{tex("\begin{quote}","")}
#colzwy1=random(1,24,1)
A)
{choose(colzwy1,m5,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m1,m4,m3,m5,m6,m2,m1,m4,m3,m
5,m6,m2)}{tex("\\","")}
B)
{choose(colzwy1,m3,m5,m6,m2,m1,m4,m4,m3,m5,m6,m2,m1,m5,m6,m2,m1,m4,m3,m3,m5,m6,m
2,m1,m4)}{tex("\\","")}
C)
{choose(colzwy1,m4,m3,m5,m6,m2,m1,m3,m5,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m5,m6,m2,m
1,m4,m3)}{tex("\\","")}
D)
{choose(colzwy1,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m6,m2,m4,m3,m5,m6,m2,m1,m2,m1,m4,m
3,m5,m6)}{tex("\\","")}
E)
{choose(colzwy1,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m6,m6,m2,m1,m
4,m3,m5)}{tex("\\","")}
F)
{choose(colzwy1,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m6,m2,m1,m4,m3,m5,m4,m3,m5,m
6,m2,m1)}{tex("\\","")}{tex("\end{quote}","")}

#ans1=choose(colzwy1,a5,a6,a2,a1,a4,a3,a5,a6,a2,a1,a4,a3,a1,a4,a3,a5,a6,a2,a1,a4
,a3,a5,a6,a2)
#ans2=choose(colzwy1,a3,a5,a6,a2,a1,a4,a4,a3,a5,a6,a2,a1,a5,a6,a2,a1,a4,a3,a3,a5
,a6,a2,a1,a4)
#ans3=choose(colzwy1,a4,a3,a5,a6,a2,a1,a3,a5,a6,a2,a1,a4,a3,a5,a6,a2,a1,a4,a5,a6
,a2,a1,a4,a3)
#ans4=choose(colzwy1,a1,a4,a3,a5,a6,a2,a1,a4,a3,a5,a6,a2,a4,a3,a5,a6,a2,a1,a2,a1
,a4,a3,a5,a6)
#ans5=choose(colzwy1,a2,a1,a4,a3,a5,a6,a2,a1,a4,a3,a5,a6,a2,a1,a4,a3,a5,a6,a6,a2
,a1,a4,a3,a5)
#ans6=choose(colzwy1,a6,a2,a1,a4,a3,a5,a6,a2,a1,a4,a3,a5,a6,a2,a1,a4,a3,a5,a4,a3
```

```
,a5,a6,a2,a1)
[ans1+", "+ans2+", "+ans3+", "+ans4+", "+ans5+", "+ans6]


     Sorting 8

#r1="correct statement"
#a1="correct answer"
#r2="correct statement"
#a2="correct answer"
#r3="correct statement"
#a3="correct answer"
#r4="correct statement"
#a4="correct answer"
#r5="correct statement"
#a5="correct answer"
#r6="correct statement"
#a6="correct answer"
#r7="correct statement"
#a7="correct answer"
#r8="correct statement"
#a8="correct answer"
{tex("{\bf ","")}{question()}{tex(".}","")}
{tex("\begin{quote}","")}
#colzwy1=random(1,24,1)
A)
{choose(colzwy1,r5,r8,r6,r2,r7,r1,r4,r3,r5,r8,r6,r2,r7,r1,r4,r3,r5,r8,r6,r2,r7,r
1,r4,r3)}{tex("\\","")}
B)
{choose(colzwy1,r3,r5,r8,r6,r2,r7,r1,r4,r1,r4,r3,r5,r8,r6,r2,r7,r8,r6,r2,r7,r1,r
4,r3,r5)}{tex("\\","")}
C)
{choose(colzwy1,r4,r3,r5,r8,r6,r2,r7,r1,r6,r2,r7,r1,r4,r3,r5,r8,r2,r7,r1,r4,r3,r
5,r8,r6)}{tex("\\","")}
D)
{choose(colzwy1,r1,r4,r3,r5,r8,r6,r2,r7,r4,r3,r5,r8,r6,r2,r7,r1,r6,r2,r7,r1,r4,r
3,r5,r8)}{tex("\\","")}
E)
{choose(colzwy1,r2,r7,r1,r4,r3,r5,r8,r6,r3,r5,r8,r6,r2,r7,r1,r4,r3,r5,r8,r6,r2,r
7,r1,r4)}{tex("\\","")}
F)
{choose(colzwy1,r6,r2,r7,r1,r4,r3,r5,r8,r2,r7,r1,r4,r3,r5,r8,r6,r7,r1,r4,r3,r5,r
8,r6,r2)}{tex("\\","")}
G)
{choose(colzwy1,r7,r1,r4,r3,r5,r8,r6,r2,r8,r6,r2,r7,r1,r4,r3,r5,r4,r3,r5,r8,r6,r
2,r7,r1)}{tex("\\","")}
```

