CHEMISTRY OUTREACH GUIDELINES AND DEMONSTRATIONS - SPRING 2005

Deadlines: **1. Register your OutReach team - Wednesday, February 23rd**
You may select your OutReach experiments, and begin practicing immediately

2. Contact a school and set up date and time for visit – Friday, April 1st (OR SOONER!)
Complete the "School Visit Information Form" (download from OutReach web page or ask Dr. Brush for a copy). Dr. Brush will send a confirmation letter to the teacher and give you a copy.

Remember: School vacation week is April 18-22; CH344 Exam III is on Friday, April 22; and the Undergraduate Research Symposium in on Friday, April 29.

3. Complete OutReach school visits – Friday, May 6th

4. Return reports and questionnaires to Dr. Brush – Friday, May 6th

General Guidelines – Please Read Before Beginning.

By participating in the Chemistry OutReach program your "Team" <u>must</u> agree to the following:

- To abide by all lab safety guidelines, including wearing eye protection at <u>all times</u>.
- To follow all demonstration procedures as written! No changes will be made or experiments added without first consulting with Dr. Brush. If you do not follow directions there will be no second chances; you will be dropped from the program, possibly with a zero grade.
- All OutReach team members are expected to contribute equally to the group's preparation and presentation. Team members will evaluate each other's efforts!
- I expect that the OutReach area and balance area in the organic lab will be kept clean, neat, and organized! Your group is responsible for cleaning up <u>immediately</u> after using OutReach supplies during lab, and <u>immediately</u> after returning from a school visit.
- You must turn in an "OutReach Check out" form to Dr. Brush upon your return from your presentation. All cleaned OutReach glassware and storage bottles should be washed and returned to the drying rack on the OutReach lab bench after practicing and immediately after returning from a visit**. There will be a minimum deduction of 10 points for sloppy work that will be accessed to your team.**
- Removal of any OutReach equipment or chemicals without Dr. Brush's permission will result in a zero OutReach grade.
- Remember that your "Team" is representing Bridgewater State College during your OutReach visit.

General Rules

1. No more than two "teams" can go out on a school visit on the same day. First-come-first-serve basis.

2. The chemical reagents, supplies, glassware, and plastic storage bottles for all demonstrations may be found on the rear lab bench in the organic chemistry lab, Room 323. Each OutReach demo is located in a drawer or cabinet, and everything should be labeled. Please return all reagents to the place where you found them. A supply of cardboard boxes for transporting your supplies will be left at the end of the lab bench.

3. Use <u>distilled water only</u> in making up the reagents and for rinsing glassware and bottles. Store stock solutions in <u>plastic bottles</u>; **the use of glass bottles is prohibited**! There are plastic cups and spoons that are suitable for mixing some reagents.

4. Do not waste reagents! All of these demonstrations are fun to practice, but limit yourself to 1-2 "practices" per team. **If a chemical reagent bottle is almost empty, contact Dr. Brush immediately so more can be ordered!**

5. All stock solutions must be PRE-MIXED AND PRE-MEASURED the day before your presentation (use plastic storage vials). You are allowed to bring only the amount of chemical reagents and supplies you will need for 1-2 runs of each experiment! Remember that other OutReach teams may need the chemicals and supplies on the same day you do. All chemical reagents must be properly labeled.

6. I strongly suggest that if you have set aside a box of chemicals and supplies for your OutReach visit, that you label the box with a big note asking that no one take any of the contents!

7. **Prepare a checklist!** On this checklist remember to include the following: phone numbers for Dr. Brush and the Chemistry Department, dust pan and brush, paper towels, a separate box or plastic bag for trash, labeled plastic waste bottles for each demonstration, eye goggles, gloves, wash bottle with water, spill kits (for acid and base spills), stir plate (if needed), evaluation sheet for the teacher, "goodies" for "volunteers" or for kids who ask good questions. The yellow buckets are for transporting waste only!

