Doing Real Chemistry in Museums
ASTC Annual Conference
Monday 14 October 2002
Harry Potter Chemistry

I'm a chemist because I love to mix things together, watch tiny bubbles rising, see colors change, and conjure up an explosion or two on a Monday afternoon. Chemistry delights, teases, and assaults all of our senses.

And when I read

> " . . . she had conjured them up a bright blue fire that could be carried around in a jam jar." Harry Potter and the Sorcerer's Stone, p. 181

I said, "I know how to do that!" And I want to show you how!

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POTIONS

Designer Potions
Potion-Unpotion

Activities with bold-faced titles are featured in today's workshop.

TRANSFORMATIONS

Swelling Solution and Deflating Draught
Shrinkable Badges
Exploding Pillows
Crystal Balls
Thickening Potion

COLORED FLAMES

Fire in a Jam Jar
Colored Flames
Flash Paper

Designer Potions
Harry Potter Chemistry

"Mrs. Weasley was telling Hermione and Ginny about a love potion she'd made as a young girl. " Harry Potter and the Prisoner of Azkaban, p. 70.
"'You'll need to drink all of this, Harry. It's a potion for dreamless sleep.'"
Harry Potter and the Goblet of Fire, p. 701.
"Harry had seen him scrubbing the message on the wall with Mrs. Skower's All-Purpose Magical Mess Remover, but to no effect."
Harry Potter and the Chamber of Secrets, p. 146.

What you need:
- dry spices, herbs, or flowers
- rubbing alcohol (70% isopropyl alcohol)
- labels
- plastic film container

Related topics:
solvent
solute
solubility
extraction
labelling
mixtures and solutions

Safety and Disposal Notes:
These potions are meant to be sniffed or used on the skin. Do not drink the liquid or consume the solids!
Liquids may be put down a drain. Solids should go in the trash.

General idea:
Make a potion by soaking dry spices in alcohol for several days. Students must label their potions with all the ingredients. Students may wish to decide what the purpose of their potion will be (repel werewolves, attract mosquitoes, turn user into a desired form, allow magic powers, etc.)

What to do:
- Your potion will contain rubbing alcohol (isopropyl alcohol) and up to 3 other ingredients. Make a label with your name, today's date, and the names of those other ingredients.
- This potion is for sniffing or for rubbing on skin. DO NOT DRINK this potion! What will your potion be used for?
- Put a small amount (a pinch, a small spoonful, a few granules, etc.) of the solid ingredients in your film container.
- Add rubbing alcohol to cover the solid ingredients. Cap the container.
- Let the potion soak for one week. Take a look at the potion ingredients after a week. What has changed?

Suggested potion ingredients:
Food coops often sell bulk spices at much lower prices than grocery stores. Look for chunks, rather than powdered spices, such as: cloves, allspice, broken cinnamon sticks, peppercorns, basil, dried lemon or orange peel, whole coffee beans, lavender, rose petals. Avoid ginger, red pepper, and garlic, because they are skin irritants.

References:

Article on how mammals distinguish odors:
http://www.sciencedaily.com/releases/1999/03/990305071120.htm

An electronic nose (yes, really!)
http://www.sciam.com/2001/0301issue/0301techbus1.html

An extensive page about anosmia (inability to smell):
http://www.personal.ecu.edu/wuenschk/anosmia.htm

Classen, Constance, David Howes, and Anthony Synnott, Aroma, the cultural history of smell, Routledge, 1994.

http://www.howstuffworks.com/question139.htm Question of the Day on How Stuff Works website, on sense of smell. Includes many good links.

Potion--Unpotion
Harry Potter Chemistry

"You are here to learn the subtle science and exact art of potion making."
Harry Potter and the Sorcerer's Stone, p. 136.
"Professor Snape was forcing them to research antidotes. . . [H]e might be poisoning one of them before Christmas to see if their antidotes worked."
Harry Potter and the Goblet of Fire, p. 234.

What you need:
- Activated charcoal powder (Flinn C0201); about 3.5 grams per student
- funnel and filter paper to fit
- 2 plastic cups
- food coloring
- food flavoring
- wash bottle of water
- flask or bottle to hold funnel

Related topics:
mixtures and solutions
adsorption
filtration
drinking water treatment
antidotes

Safety and Disposal Notes:
Dry activated charcoal is very messy. Be sure not to spill it!
Food coloring will stain skin and clothing.
Do not taste the potion before or after filtering.
All liquids can be poured down the drain.
Solids can be put in the trash.

General idea:
Make a potion with water, food coloring, and food flavoring (for smell). Then pour the potion through a funnel filled with a black powder that adsorbs both color and odor.

