The Educational Value of Chemistry Demonstrations in a College Lecture Hall

Mr. William Butler
wgbsch@rit.edu
Chemistry Department
Adjunct Facility Learning Community
Summer, 2010

My name is William Butler and I am an adjunct with the Chemistry department. I am researching the benefits of incorporating chemistry demonstrations into the curriculum.

Chemistry demonstrations offer many benefits to a student's understanding of the concepts of Chemistry. The study of the interactions between microscopic particles is at the heart of Chemistry. Understanding these theories is enhanced by using models, activities and chemical demonstrations that show on a macroscopic level what we believe is occurring at an atomic level.

My first awareness of chemical demonstrations occurred in 1980 when I participated in a workshop hosted by Dr. Kenneth Schlecht at SUNY Brockport. Dr. Schlecht is a nationally recognized contributor to chemical demonstrations.

Since that time I have developed or edited over 90 different demonstrations that were used in classes from non-Regents Chemistry to Advanced Placement.

I also had the opportunity during a conference for outstanding chemistry teachers from across the country that was held at Princeton University to attend several workshops given by Dr. Hubert Alyea. Dr. Alyea is considered to be the modern day ‘founder’ of chemical demonstrations in the world.

I will use these demonstrations in 1011 Chemistry 208.
This course is a survey of several topics in general inorganic chemistry. The students are primarily freshman who major in engineering. The course is taught in an auditorium with about 125 students. Instruction is usually done via power point slides. There is no lab activity associated with this course.

The demonstrations that I will incorporate are:

1) Lesson 1. Density. Using containers of Pepsi the value of density differences as a separating/identifying activity will be shown.
2) Lesson 7. Water Grabber. Using sodium polyacrylate & water a polymer will be produced and then broken.
3) Lesson 10. Red Cabbage Indicator. Using the juice from red cabbage the acidic or alkaline nature of several common liquids will be shown
4) Lesson 13. Gatorade Clock. A chemical reaction involving copper, magnesium and an electrolytic solution provide enough energy to run a clock that normally uses 1- AA battery. Themochemistry.
5) Lesson 16. Commercial hot & cold packs.
6) Lesson 29. Mentos. The addition of Mentos candy to soda pop produces a geyser. Gas laws.

The use of these will be assessed at the end of the course via a survey.

There are many articles that support the educational value of chemical demonstrations.

H. Beall (1) of the Department of Chemistry at Worcester Polytechnic Institute reported on Dr. Paul Kelter who made a presentation at a 8th Annual Worcester Polytechnic Institute Conference held October 15, 1994.

Dr. Paul Kelter of the University of Nebraska presented several questions for teachers of Chemistry to consider:

1) Who is the audience?
2) Why do we want them to learn the material?
3) What do we want them to learn?
4) Where do chemical demonstrations fit into the course?
5) Which are the most appropriate chemical demonstrations?
6) Are most appropriate chemical demonstrations the same for large vs. small class?

"Kelter concluded by stating that the greatest value of chemical demonstrations is that they promote an atmosphere of interactive conversation in the classroom between the student and teacher" p642

William Deese, Linda Ramsey, Jeffery Walczyk, and Danny Eddy, from Louisiana Tech Institute (2) wrote a detailed report that begins with:

"The traditional demonstration/discussion model breaks the monotony of the traditional lecture format and makes the teaching experience more enjoyable" p 1511

This article presents the findings of a study involving general chemistry students at Louisiana Tech University at Ruston, Louisiana. One section of students was evaluated with demonstration assessment while the other was given traditional biweekly quizzes. The report describes the nature of a demonstration assessment.

"Students in the experimental group [using demonstration assessments] outperformed students in the control group on the Chemistry Conceptual Assessment given at the end of the course, indicating that the intervention [demonstration assessment] promoted better conceptual understanding." p1514

Theodore Miller (3) of Ohio Wesleyan University remarks at the beginning of his article that: "I started using more and more demonstrations during class after I discovered that the students could create concepts out of their participation in classroom activities. " p 188

In my own experience as a high school Chemistry I found the same result. As I brought more demonstrations into my curriculum I believe my students were able to make the transition from microscopic world of the atom to the world that they lived in.

Miler also ran a study to determine how students who were taught using his Demonstration-Exploration-Discussion scored on standardized tests. These students scored as well as those who attended a more traditional lecture class. p 188

Charles Ophardt, Michelle Applebee, and Eugene Losey, (4) from Elmhurst College reported that some chemistry teachers have gone so far as to replace traditional 'cookbook' laboratory activities with the development and presentation of demonstrations. Originally this program was made available to students majoring in education. Eventually it was made available to any non-Chemistry major. The students' grades were comparable to the students who had a traditional laboratory experience. The students overwhelmingly preferred the demonstration based experience.

Thomas O’Brien (5) at SUNY Binghamton is of the opinion that the debate over demonstrations vs. laboratory is not the salient issue: “Not either/or, but when and for what purpose?”

He discusses the issues:

1) Preparation & practice of demonstrations.
2) How does the demonstration fit into the curriculum?
3) What prior knowledge is necessary to understand the demonstration?
4) Carefully review the available chemical demonstrations for the one that best suits your teaching situation.
5) What are you going to say during the demonstration?

The article concludes by reminding teachers of the value of a post demonstration activity.

In conclusion even with my limited literature search many articles that support the value of chemistry demonstrations were easily found. From my own experience of twenty years of teaching high school chemistry I know this is true.

However there are several issues that are detriments to their use. The materials must be collected and stored for future use. Successful chemistry demonstrations require practice. If a chemistry demonstration is to be of educational value it needs to be integrated into the curriculum.