8. Unless stated otherwise, IMMEDIATELY bring all supplies and chemicals back to BSC; do not dispose of anything at the school you visit. Be sure to bring waste bottles and to dispose of waste properly at BSC, clean and return all glassware, and replenish any used reagents. Failure to clean-up will result in a minimum 10-point deduction. During your demo make sure that the students are sitting 5-10 feet back from demonstration table.

Important phone numbers: (508) 531-2116 (Dr. Brush's office)
(508) 531-1233 (chemistry office)

Suggestions about what to say or questions to ask before, during, and after your presentation:

- Be sure to introduce yourselves (first name basis!), and say that you are science students from BSC.
- Ask the kids what they know about science and/or chemistry. Science is a way of explaining how and why things happen in nature: biology – living things, astronomy – stars and planets, chemistry – study of what things are made of and how they form.
- Tell the kids how you got interested in science, what your favorite area of science is, your favorite class, etc. The kids want to know about YOU! Remember that you are a scientist "role model" to them. Tell them what you want to do after you graduate.
- Ask about states of matter (solid-liquid-gas), what a reaction is, how you can tell that a reaction is happening (color change, noise, gas given off, etc.). Chemists know how and why a reaction occurs – it is not magic – it can all be explained.
- **Focus on safety!** Point out that scientists are careful, we wear goggles, we never do experiments that might be dangerous, we never do experiments without supervision. Tell the kids to yell at you should you "accidently" remove your goggles; they love that and it keeps them all involved!
- You may need to "scale-up" your demonstrations so they can be seen by your audience. Be sure that you practice the scaled-up version first!
- At the end, ask what they learned, or if any of them want to be scientists. Tell the kids that if they work hard, anyone can be a scientist!
- Ask the class and the teacher if the kids would draw a picture or write a short story about their favorite demo. Have these mailed to Dr. Brush at BSC.
- Remind your audience that this is NOT magic - it's chemistry. A true scientist understands and can explain the chemical reactions. You are not a Harry Potter!

OutReach Demonstration Experimental Procedures

(1) "Elephant Toothpaste" Foam, or "The Volcano!".

CAUTION: 30% H_2O_2 is a strong oxidizing agent and will cause burns if it comes into contact with the skin or eyes. Gloves and goggles MUST be worn at all times when using and dispensing this reagent!

Reagents
A. 30% H_2O_2 (may be found in the refrigerator in the undergraduate research lab)
B. Liquid dish soap
C. 2M potassium iodide (KI) catalyst. Dissolve 3.3 grams of potassium iodide in 10 mL of distilled water. This solution may turn yellow with time, but is stable for at least one week.

Procedure: In a 1000 or 2000 mL graduated cylinder add 20 mL of 30% H_2O_2 (**CAUTION!**), 5 mL of soap, and mix by swirling. Note no reaction. Add about 10 mL of KI catalyst and stand back! Hot foam and steam erupts from the top of the cylinder. If you let a couple of drops of food coloring run down the sides of the grad cylinder just before adding the KI catalyst the foam will have colored bands much like some brands of toothpaste. The reaction is exothermic, and steam can be seen emerging from the warm grad cylinder. The foam should not blow skyward, but does make a mess so use a plastic tray or newspaper under the grad cylinder. Be careful not to get any of the foam on your skin or on any of your audience as it may contain unreacted H_2O_2. You may safely rinse the foam down the sink with water in the lab or at the school. If necessary, use less KI catalyst if the reaction is too vigorous.

Discussion: The potassium iodide acts as a catalyst that speeds up the decomposition of hydrogen peroxide. Ask the students if they know what a "catalyst" is? What examples can you give them? The brown color of the foam is due to a small amount of I_2 (iodine) that is formed as a by-product in the reaction.

$$\mathbf{2\ H_2O_2\ (aq) \rightarrow 2\ H_2O\ (l) + O_2\ (g) + Energy}$$

Hydrogen peroxide is used to disinfect skin cuts, and it is actually produced in our body as a harmful "waste product" from the oxygen we breathe. Fortunately, we have enzymes that also "catalyze" the decomposition of hydrogen peroxide just like the KI does. We don't have "foam" formed in our blood stream though!