Activated charcoal has zillions of tiny holes or pores in each particle. Color and odor molecules are trapped in these pores. Many drinking water utilities use activated charcoal to remove odors and colors from water. Activated charcoal is also used as an adsorbent for some poisons.

What to do:
- Half-fill a plastic cup with tap water.
- Add 1 drop of food coloring and 1 drop of food flavoring to the cup of water. Be sure you can see the color and smell the odor of your potion.
- Fold a filter paper circle into quarters. Make a "pocket" in the folded paper by putting your finger between layers 1 and 2 of the 4 quarters. Put the paper cone in the funnel. Set the funnel in the flask or bottle.
- Wet the filter paper with water so the paper will stick to the funnel.
- Put about a teaspoon of activated charcoal in the filter paper. Wet the charcoal VERY CAREFULLY with water from the wash bottle. You don't want the stream of water to blow the charcoal powder out of the funnel.
- Now pour your colored, smelly potion through the charcoal in the funnel. How does the liquid coming out the funnel look? How does it smell?

References:
http://www.howstuffworks.com/question209.htm
on the How Stuff Works website describes activated charcoal and has additional links about the water filtration process.

Borgford, Christie L. and Lee R. Summerlin, "Charcoal: A chemical that eats odors and colors," in Chemical Activities, American Chemical Society, 1988, pp 271-2. This experiment suggests filtering pickle juice through activated charcoal. You might also try filtering colored non-carbonated drinks or coffee.

Poison antidote:
http://www.kidsource.com/kidsource/content3/fda.poisoning.all.safety.html#top
http://www.ilpi.com/msds/ref/activatedcharcoal.html

Alternate source for charcoal:
Try contacting your local drinking water facility. Many such utilities use tons of powdered activated carbon (PAC) and would be willing to give you some for experiments.

Neither aquarium charcoal nor barbecue charcoal will work because they do not have the pore structure to trap color or odor molecules.

Swelling Solution and Deflating Draft
Harry Potter Chemistry

" Goyle's potion exploded, showering the whole class . . . with Swelling Solution. Snape roared, 'Come here for a Deflating Draft. When I find out who did this . . . '"
Harry Potter and the Chamber of Secrets, p. 187.

What you need:
- 3 raw eggs
- vinegar
- beakers or jar to hold eggs
- water
- corn syrup

Related topics:
diffusion
osmosis
pickling
transpiration

Safety and Disposal Notes:
Handle eggs carefully, especially after their shells are dissolved. Do not cover the egg-in-vinegar jar tightly because carbon dioxide gas is formed as the shell dissolves. Dispose of eggs in trash that will be emptied soon, or compost them.

General idea:
Vinegar will dissolve an egg's shell, leaving a fairly tough membrane surrounding the white and yolk. This membrane will allow water to diffuse into or out of the cell, depending on the concentration of solute in the water.

What to do:
- Place the eggs in a beaker or jar and cover them with vinegar. Leave at least 24 hours, perhaps 48 hours. Bubbles of carbon dioxide gas will form as the calcium carbonate in the shell dissolves.
- When the shells seem to be dissolved, VERY CAREFULLY drain off the vinegar and remove the eggs from the jar.
- Place one naked egg in a beaker of corn syrup and a second egg in a beaker of water. Leave the third egg in fresh vinegar as a control.
- After half an hour , compare the sizes of the eggs. Take another look after 24 hours.

References: Flinn Scientific's BIOFAX publication, Over Easy.

Shakhashiri, Bassam, "Osmosis Through the Membrane of an Egg," in Chemical Demonstrations, vol. 3, University of Wisconsin Press, 1989, pp. 283-5.

Shrinkable Badges
Harry Potter Chemistry

I think these would have been quite useful to students at Hogwarts, don't you?

What you need:
- #6 plastics (polystyrene)
- toaster oven
- aluminum foil
- permanent markers
- hole punch
- string
- tongs and oven mitts

Related topics:
polymers
heat-shrink tubing
surface area
volume
density
recycling
Styrofoam

Safety and Disposal Notes:
Use ONLY plastics you are sure are #6, polystyrene. It is colorless and rigid. Other polymers may melt, ignite, emit gases, or otherwise behave rudely when heated. Do not try to use a microwave oven because you cannot control the temperature. Be sure to supervise use of the oven by students. Wait until badges are cool before handling them.

General idea:
Polystyrene plastics are formed into shapes while the polymer is hot. If you re-heat a cool piece of polystyrene, the plastic will shrink to about 1/9 its original size. Colors get more intense as the plastic shrinks. Holes in badges shrink also!

Foamed polystyrene, also called Styrofoam, is used for building insulation and food containers.