```
H)
{choose(colzwyl,r8,r6,r2,r7,r1,r4,r3,r5,r7,r1,r4,r3,r5,r8,r6,r2,r1,r4,r3,r5,r8,r
6,r2,r7)}{tex("\\","")}
{tex("\end{quote}","")}

#ans1=choose(colzwyl,a5,a8,a6,a2,a7,a1,a4,a3,a5,a8,a6,a2,a7,a1,a4,a3,a5,a8,a6,a2
,a7,a1,a4,a3)
#ans2=choose(colzwyl,a3,a5,a8,a6,a2,a7,a1,a4,a1,a4,a3,a5,a8,a6,a2,a7,a8,a6,a2,a7
,a1,a4,a3,a5)
#ans3=choose(colzwyl,a4,a3,a5,a8,a6,a2,a7,a1,a6,a2,a7,a1,a4,a3,a5,a8,a2,a7,a1,a4
,a3,a5,a8,a6)
#ans4=choose(colzwyl,a1,a4,a3,a5,a8,a6,a2,a7,a4,a3,a5,a8,a6,a2,a7,a1,a6,a2,a7,a1
,a4,a3,a5,a8)
#ans5=choose(colzwyl,a2,a7,a1,a4,a3,a5,a8,a6,a3,a5,a8,a6,a2,a7,a1,a4,a3,a5,a8,a6
,a2,a7,a1,a4)
#ans6=choose(colzwyl,a6,a2,a7,a1,a4,a3,a5,a8,a2,a7,a1,a4,a3,a5,a8,a6,a7,a1,a4,a3
,a5,a8,a6,a2)
#ans7=choose(colzwyl,a7,a1,a4,a3,a5,a8,a6,a2,a8,a6,a2,a7,a1,a4,a3,a5,a4,a3,a5,a8
,a6,a2,a7,a1)
#ans8=choose(colzwyl,a8,a6,a2,a7,a1,a4,a3,a5,a7,a1,a4,a3,a5,a8,a6,a2,a1,a4,a3,a5
,a8,a6,a2,a7)
[ans1+ans2+ans3+ans4+ans5+ans6+ans7+ans8]


        Sorting 10

#m1="correct statement"
#a1="correct answer"
#m2="correct statement"
#a2="correct answer"
#m3="correct statement"
#a3="correct answer"
#m4="correct statement"
#a4="correct answer"
#m5="correct statement"
#a5="correct answer"
#m6="correct statement"
#a6="correct answer"
#m7="correct statement"
#a7="correct answer"
#m8="correct statement"
#a8="correct answer"
#m9="correct statement"
#a9="correct answer"
#m10="correct statement"
#a10="correct answer"
```