Liquids are mixed to form a "foam", which is just a gas trapped inside of a liquid. A gas (oxygen) is formed very quickly by the decomposition of hydrogen peroxide, and the gas gets trapped in liquid soap to form millions of tiny soap bubbles. Show that if you turn the graduated cylinder upside down, no liquid comes out. Ask the kids to give some examples of foams (shaving cream, fire extinguishers, etc.).

(2) "Elmers Glue" Silly Putty.

CAUTION: Some people are allergic to Borax. Wash hands when you are through.

Reagents
Solution A: "White" Elmer's Glue Solution. To 25 mL of distilled water slowly add 25 mL of white Elmer's glue. Stir until homogeneous and store in plastic bottles.

Solution B: Saturated Borax Solution. Shake 1.7g of Borax in 25 mL of distilled water at room temperature. Store in a plastic bottle at room temperature.

Note #1: Instead of a plastic cup or beaker, try using zip-lock bags!

Note #2: This is a good demo for group participation. If you decide to have the kids do this with you, remember to bring enough cups and spoons (or zip-lock bags), and I have plastic "Easter eggs" that the kids to store their silly putty in.

Procedure: Add 25 mL of Solution A to a plastic cup or plastic beaker; add a few drops of food coloring if you wish. Add 10 mL of Solution B and stir with a spoon or spatula for about one minute. The polymer forms quickly and may be removed from the beaker and kneaded with your hands very easily.

Discussion: Two liquids are mixed and they form a gel or "slime" that behaves like "Silly Putty". The "silly putty" will stretch if pulled slowly, and break if pulled quickly. If rolled into a ball, it will bounce if dropped! The silly putty will also "pick up" the writing from water-based felt tip ink pens. This is also called a polymer (examples of other types of polymers?). Polyvinyl alcohol (PVA) is a commercial polymer with a structure composed of repeating vinyl alcohol "mer" units. Have student volunteers help you, and/or pass the final product around the room but stress that scientists do not taste the things they make! The polymer can act like a solid (it breaks cleanly if pulled sharply), and it can also flow like a liquid (it stretches easily if pulled slowly). If you place the slime in a wide mouth funnel ("powder funnel"), it will slowly flow through the funnel like a liquid; or leave a ball of slime on the desk and it will slowly form a "puddle". You may want to demonstrate what a polymer is by having the kids hold hands and form two "chains" of molecules. Point out that the molecule chains can move easily around the room. Then, have 2-3 kids "crosslink" the two chains (role of the borax). Now you have a polymer molecule, and it is much more difficult for the big molecule to move about the room. The "crosslinks" can allow the chains to slide slowly past each other, just as the slime can be slowly stretched. If the human chains are tugged, they break, just like the slime.

(3) Oscillating Chemical Reaction – Blue-yellow-colorless (Briggs-Rauscher reaction).

CAUTION: 30% H_2O_2 is a strong oxidizing agent and will cause burns if it comes into contact with the skin or eyes. Gloves and goggles MUST be worn at all times when using and dispensing this reagent! Sulfuric acid is a strong acid and will cause burns of the skin and eyes.

CAUTION: Do not confuse potassium iodate (KIO_3), with potassium iodide (KI).

Reagents

A. 9% H_2O_2 (dilute 30 mL of 30% H_2O_2 to 100 mL). Store refrigerated in a plastic bottle. This solution is stable for at least one week.

B. Potassium iodate - sulfuric acid solution. Add 0.5 mL of concentrated H_2SO_4 (**CAUTION!**) to 100 mL of water, then add 4.3 g of KIO_3 and stir to dissolve. Store at room temperature in a plastic bottle.