What to do:
- Heat toaster oven to 325° F.
- Cut pieces of #6 plastics small enough to fit inside toaster oven, if necessary. You can use the entire top or bottom of a salad or sandwich box. Just leave the sides attached.
- Use permanent markers to decorate polystyrene pieces.
- If you wish to hang badges from neck cords, punch LARGE holes in the upper corners of decorated badges.
- Set decorated badges on foil in hot toaster oven.
- Watch carefully as badges heat for 30 to 60 seconds. You'll probably see them curl up and shrink. Be patient, because usually the plastic pieces will flatten out.
- Remove badges on foil sheet. Flatten any curly ones with oven-mitted hand.
- Be sure to let badges cool before handling them.

References:
http://www.polystyrene.org/ed_resources/education.html
web page from Polystyrene Packaging Council, including some educational resources.

http://www.cpra-canada.com/
information from the Canadian Polystyrene Recycling Association.

http://www.eecs.umich.edu/~coalitn/sciedoutreach/funexperiments/quickndirty/eric/polyc
ont.html
a lesson plan about insulating properties of foamed polystyrene food containers.

http://www.yorkville.k12.il.us/webquests/webqwille/webqkwillie.htm
a 7th grade project with many other weblinks.

http://www.plasticsresource.com/
a good page from the American Plastics Council; lots of recycling info.

http://www.teachingplastics.org/
LOTS of teaching ideas

TURN YOUR COMPUTER SOUND OFF BEFORE YOU LOAD THIS ONE:
http://www.geocities.com/CapeCanaveral/cockpit/8107/polymers.html
Has lots of fine info, but the song drives ME wild!

Exploding Pillows
Harry Potter Chemistry

I haven't really caught Harry and friends making these, but I have a feeling they would love the chance!

What you need:
- quart zip-lock bags
- dry ice
- water

Related topics:
changes of state
sublimation

Safety and Disposal Notes:
Dry ice is solid carbon dioxide. Its surface temperature is -109° F, a serious frostbite hazard. No bare skin on dry ice! Dry ice sublimes rapidly (turns from a solid to a gas), so do not trap it in a closed container. Carbon dioxide is not poisonous, but it does slow down breathing reflexes. Be sure to have plenty of ventilation in your room. Allow excess dry ice to sublime in a safe place

This experiment can be done outdoors or over a sink if you are concerned about a wet spot or two.

General idea:
Dry ice sublimes rapidly at temperatures above zero F. In a closed container, this would constitute a bomb. But in a zip-lock bag, we have an exceptionally nice exploding pillow.

What to do:
- Each student needs a zip-lock bag with a little water in it.
- Carefully add 2 or 3 small chunks of dry ice to each bag and zip it shut.
- Keep your face away from the mouth of the bag.

Where to get dry ice:
Check the yellow pages of your phone book under "dry ice". Some grocery stores have frozen food delivered packed in dry ice. Some bait stores carry dry ice for fishing trips. It generally costs less than $1 per pound. Be sure to protect your hands with thick gloves. Store dry ice in a vented cooler. Keep a car window open when you travel with dry ice.

References:
http://dryiceinfo.com has many good ideas and references.

http://ousdmail.ousd.k12.ca.us/~codypren/Dry_Ice.html has some great lesson plans.

Dry Ice Investigations for grades 6-8, Lawrence Hall of Science, 1999, a GEMS guide.

Crystal Balls
Harry Potter Chemistry

" Glowing on every little table was a crystal ball full of pearly white mist."
Harry Potter and the Prisoner of Azkaban, p. 296.

What you need:
- plastic ice cream bucket or bowl about 12" in diameter
- small plastic cups
- plastic or metal tray
- bubble solution (1 part Dawn dish detergent + 12 parts water)
- fleece fabric 2"x24"
- dry ice
- water

Related topics:
changes of state
sublimation

Safety and Disposal Notes:
Dry ice is solid carbon dioxide. Its surface temperature is -109° F, a serious frostbite hazard. No bare skin on dry ice! Dry ice sublimes rapidly (turns from a solid to a gas), so do not trap it in a closed container. Carbon dioxide is not poisonous, but it does slow down breathing reflexes. Be sure to have plenty of ventilation in your room. Allow excess dry ice to sublime in a safe place.

General idea:
Dry ice and water in a wide-mouthed container generate clouds of water vapor mixed with carbon dioxide. A bubble solution film across the mouth of the container blows up into a foggy "crystal ball". The effect is charming as a large-scale demonstration as well as "in a teacup".

What to do:
- Large-scale demonstration: put about 1" of water and a few lumps of dry ice in the ice cream bucket or bowl. Set the bowl on a tray. Wet the fleece fabric with bubble solution. Wipe the fabric carefully over the mouth of the bucket or bowl. Keep at it until you form a bubble film on the container. If you happen to drip bubble solution into the bucket, you will get a lot of small bubbles instead of the one larger one. Admire!