```
{tex("{\bf ","")}{question()}{tex(".}","")}
{tex("\begin{quote}","")}
#colzwy1=random(1,24,1)
A)
{choose(colzwy1,m2,m3,m5,m7,m10,m6,m6,m2,m6,m9,m2,m1,m7,m1,m2,m1,m2,m3,m3,m10,m5
,m2,m7,m10)}{tex("\\","")}
B)
{choose(colzwy1,m8,m9,m10,m4,m9,m4,m4,m1,m2,m1,m1,m2,m10,m6,m8,m3,m7,m7,m7,m8,m1
,m5,m10,m6)}{tex("\\","")}
C)
{choose(colzwy1,m5,m7,m4,m2,m1,m1,m2,m9,m8,m4,m4,m4,m9,m5,m7,m9,m5,m2,m8,m3,m9,m
10,m5,m3)}{tex("\\","")}
D)
{choose(colzwy1,m6,m10,m6,m5,m3,m9,m1,m6,m10,m3,m8,m9,m4,m2,m9,m6,m6,m8,m5,m4,m4
,m8,m6,m8)}{tex("\\","")}
E)
{choose(colzwy1,m1,m4,m3,m10,m8,m10,m9,m5,m7,m7,m9,m7,m3,m8,m1,m8,m4,m5,m10,m7,m
3,m6,m3,m5)}{tex("\\","")}
F)
{choose(colzwy1,m3,m8,m1,m8,m4,m5,m10,m7,m3,m6,m3,m5,m1,m4,m3,m10,m8,m10,m9,m5,m
7,m7,m9,m7)}{tex("\\","")}
G)
{choose(colzwy1,m4,m2,m9,m6,m6,m8,m5,m4,m4,m8,m6,m8,m6,m10,m6,m5,m3,m9,m1,m6,m10
,m3,m8,m9)}{tex("\\","")}
H)
{choose(colzwy1,m9,m5,m7,m9,m5,m2,m8,m3,m9,m10,m5,m3,m5,m7,m4,m2,m1,m1,m2,m9,m8,
m4,m4,m4)}{tex("\\","")}
I)
{choose(colzwy1,m10,m6,m8,m3,m7,m7,m7,m8,m1,m5,m10,m6,m8,m9,m10,m4,m9,m4,m4,m1,m
2,m1,m1,m2)}{tex("\\","")}
J)
{choose(colzwy1,m7,m1,m2,m1,m2,m3,m3,m10,m5,m2,m7,m10,m2,m3,m5,m7,m10,m6,m6,m2,m
6,m9,m2,m1)}{tex("\\","")}
{tex("\end{quote}","")}

