

A Program of Lecture Demonstrations Used on the CAPOW Van

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- Some excellent sources of lecture demonstrations may be found in the following sources:
Shakhashiri, Bassam *Chemical Demonstrations*. Madison, University of Wisconsin Press (several volumes, 1980s).
Summerlin, Lee R. and Ealy, James L. *Chemical Demonstrations*. Washington, D.C., American Chemical Society (several volumes, 1980s).
Borgford, Christie L. and Summerlin, Lee R. *Chemical Activities*. Washington, D.C., American Chemical Society, 1988.
- C. Marvin Lang and Donald L. Showalter, professors of Chemistry at the University of Wisconsin at Stevens Point, present excellent chemistry demonstrations and have published many of their ideas.
- If you can find them, some older editions of *Tested Demonstrations* compiled by Hubert Alyea and Frederic Dutton from demonstrations submitted to the *Journal of Chemical Education* are useful, as are many of the demonstrations published in that journal and in the *Journal of College Science Teaching*.
- Many of the demos described here (and many excellent suggestions for presentation) are presented in the third edition of *Fundamentals of General, Organic, and Biological Chemistry* by John McMurray and Mary Castellion, Upper Saddle River, NJ Prentice Hall, 1999.
- Unfortunately, many demonstration manuals go for cute and flashy rather than order (it's hard to find an index in some of these), so you may have to dig a bit to find the demo that illustrates your purpose. All the same, these books are all excellent sources.
- **If you use demonstrations from older sources, be aware that new information regarding safety of some demos and toxicity of some chemicals may prevent their use. Also, some special regulations may apply for disposal of spent reagents. It's a good idea to carry a set of MSDS sheets for all chemical substance you have along, and to also plan for occasional spills, which you can probably manage more effectively than most non-chemists. Choose wisely. Demonstrations really liven up a class session and help make important points more memorable, but no demonstration is worth presenting a serious hazard to your students or to yourself. If appropriate, issue protective equipment (such as safety goggles) or use safety shields or perform the demonstration in a fume hood. *If in doubt, don't.* Use these demonstrations at your own risk, and try them before using them in class. Please send me suggestions as to improvements or variations, and contact me if you have a question about any of the procedures.**

Demonstrations:

Use a **magician's burning book** as an attention-getter. These can be purchased at magic supply houses, but you can make your own using an out-of-date physics or chemistry book. Find a metal can or box (say, 2 cm x 25 cm) to hold the flammable components. Divide the can into two compartments and place a fire-resistant pad in one. Two AA batteries power the igniter of a kerosene heater. Use a micro switch to control, and remove batteries when not in

use. The igniter protrudes through a metal wall from the battery and switch compartment into the flame compartment. Cut out the pages of the book to accommodate the can. Glue the can in and glue the pages around the can together. Add a sheet of foil to the pages where the book opens. Add **a little** lighter fluid to the flame-resistant pad and allow the book to stand with the cover closed for a few minutes. Open the book and press the switch to ignite. **Care!** I've heard some very effective demonstrators open the book and pretend to read a description or definition of combustion while igniting the fluid.

Use calcium acetate handwarmers to illustrate an exothermic physical change. These contain a supersaturated solution of calcium or sodium acetate and act when you press a small disk in the bag. The disk provides surfaces which initiate crystallization, with concomitant release of heat. These handwarmers are often sold at sporting goods stores along with hunting or fishing supplies. One brand is EZ Heat, supplied by Prism Technologies of San Antonio, Texas. Cost: about \$4.00, but reusable. (Place the used bag in boiling water for a few minutes to re-dissolve the salt.)

Prepare an alcohol gel by pouring 120 mL of 95% (v/v) ethanol from a 250 mL beaker into 20 mL of 80% saturated (58g salt in 200 mL water) calcium acetate in another 250 mL beaker. With a little practice, you can time the pouring so that on the second or third pour, the solution gels, forming a flammable mixture similar to Sterno or Canned Heat. Use salts such as CuSO_4 , NaCl , KCl , and SrCl_2 to show colors produced by elements when electrons are excited. Sift a small portion of the salt from your hand or a spatula directly into the flame. If available, a spectroscope can be used to show individual lines in the spectrum. Use a few strips of magicians' flash paper (available at magic supply stores). Light the paper from the alcohol flame and toss it up into the air. It will float and burn (take care that no flammable materials are near). Note the color. What element is present?