C. Starch - malonic acid - manganous sulfate solution. Boil 100 mL of water, then add 0.1g soluble starch and stir to dissolve. Boil 5 more minutes, cover with a watch glass, and allow the solution to cool. Add 1.5g malonic acid $(CH_2COOH)_2$ and 0.4g manganous sulfate, $MnSO_4 \bullet H_2O$, and stir to dissolve. Store in a plastic bottle at room temperature.

Procedure: Mix equal volumes of solutions A, B, and C into a beaker or Erlenmeyer flask. Stir with a stir bar or glass rod. Bubbles will begin to appear and shortly thereafter yellow, blue, and colorless oscillations will occur. The oscillations will continue for about 5 minutes. It is helpful to bring a stir plate and stir bar for this demonstration.

Discussion: Chemical reactions take place in steps, and each color change represents a different step of the reaction. In some reactions the steps can occur over and over again, and act like a clock (i.e., pendulum of a grandfather's clock). Three colorless solutions are mixed to produce a yellow solution (I_2), which suddenly turns blue (I_3^{-2} complex with starch), then yellow, blue, yellow, etc. Bubbles are also observed as O_2 and CO_2 are produced. The reaction mechanism is complex and involves 10-12 steps.

(4) Chemiluminescence: The Firefly Reaction.

CAUTION: Sodium hydroxide is a caustic reagent and can cause burns to the skin and eyes. Wear gloves and eye protection.

Reagents
A. 0.1 M NaOH: Dissolve 2g of NaOH in 500 mL of distilled water.

B. Luminol solution: Dissolve 0.25g of luminol (3-aminophthalhydrazide) in 500 mL of Solution A. This solution can be stored for at least one week in the refrigerator. Store in a plastic bottle and protect from light.

C. Bleach solution: Add 50 mL of Clorox bleach to 450mL of water.

Procedure: The demonstration is best performed in a darkened room. SLOWLY mix equal volumes of solutions B and C in a glass beaker or flask to produce a short-lived blue fluorescence. Last year, students got a very nice effect by pouring the solutions simultaneously into a funnel connected to a coiled plastic tube. The solutions mix as they pass through the tubing and make for a very interesting demonstration! There are three "coil towers" with the OutReach supplies.

Discussion: Two liquids produce light when mixed. Ask the kids how they know whether a chemical reaction occurred? This demonstration illustrates the conversion of chemical energy into light! You may want to include "lightsticks" or fireflies in your discussion.

(5) Methanol Cannon.

CAUTION: Methanol is toxic and flammable. The loud "pop" may frighten some children. Be sure to point the bottle away from kids and windows.

WARNING: I have had four of my "cannons" stolen over the past three years. Unfortunately, these now must be signed out from my office.

Note #1: Clean the nail "electrodes" with steel wool before use.

Note #2: This demo is tough to repeat with the same bottle due the the water formed from the combustion.

Procedure
(a) The "cannon" consists of two, rust-free nails pushed through the sides of a 500 mL plastic bottle. The points of the nails should be nearly touching to provide a spark gap.

(b) The spark is provided by a gas bar-b-q igniter. Clip a wire from the igniter to each nail. When you push the igniter button, a spark should jump the gap between the two nails. If no spark is observed, check your electrical connections, and push the nail points closer together.

CHECK THE SPARK BEFORE YOU ADD METHANOL TO THE BOTTLE!

(c) Add 10 drops (no more) of methanol to the dry bottle. Place a <u>cork</u> into the mouth of the bottle so that it is "snug", and not too tight!
(d) Shake or swirl the bottle to vaporize and distribute the methanol.
(e) Direct the mouth of the bottle up and away from the children and windows.