Good teaching requires adequate preparation. Great teaching demands more than that.

Bibliography:

1. Beall, H. Report on the WPI Conference : Demonstrations as a Teaching Tool in Chemistry: Pro and Con Journal of Chemical Education [Online], July 1996, p. 641 -642.

2. Deese, W.; Ramsey, L.; Walczyk, J.; Eddy, D. Using Demonstration Assessments to Improve Learning Journal of Chemical Education [Online], November 2000, p. 1511-1516.

3. Miller, T. L. Demonstration-Exploration-Discussion: Teaching Chemistry with Discovery and Creativity Journal of Chemical Education [Online], March 1993, p. 187-189.

4. Ophardt, C.; Applebee, M.; Losey, E. Chemical Demonstrations as the Laboratory Component in Non Science Majors Courses Journal of Chemical Education [Online], August 2005, p. 1174-1177.

5. O'Brien, T. The Science and Art of Science Demonstrations Journal of Chemical Education [Online], November 1991, p. 933-936.

Chemical Demonstrations

Lesson 1: DENSITY

Material:

Clear plastic pitcher
Cans of regular and diet Pepsi soda
Water

Procedure:

1) Fill the pitcher with COLD water.
2) Place the cans of pop in the water.
3) Observe
4) Remove the pop cans.

Discussion:

The property of a material floating in a liquid is determined by several factors. Density of the two materials is one of those factors. Density is defined as the ratio of mass over volume. D=M/V. The density of pure water is defined as 1 gm/ 1 mL or more simply as 1. Material that has a density of less than 1 will float in water.

The two cans of pop have the same volume but the diet pop floats because it has a smaller mass as compared to the regular pop. This is because the weight of aspartame needed to sweeten a beverage is much smaller than the sugar needed to obtain the same level of sweetness.

Lesson 7, WATER GRABBER

Material:

Sodium polyacrylate Na $[H_2C{=}CHOO^{-1}]_n$
Glass container
Distilled Water
Table salt

Procedure:

1) Place the sodium polyacrylate Na $[H_2C{=}CHOO^{-1}]_n$ in the bottom of a DRY container.
1) Slowly add distilled water to the container.
2) Stir
3) Observe
4) Slowly add table salt. Stir.

Discussion:

Super absorbent polymers are partially neutralized polyacrylate, with incomplete cross-linking between units. Only 50–70% of the COOH acid groups have been converted to their sodium salts. The final chemical has very long carbon chains bonded with sodium atoms in the center of the molecule. When sodium polyacrylate is exposed to water, the higher concentration of water outside the polymer than inside (lower sodium and polyacrylate solute concentration) draws the water into the center of the molecule via osmosis. Sodium polyacrylate will continue to absorb water until there is an equal concentration of water inside and outside the polymer.

When salt [NaCl] is added to the gel the concentration of water is higher in the gel than outside or the concentration of Na^{+}(aq) is higher outside the gel creating a concentration gradient. The osmosis of the water flows from inside the gel out.

Uses:

Baby diapers, nursery-potting soil, and as a fuel additive to remove moisture from the fuel

Lesson 10 : RED CABBAGE INDICATOR

Introduction

Red cabbage contains a pigment molecule called flavin (an anthocyanin). This water-soluble pigment is also found in apple skin, plums, poppies, cornflowers, and grapes.

Very acidic solutions will turn anthocyanin a red color. Neutral solutions result in a purplish color. Basic solutions appear in greenish-yellow.

Materials

Household chemicals

Lesson 13: GATORADE CLOCK

Material:

Wall clock that runs on 1 AA battery
2 test leads
Gatorade
Magnesium strip   Copper wire -solid

Directions:

1) Attach the copper wire to the test lead that is connected to the positive terminal on the back of the clock.
2) Fold the magnesium strip to form a strip about 1½ inches long. Attach the magnesium to the negative terminal.
3) Pour the Gatorade into the steady container.
4) Attach the test leads with the wire strips to opposite sides of the container using the cloths pins. Be sure that the wire strips do not touch each other.

Explanation:

This reaction is an example of the chemistry of dissimilar metals. All metals have valence electrons that they do not ‘want’. The loss of these electrons, which changes the element’s atom into ions, makes the material much more chemically stable.

The more reactive metal’s atoms force the weaker metal’s atoms to accept the stronger metal’s electrons. The more reactive metal, losing electrons, becomes positively charged and the less reactive metal becomes negatively charged.

The reaction that occurs in the fluid is the oxidation of magnesium and the reduction of water. This reaction produces bubbles at the magnesium electrode that are hydrogen gas. The mixture is becoming more basic with an increase in pH.

The movement of electrons from the magnesium electrode to the copper electrode [electrical current] provides the electrical energy to operate the clock.

The copper electrode provides a sufficient reduction potential so that the reaction is spontaneous.

Lesson 28; MENTOS

Material

- Mentos candies
- 2-liter bottles of diet soda
- Delivery apparatus

Here's How:

1) Stack 4-5 Mentos candies in the delivery apparatus
2) Carefully screw the delivery apparatus onto the bottle.
3) Step back and release the Mentos.

Explanation:

The Mentos cause the rapid release of the CO_2 that is dissolved in the soda. The carbonation of most drinks is done at four times normal atmospheric pressure. The Mentos provide a surface [called a nucleation site] on which the CO_2 converts from dissolved in the soda to a free gas. Nucleation sites can be scratches on a surface or specks of dust. Mentos seem to be loaded with these.