#ans1=choose(colzwy1,a2,a3,a5,a7,a10,a6,a6,a2,a6,a9,a2,a1,a7,a1,a2,a1,a2,a3,a3,a
10,a5,a2,a7,a10)
#ans2=choose(colzwy1,a8,a9,a10,a4,a9,a4,a4,a1,a2,a1,a1,a2,a10,a6,a8,a3,a7,a7,a7,
a8,a1,a5,a10,a6)
#ans3=choose(colzwy1,a5,a7,a4,a2,a1,a1,a2,a9,a8,a4,a4,a4,a9,a5,a7,a9,a5,a2,a8,a3
,a9,a10,a5,a3)
#ans4=choose(colzwy1,a6,a10,a6,a5,a3,a9,a1,a6,a10,a3,a8,a9,a4,a2,a9,a6,a6,a8,a5,
a4,a4,a8,a6,a8)
#ans5=choose(colzwy1,a1,a4,a3,a10,a8,a10,a9,a5,a7,a7,a9,a7,a3,a8,a1,a8,a4,a5,a10
,a7,a3,a6,a3,a5)
#ans6=choose(colzwy1,a3,a8,a1,a8,a4,a5,a10,a7,a3,a6,a3,a5,a1,a4,a3,a10,a8,a10,a9
```

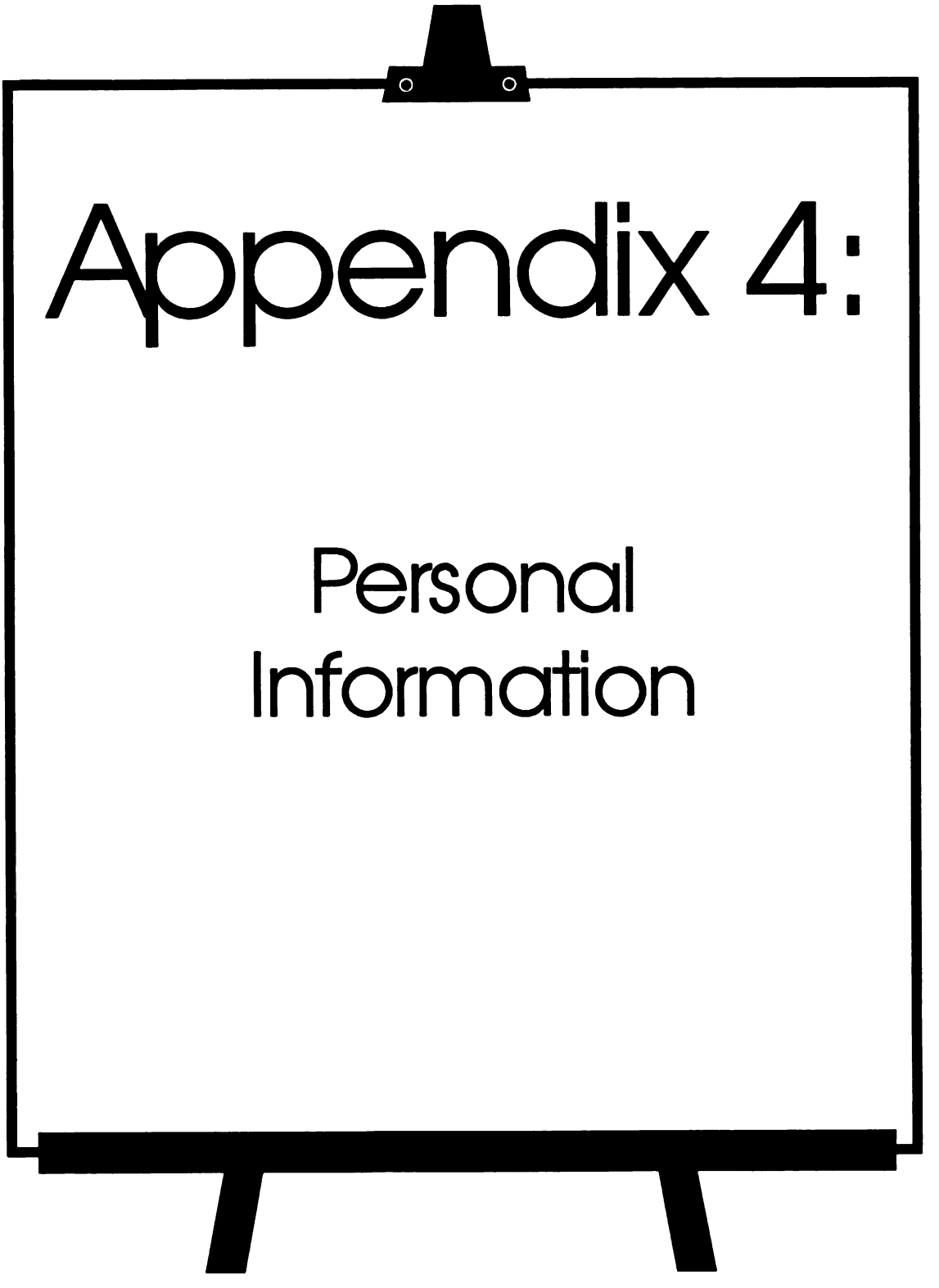
```
,a5,a7,a7,a9,a7)
#ans7=choose(colzwy1,a4,a2,a9,a6,a6,a8,a5,a4,a4,a8,a6,a8,a6,a10,a6,a5,a3,a9,a1,a
6,a10,a3,a8,a9)
#ans8=choose(colzwy1,a9,a5,a7,a9,a5,a2,a8,a3,a9,a10,a5,a3,a5,a7,a4,a2,a1,a1,a2,a
9,a8,a4,a4,a4)
#ans9=choose(colzwy1,a10,a6,a8,a3,a7,a7,a7,a8,a1,a5,a10,a6,a8,a9,a10,a4,a9,a4,a4
,a1,a2,a1,a1,a2)
#ans10=choose(colzwy1,a7,a1,a2,a1,a2,a3,a3,a10,a5,a2,a7,a10,a2,a3,a5,a7,a10,a6,a
6,a2,a6,a9,a2,a1)
[ans1+", "+ans2+", "+ans3+", "+ans4+", "+ans5+", "+ans6+", "+ans7+", "+ans8+",
"+ans9+", "+ans10]
```

Sorting 12