Illustrate **effects of concentration and surface area** by lighting a candle. Ask students how you could make the candle burn faster. (Gasoline doesn't help.) Light the other end. Ask again how to make it burn faster. Someone usually suggests lighting the middle. Instead, use some lycopodium powder in a glass tube. Blow the powder through a burner flame or the flame of a calcium acetate-ethanol gel. **Take care not to inhale the powder, and don't blow the flame onto anyone.** If lycopodium powder is not available, try some powdered non-dairy creamer. Note that dust explosions frequently destroy flour mills and grain elevators.

For a demonstration of the **effect of concentration on reaction rate**, do the iodine clock reaction (Shakhashiri, Bassam *Chemical Demonstrations*. Madison, University of Wisconsin Press Volume 4). An effective example uses 40 mL each of the potassium iodate and starch-bisulfate solutions. Select a few students who have watches with second hands as timers and assign the others as observers (alternatively, students can count, "one thousand-one, one thousand-two, etc.") Measure one solution (using a 100 mL graduate) and add to a 400 mL tall form beaker. Rinse the graduate with about 50 mL water and measure 40 mL of the second solution. Instruct the observers to say "Start!" when you add the two solutions together and "stop" when they see the blue-black color form. Choose a new set of timers and repeat. The second time, rinse the graduate more thoroughly, adding about 150 mL of water. The reaction will take much longer, and this provides a chance to discuss just what the water is doing to

slow the reaction.

To show the **speed of reactions in gases**, have a balloon of hydrogen gas on a string. Ignite it, using a wood splint on the end of a meter stick. (**Warn students to cover their ears.**) A pinch of powdered iron in the balloon will produce yellow sparks when the balloon is ignited. **If the lecture hall is large enough**, try a mixture of one part oxygen and two parts hydrogen for a spectacular boom!

Use a carbon dioxide fire extinguisher to show change of phase, forming dry ice. **Be certain** that you have a carbon dioxide extinguisher, and point this out to the class. Grasp the extinguisher tightly (they sometimes jump around), and shoot the extinguisher onto the coat of a well-insulated student (watch the ears). Note that some of the molecules in the tank were probably exhaled by dinosaurs hundreds of millions of years ago. The average velocity of a carbon dioxide molecule in the tank is about 600 mph. Spray the carbon dioxide into the air over the students (not onto them). Some CO₂ snow may fall. Ask them to catch it and watch it sublime. Feel the tank. Hot or cold? Do chemicals ever fall from the sky on our planet?

Use some powdered polyacrylamide such as Soil Moist (JRM Chemical, 13600 Broadway Ave., Chicago, IL 44125) or similar compounds available at garden supply stores. Place a teaspoonful of the powder in a plastic foam cup, add water to fill the cup, and stir. After you are certain the liquid has been absorbed by the powder, invert the cup over the head of a student, pretending that you are going to dump the water over them. Hydrogen bonding causes the polyacrylamide to absorb the water. This stuff is now used to protect homes during forest fires. Polyacrylamide powder may be mixed with water and spread atop roofs of endangered homes, protecting them for a few hours. Similar material is used in diapers and sweat bands.

Do the **howling Gummi Bear demonstration** (*Journal of Chemical Education* 69 #4, 1992, p. 326). In a large test tube behind a safety shield, place about 10 grams of potassium chlorate. Use a propane torch to melt the salt, then drop in a Gummi Bear. The bear jumps, screams, and emits impressive amounts of light.

Generate some **liquid oxygen** and pour it over a cracker or sugar cookie in an evaporating dish. Light the carbohydrate with a match or charcoal lighter. Collect the liquid oxygen by holding a metal coffee pot containing liquid nitrogen over a styrofoam cup and allow about twenty mL of blue lox to collect. Liquid oxygen has been used as an oxidant with charcoal or other reducing agents in blasting. Lox has the advantage of evaporating away if the charge is not fired, reducing the danger of removing unexploded charges.

Demonstrate the effects of a **catalyst** by using a 2 L plastic soda bottle containing about 50 mL of 30% H₂O₂. (Care! 30% H₂O₂ is a very powerful oxidant and can cause small, but painful blisters). Prepare a small bag containing 0.1 g MnO₂ wrapped in a single sheet of tissue (e.g., toilet) paper. Use a short length of string to suspend the bag under a one-hole stopper at the top of the soda bottle. When you remove the stopper, the bag will fall into the peroxide solution. The catalyst facilitates an exothermic decomposition, resulting in vigorous boiling (which allows the bottle to shrink). This is a very effective demo for groups of

children. Some instructors tell the tale of a genie in the bottle and note that when the genie comes out, the bottle doesn't need to be as large. Since you have a used soda bottle which seems to be worthless, talk a little about recycling. Ten of these bottles are enough to make a lab jacket and twenty supply materials for a warm sweater.