(f) **WARN THE CHILDREN THAT IF THEY ARE SCARED OF LOUD NOISES THEY SHOULD COVER THEIR EARS.** Dim the lights in the room, and push the igniter button. There will be a loud "POP", jet of blue flame, and the cork will be shot across the room.

(g) The kids will want you to do this demonstration again, so squeeze the bottle a few times to blow out the "exhaust" (H_2O and CO_2), and you are ready to try again. You can also do this demonstration without the cork, and focus on the combustion of methanol only where you see a blue flame and hear a soft "whoosh". Quite different from the sound of the cork being shot off!

Discussion: This demo illustrates how chemical energy can be used to do work. The methanol is a fuel that turns into a gas in the bottle. The "spark plug" lights the gas causing a chemical reaction that produces a small fire and energy, causing the cork to fly off. The real-world analogy here is how a car engine works where chemical reactions produce small explosions in the engine, which move the pistons, and move the car. Be prepared to answer questions about making explosives!

(6) Water-Juice-Milk-Soda.

CAUTION: 12M HCl is strongly acidic and will cause burns to the skin or eyes.

Reagents
A. Dissolve 0.4g of $NaHCO_3$ and 0.8g of Na_2CO_3 in 200 mL of water.
B. Phenolphthalein solution
C. 25 mL of a saturated solution of $BaCl_2$. Stir 10 grams of $BaCl_2$ in a total volume of 25 mL of distilled water.
D. 12 M HCl (concentrated HCl; CAUTION!)
E. Bromothymol blue

NOTE: One full eye dropper is approximately 1 mL.

Procedure
You will need 4 "glasses" for water, juice, milk, and soda. During your set up time, add 1 mL (one eye dropper) of the phenolphthalein solution to the juice glass (swirl to coat), add about 25 mL of saturated $BaCl_2$ solution into the milk glass, and 2 mL 12 M HCl and 2 mL bromothymol blue to the soda glass. Place the 4 prepared glasses in order (water, juice, milk, soda), such that your audience can not see that you have added any reagents to the glasses. Pour 200 mL of the clear, colorless Solution A into the water glass. Next, pour the contents of the water glass into the juice glass and note the color change to red "bug juice". Then, pour the contents of the juice glass into the milk glass and note the formation of the white precipitate ($BaCO_3$ - "milk"). Finally, pour the contents of the milk glass into the soda glass and note the color change to yellow and formation of bubbles ("soda" with "carbonation").

Discussion: In this demo you will transfer a liquid from a water glass (clear colorless solution), to a juice glass (red solution – basic sodium carbonate turns indicator red), to a milk glass (milky white suspension, $BaCO_3$ precipitate), to a soda glass (yellow solution – pH indicator change, bubbles due to acid reaction of carbonates to release CO_2, and $BaCO_3$ precipitate dissolves). Stress that this is not magic, its chemistry! Explain what you did, and that each glass contained a small amount of a special chemical reagent such that the changes in color and physical state result from chemical reactions that a chemist understands and can explain. ALSO, be sure to mention that since these are chemical changes, we can not "drink" from any of these glasses!

(7) "Iron-Fortified" Cereals

Procedure.
Large Demo. Set this demo up in the beginning of your presentation. Open a box of cereal (Total or Lucky Charms - you can use almost any other cereal but test first), remove the "bag" from the box, and crush the cereal flakes (or have one of the kids do this). Add a large stir bar to a large beaker, and pour in about half of the crushed cereal (Total or Lucky Charms) to reach the one liter mark. Add enough water to bring the volume up to about the 1750 mL mark (or more if you can). Let the mixture stir for the extent of your presentations, coming back to it at the end. Use your gloved hand or a stir bar retriever, recover the stir bar, gently rinse it with distilled water, and note the presence of iron filings on its surface!

Student Participation. Bring pouches of instant oatmeal, and several small stir bars. Have the kids (small groups) make a small tear in the pouch and drop in a magnet. Hold the pouch closed and shake for a couple of minutes. Remove the magnet and examine for iron filings.