```
#m1="correct statement"
#a1="correct answer"
#m2="correct statement"
#a2="correct answer"
#m3="correct statement"
#a3="correct answer"
#m4="correct statement"
#a4="correct answer"
#m5="correct statement"
#a5="correct answer"
#m6="correct statement"
#a6="correct answer"
#m7="correct statement"
#a7="correct answer"
#m8="correct statement"
#a8="correct answer"
#m9="correct statement"
#a9="correct answer"
#m10="correct statement"
#a10="correct answer"
#m11="correct statement"
#a11="correct answer"
#m12="correct statement"
#a12="correct answer"
{tex("{\bf ","")}{question()}{tex(".}","")}
{tex("\begin{quote}","")}
#colzwy1=random(1,24,1)
A)
{choose(colzwy1,m2,m3,m5,m7,m10,m6,m12,m11,m6,m9,m12,m1,m7,m1,m12,m1,m2,m3,m3,m1
0,m5,m11,m7,m11)}{tex("\\","")}
B)
```

```
{choose(colzwy1,m8,m9,m10,m4,m9,m4,m6,m2,m11,m1,m2,m12,m10,m11,m2,m3,m7,m7,m7,m1
2,m1,m2,m10,m10)}{tex("\\","")}
C)
{choose(colzwy1,m12,m7,m4,m2,m1,m11,m4,m1,m2,m4,m1,m2,m9,m6,m11,m9,m5,m2,m8,m8,m
9,m5,m5,m6)}{tex("\\","")}
D)
{choose(colzwy1,m5,m10,m6,m5,m12,m1,m2,m9,m8,m12,m4,m4,m4,m5,m8,m12,m6,m8,m5,m3,
m4,m10,m6,m3)}{tex("\\","")}
E)
{choose(colzwy1,m6,m4,m3,m11,m3,m9,m11,m6,m10,m3,m11,m9,m3,m12,m7,m6,m11,m5,m10,
m4,m3,m8,m3,m8)}{tex("\\","")}
F)
{choose(colzwy1,m11,m8,m1,m10,m8,m10,m1,m5,m12,m7,m8,m7,m1,m2,m9,m8,m4,m12,m9,m7
,m7,m6,m9,m5)}{tex("\\","")}
G)
{choose(colzwy1,m1,m2,m9,m8,m4,m12,m9,m7,m7,m6,m9,m5,m11,m8,m1,m10,m8,m10,m1,m5,
m12,m7,m8,m7)}{tex("\\","")}
H)
{choose(colzwy1,m3,m12,m7,m6,m11,m5,m10,m4,m3,m8,m3,m8,m6,m4,m3,m11,m3,m9,m11,m6
,m10,m3,m11,m9)}{tex("\\","")}
I)
{choose(colzwy1,m4,m5,m8,m12,m6,m8,m5,m3,m4,m10,m6,m3,m5,m10,m6,m5,m12,m1,m2,m9,
m8,m12,m4,m4)}{tex("\\","")}
J)
{choose(colzwy1,m9,m6,m11,m9,m5,m2,m8,m8,m9,m5,m5,m6,m12,m7,m4,m2,m1,m11,m4,m1,m
2,m4,m1,m2)}{tex("\\","")}
K)
{choose(colzwy1,m10,m11,m2,m3,m7,m7,m7,m12,m1,m2,m10,m10,m8,m9,m10,m4,m9,m4,m6,m
2,m11,m1,m2,m12)}{tex("\\","")}
L)
{choose(colzwy1,m7,m1,m12,m1,m2,m3,m3,m10,m5,m11,m7,m11,m2,m3,m5,m7,m10,m6,m12,m
11,m6,m9,m12,m1)}{tex("\\","")}
{tex("\end{quote}","")}

#ans1=choose(colzwy1,a2,a3,a5,a7,a10,a6,a12,a11,a6,a9,a12,a1,a7,a1,a12,a1,a2,a3,
a3,a10,a5,a11,a7,a11)
#ans2=choose(colzwy1,a8,a9,a10,a4,a9,a4,a6,a2,a11,a1,a2,a12,a10,a11,a2,a3,a7,a7,
a7,a12,a1,a2,a10,a10)
#ans3=choose(colzwy1,a12,a7,a4,a2,a1,a11,a4,a1,a2,a4,a1,a2,a9,a6,a11,a9,a5,a2,a8
,a8,a9,a5,a5,a6)
#ans4=choose(colzwy1,a5,a10,a6,a5,a12,a1,a2,a9,a8,a12,a4,a4,a4,a5,a8,a12,a6,a8,a
5,a3,a4,a10,a6,a3)
#ans5=choose(colzwy1,a6,a4,a3,a11,a3,a9,a11,a6,a10,a3,a11,a9,a3,a12,a7,a6,a11,a5
,a10,a4,a3,a8,a3,a8)
#ans6=choose(colzwy1,a11,a8,a1,a10,a8,a10,a1,a5,a12,a7,a8,a7,a1,a2,a9,a8,a4,a12,
a9,a7,a7,a6,a9,a5)
```