Make some **elephant toothpaste**. Pour about 50 mL of 30% H_2O_2 into a 2 L graduate sitting on newspaper or absorbent lab soaker. Add a few drops of kitchen detergent and swirl. This preparation can stand for hours until you are ready to use it. When ready, dump in about 10 mL of saturated potassium iodide solution. The peroxide decomposes rapidly and a foam column shoots out of the top of the graduate. **Careful! If you use too much or too concentrated a solution of peroxide, or if it is warmer than usual, it may shoot up and hit the ceiling.** If the resulting foam stains the table, some 0.1 M sodium thiosulfate solution should remove the iodine stains. (This should be the last demonstration on your program, as it will require some cleanup afterward.) Warn students against touching the foam - it's messy and will stain their fingers.

For another **kinetics** experiment, use 100 mL of 0.133 M glucose in a 500 mL stoppered flask. Add 500 mL of 1 M NaOH. Add 15 mL of 1% (w/v) indigo carmine in alcohol. Stopper and shake. Allow to stand a few minutes and shake again. You can do this from time to time during your lecture. There are many more clock reactions, producing various colors and with various periods. Some alternate color for hours if stirred.

Show how the old-timers determined **proof of spirit** by donning a top hat and bringing a Bowie knife to class, along with an airline-sized bottle of 70% (v/v) alcohol. Assume the persona of a fur trapper from Wyoming Territory in the early 1800s. Tell the class that you have just returned from trapping for furs and are ready for some R and R, but that you're not certain that the booze you bought at the local trading post is really high-grade alcohol. In short, you doubt that the alcohol concentration is high enough (fairly dilute solutions of ethanol will burn or intoxicate). Pour a small amount of black gunpowder onto a protective tray on the desk top, then pour on enough alcohol to cover the powder and ignite it. (**Take care to keep the remainder of the black powder away!**). If the alcohol has proof of spirit (is at least 50% ethanol), it will burn away, leaving little water behind, so that the gunpowder will ignite. This indicates that the alcohol is at least 100 proof.

Bring a 1 gallon plastic milk jug to class. Add a few mL of 95% ethanol, cap the jug and swish it around. Douse the room lights. Pretend that you are checking your **gasoline tank** and drop a lit match into the jug. An impressively loud and bright but generally harmless explosion results. Drop a second match in and ask students to explain why there is no second explosion.

Use an eight-foot polyethylene sleeve which is designed to be placed around fluorescent tubes so that they don't break and fall on people. Fit rubber stoppers (#9) to the ends; fasten one of the stoppers to the end with tape. Add about 15 mL 95% (v/v) ethanol and tilt the tube back and forth a few times to allow evaporation (it works well to do the tilting at the beginning of the program as children are coming in). Drain the excess alcohol. Select four or five members of the audience and fit them with safety glasses. Taking care that no alcohol has leaked, have

several kids hold the tubes with their hands about 10 cm in from the ends. Raise one end about 10 cm higher than the other (to allow excess ethanol to pool at the lower end), and quickly pull one stopper out of the upper end and ignite the ethanol fumes (it's best to use one of the piezo-electric/butane hand lighters). A wall of flame will shoot down through the tube. If you replace the stopper immediately, the tube will flatten later. Remember to have the kids wear safety glasses if they're near the chemicals. These tubes may be used over and over, but check the ends for cracks occasionally. If the tubes crack, trim a little off the end to renew it.

Shakhashiri has an interesting version of the **nonburning towel** in Volume 1. (Shakhashiri, Bassam *Chemical Demonstrations*. Madison, University of Wisconsin Press, 1983.)

Use liquid nitrogen to demonstrate relative absence of energy (pouring it into an old plastic-handled metal coffee pot will facilitate handling).

-Pour a small amount of liquid nitrogen into a 250 mL Erlenmeyer flask and cover the mouth with a balloon. The balloon will inflate and may either explode or blow off the flask and fly around the room.

-**If the room is large enough**, use a 20 oz. plastic soda bottle and a large trash can for a tremendous explosion. Position the trash can well away from the audience. Pour about 100 mL of liquid nitrogen into the bottle, cap it, and toss it into the can. Depending on the effect you want, place the cover **loosely** on the can, or leave it uncovered. About four or five minutes later, the bottle will explode, making lots of noise and sending some fragments of the bottle flying. This explosion is powerful enough to damage a plastic can, so make certain no one is close, and remember to warn your audience that some unexpected explosions may occur. (Particularly, advise small children to cover their parents' ears.)