Discussion. Soluble iron is an important trace metal that plays an important role in the ability of the blood to carry oxygen - through the iron-containing protein, hemoglobin. Tell the students that there are two chemical forms of iron, iron (II) (soluble iron), and iron (III) (insoluble). Remember, they may not know what "soluble" and "insoluble" mean. Iron is added to many foods as a nutritional supplement. The iron filings are dissolved by acid in our stomach to form iron (II) (soluble) that helps make healthy hemoglobin. This is actually an example of a "Redox" reaction:

$$\mathbf{Fe\ (s) \quad + \quad 2H^{+}\ (aq) \quad \rightarrow \quad Fe^{+2}\ (aq) \quad + \quad H_2\ (g)}$$

(8) The Vitamin C Chemical Clock Reaction.

This demo uses supermarket chemicals to perform a "clock reaction". Reagents are mixed to form a nearly colorless solution that abruptly changes to blue-black when the "endpoint" of the reaction is reached. The time required to reach the endpoint can be changed by varying the amounts of reagents.

CAUTION: This reaction produces elemental iodine. At the end of the reaction add vitamin C stock solution to the reaction mixture until the iodine color is discharged, then wash the mixture down the sink.

Reagents:
Vitamin C Stock. Crush a 1000 mg vitamin C tablet to a fine powder on a sheet of paper and add to 60 mL of distilled water. Stir thoroughly. This will give a cloudy solution due to insoluble binders in the vitamin C tablet.

Solution A. Add 10 mL of the vitamin C solution to 120 mL of water, then add 5 mL of tincture of iodine. The yellow-brown iodine color should dissipate as the I_2 is reduced to HI by vitamin C.

Solution B. Add 15 mL of 3% (commercial) hydrogen peroxide to 120 mL of distilled water. "Spray" the laundry starch into the solution for 2-3 seconds, and stir. The white cloudiness will dissipate with stirring. (The 3% H_2O_2 may be found in the refrigerator in the undergraduate research lab)

Procedure. Combine Solutions A and B and mix thoroughly. This clock reaction should reach its endpoint in approximately 60 seconds.

Variations.

(1) By decreasing the amount of water added to each Solution you can decrease the time required to reach the endpoint. It may be possible to set up a series of beakers with different amounts of water in the reagent solutions. By mixing each solution simultaneously, you should be able to have the beakers all change color in sequence. If you have the timing down right, you should be able to "tap" each beaker at the appropriate time when the endpoint is reached.

(2) This same clock reaction can conceivably be done with any solution that contains vitamin C. With orange juice: Add 5 mL of tincture of iodine to 280 mL of room temperature orange juice. Stir until the dark iodine color is discharged. Now spray in the laundry starch. Now add 50 mL of 3% hydrogen peroxide to start the reaction, and stir thoroughly. This orange-to-black endpoint is reached in about 40 seconds.

Discussion. This clock reaction involves a series of Redox reactions that reach an endpoint when the limiting reagent, vitamin C, has been consumed. This demo can be introduced as showing how vitamin C is able to detoxify iodine (I_2) until the vitamin C has been used up. Vitamin C is oxidized as iodine is reduced:

$$\mathbf{I_2\,(aq) + vitamin\ C\ (reduced)\ (aq) \rightarrow 2\,HI\,(aq) + vitamin\ C\ (oxidized)\ (aq)}$$

The HI is easily oxidized back to I_2 by hydrogen peroxide:

$$\mathbf{2\,HI\,(aq) + H_2O_2\,(aq) \rightarrow I_2\,(aq) + 2\,H_2O\,(l)}$$

This reaction cycle continues until all of the vitamin C is used up, and the excess I_2 forms the characteristic blue complex with starch:

$$\mathbf{I_2\,(aq) + starch\ (colorless) \rightarrow starch\text{-}I_2\,(aq)\ (blue)}$$