```
#ans7=choose(colzwy1,a1,a2,a9,a8,a4,a12,a9,a7,a7,a6,a9,a5,a11,a8,a1,a10,a8,a10,a
1,a5,a12,a7,a8,a7)
#ans8=choose(colzwy1,a3,a12,a7,a6,a11,a5,a10,a4,a3,a8,a3,a8,a6,a4,a3,a11,a3,a9,a
11,a6,a10,a3,a11,a9)
#ans9=choose(colzwy1,a4,a5,a8,a12,a6,a8,a5,a3,a4,a10,a6,a3,a5,a10,a6,a5,a12,a1,a
2,a9,a8,a12,a4,a4)
#ans10=choose(colzwy1,a9,a6,a11,a9,a5,a2,a8,a8,a9,a5,a5,a6,a12,a7,a4,a2,a1,a11,a
4,a1,a2,a4,a1,a2)
#ans11=choose(colzwy1,a10,a11,a2,a3,a7,a7,a7,a12,a1,a2,a10,a10,a8,a9,a10,a4,a9,a
4,a6,a2,a11,a1,a2,a12)
#ans12=choose(colzwy1,a7,a1,a12,a1,a2,a3,a3,a10,a5,a11,a7,a11,a2,a3,a5,a7,a10,a6
,a12,a11,a6,a9,a12,a1)
[ans1+", "+ans2+", "+ans3+", "+ans4+", "+ans5+", "+ans6+", "+ans7+", "+ans8+",
"+ans9+", "+ans10+", "+ans11+", "+ans12]
```



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References

Berners-Lee, T., R. Cailliau, A. Luotonen, H.F. Nielsen, and A. Secret, *The World-Wide Web*, Communication of the ACM, (8)1994.

Chiu, C.B., *Knowledge of Performance as an Incentive in Repetitive, Monotonous Tasks*, Journal of Applied Psychology, (4)1964.

Connell, J.H., *Personalized Homework Pioneer*, American Journal of Physics, (7)1994.

Karraker, Roger, *Highways of the Mind*, Whole Earth Review, Spring 1991.

Kashy, E., B.M. Sherrill, Y. Tsai, D. Thaler, D. Weinshank, M. Engelmann, and D.J. Morrissey, *CAPA -- An Integrated Computer Assisted Personalized Assignment System*, American Journal of Physics, December 1993.

Kashy, E., *CAPA, a Tool for Teachers and Students*, presented in the spring of 1994 for the teacher's weekend workshops.

Kashy, E., D.J. Morrisey, Y. Tsai, and S.L. Wolfe, *CAPA: A Versatile Tool for Science Education*, Michigan State University, September 1995.

Kashy, E., D.J. Morrissey, and Y. Tsai, *CAPA - System Decryption and User's Manual*, MSUCL-925, January 1994.

Kashy, E., D.J. Morrissey, and Y. Tsai, *CAPA System Update*, Michigan State University, May 1994.

Kashy, E., Michigan State University Cyclotron, private communication.

Kashy, E., S.J. Gaaf, N.H. Pawley, W.L. Stretch, and S.L. Wolfe, *Conceptual Questions in Computer-Assisted Assignments*, American Journal of Physics, January 1995.

Morrissey, D.J., E. Kashy, and Y. Tsai, *Using Computer-Assisted Personalized Assignments for Freshman Chemistry*, Journal of Chemical Education, February 1995.

Watson, F.G., Research on Teaching Science, *Handbook of Research on Teaching*, American education Research Association, 1963.

Wolfe, S.L., Michigan State University Cyclotron, private communication.

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