-Freeze a racquetball and break it against a brick or concrete wall.

-Freeze a flower. Flick it with a finger and it will fragment.

-An apple frozen in liquid nitrogen will fragment into many pieces if dropped on a hard surface. (Clean up the pieces quickly or you'll be unpopular with janitors.)

-Using liquid nitrogen, freeze miniature marshmallows in a clean beaker. When the mixture stops smoking, pass the marshmallows out and have students bite them quickly. They crunch, and students will blow "smoke."

-For small classes, some instructors freeze ice cream mix quickly using liquid nitrogen. Pour the mix into a metal bowl and stir with a wooden spoon as you add liquid nitrogen. Serve when it stops "smoking."

-Construct a 9 volt battery-powered LED (use about a 1,000 ohm resistor). Place the battery in liquid nitrogen and observe that the light fails. Discuss car batteries and Nebraska winters.

-Pour liquid nitrogen into an old metal coffee pot. Note the liquid oxygen dripping off the bottom.

-Place a balloon of oxygen gas containing a cigarette on a fiberglass cafeteria tray.

Pour liquid nitrogen over the balloon, and the balloon will shrivel, collecting a pool of blue liquid oxygen in the bottom. Allow the balloon to reinflate (as you discuss volume of liquids and solids). Again, liquefy the oxygen. Cut the balloon open and **discard the remaining liquid oxygen and balloon**. Holding the cigarette with forceps, light the cigarette; it burns like a sparkler. (*Journal of Chemical Education* 68 #12, 1991, pp 1036-1037.)

-While you have liquid nitrogen on hand, place some in a length of metal pipe and shoot corks over (not at) the audience. Construct a pipe by putting together sections of 2 1/2" galvanized

iron pipe, with a reducer to 1 1/2"; this makes a large chamber to hold liquid nitrogen and helps to prevent splashing. Hold the tube vertical at first and take care not to splash liquid nitrogen over the students.

-While you're at it, if your classroom floor is a hard surface, clean the floor for the janitors. Take a 1 L container (an old coffee pot works well) of nitrogen to one side of the room and pour or toss it onto the floor. As the nitrogen runs across the floor, it will dissolve some dirt and blow other dust and dirt ahead, piling the dirt against a wall. The liquid nitrogen also shows nice balls of liquid, illustrating surface tension. This works especially well in a tiered classroom.

Have a piece of fiber optic cable or some other important **plastic** material on hand to display. Note that plastics are polymers made up of monomers (as are starch, protein, and DNA). Use some beaded metal chain to represent a polymer. A 5 m length of 5 mm beaded chain (obtained from hardware stores or catalog) can be placed in a large beaker. Add the chain to the beaker carefully so that it doesn't tangle. Hold the beaker as high as you can and allow the chain to run out. Why does the chain rise above the top of the beaker?

Make some plastic. Use about 20 mL each of resin and activator (Eager Plastics, 3350 W. 48th Place, Chicago, IL 60632). Pour these into a 500 mL plastic cup (or, you could use smaller amounts in a surgical glove). Mix and observe. The reaction is exothermic and releases a blowing agent (usually carbon dioxide) which expands and causes the product to foam up to (and sometimes, beyond) the top of the cup. Make certain no one handles the product before it solidifies (about ten minutes). Plastics such as this have been used to subdue psychotic persons holding weapons, and the United States Marines are reported to have used similar material to keep children from running into their camp as the marines exited a riot area.

Use **sulfur hexafluoride** gas to alter your voice. Add about 1 L of reagent grade SF₆ to a balloon and tie it off. When ready, caution students about inhaling unknown gases, and point out that the sulfur and fluorine are both dangerous (several early researchers were killed by fluorine fumes), but that the combination is inert (it **does** decompose in an electric spark, but is not affected by molten sodium). Cut the balloon open and quickly inhale the gas. With practice, you can speak for four or five minutes by talking and then taking in some air. Be sure to bend over and exhale all the remaining sulfur hexafluoride - it doesn't poison you, but it doesn't support life, either.

For an excellent demonstration of the chemical reactivity of seemingly ordinary substances, use two heavy steel or iron balls (old cannon balls will do, or use some of the balls from mills used to grind rocks for concrete). Wrap one of the balls with thin aluminum foil and smack them together. A loud report is heard, reminiscent of the thermite reaction.

Within six months after a course ends, students typically forget ninety percent of the subject matter facts memorized. They tend to remember material presented in anecdotal and demonstration fashion, and even the toughest instructors in our university receive good evaluations when they use demonstrations and discussion as teaching techniques.