- Student-size crystal ball in a cup: use water and dry ice in a plastic cup. Cut the fleece fabric into strips slightly longer than the diameter of the mouth of the cup. Place cup on tray. Wet the fleece fabric with bubble solution and use it to form a bubble film on the mouth of the cup. Try hard NOT to get soap solution into the cup. Admire!

Where to get dry ice:
Check the yellow pages of your phone book under "dry ice". Some grocery stores have frozen food delivered packed in dry ice. Some bait stores carry dry ice for fishing trips. It generally costs less than $1 per pound. Be sure to protect your hands with thick gloves.

Store dry ice in a vented cooler. Leave a window open in your car while you transport dry ice.

References:

The large crystal ball demonstration is copyrighted by Bob Becker in 20 Demonstrations to knock your socks off!, Flinn Scientific, 1994, pp. 52-3. The small version and the Harry Potter connection are my contributions.

http://dryiceinfo.com has many good ideas and references.

http://ousdmail.ousd.k12.ca.us/~codypren/Dry_Ice.html has some great lesson plans.

Dry Ice Investigations for grades 6-8, Lawrence Hall of Science, 1999, a GEMS guide.

Thickening Potion
Harry Potter Chemistry

"Try as Harry might, he couldn't get his Confusing Concoction to thicken."
Harry Potter and the Prisoner of Azkaban, p. 318.

What you need:
- small beakers or plastic cups
- water
- sodium polyacrylate Flinn # 0012
- table salt
- chemical scoop or spoon

Related topics:
Super absorbent polymers
Cross-linking

Safety and Disposal Notes:
Do not inhale or get sodium polyacrylate powder in your eyes. The polymer is also very slippery when it is wet. The gelled polymer can be disposed of in the trash. Liquids can be poured down a drain.

PLEASE wear safety glasses when handling SPA.

General idea:
A small amount of a white powder can turn a beaker of water into a gel. Sodium polyacrylate absorbs about 800 times its weight in water. This substance finds much use in disposable diapers.

A second white powder (table salt) stirred into the thick mixture turns it into a fluid again.

What to do:
- Add a small scoop of sodium polyacrylate to a beaker or cup of water.
- Pour the water back and forth between its original container and a second beaker or cup.
- Once the polymer as "thickened" the water, add a scoop of table salt and stir the gel.

References: [checked 10/05]

http://www.pbs.org/wgbh/aso/resources/guide/techact4index.html Recipe for obtaining the polymer from diapers, and a quantitative experiment.

http://www.engineering.usu.edu/jrestate/workshops/waterlock/waterlock.php teacher workshop on the activity with many links.

http://www.sciam.com/2000/1200issue/1200working.html A Scientific American "Working Knowledge" feature on super absorbers. [must actually buy downloads now 10/05. Search index is at http://www.sciamdigital.com/index.cfm

Shakhashiri, Bassam, "Staying Dry: Phase Transitions of a Poly(acrylamide) Gel," in Chemical Demonstrations, vol. 3, University of Wisconsin Press, 1989, pp. 368-71.

Fire in a Jam Jar
Harry Potter Chemistry

"The day before Harry's first Quidditch match the three of them were out in the freezing courtyard during break, and she had conjured them up a bright blue fire that could be carried around in a jam jar." Harry Potter and the Sorcerer's Stone, p. 181

What you need:
- small baby food jar with lid, label removed
- 50 mL 95% ethanol
- 10 mL saturated aqueous solution of calcium acetate [solid calcium acetate Flinn C0262]
- 50 mL and 10 mL graduated cylinders or 2 graduated beakers
- matches
- tongs

Related topics:
saturated solution
gel
fire starting methods

Safety and Disposal Notes:
Ethanol and the gelled product are flammable, and the flames are almost invisible. Baby food jars are the most convenient containers to use, but they may break from the heat of the flame. Jars will be hot after the little fire has been burning. After the mixture has "burned out", dissolve the remaining calcium acetate in water and flush down a drain.

General idea:
Two colorless liquids are poured together. The resulting mixture gels firmly and is flammable. You may know the commercial product as Sterno, which is often used for heating foods.

Be SURE the calcium acetate solution is saturated, as evidenced by some solid left in the bottom of the bottle. About 40 g solid will dissolve in 100 mL water.

What to do:
- Measure 50 mL of 95% ethanol and 10 mL saturated calcium acetate solution in two separate graduated cylinders or beakers.
- Pour the two liquids simultaneously into a clean, dry baby food jar. Do not stir the mixture.
- After about 10 seconds, is the mixture still fluid or has it gelled?
- Light the gelled alcohol, turn out the room lights, and admire.
- Put the flame out by setting the lid on top of the jar.
- Jar and lid will be HOT, so be careful!

References:
Shakhashiri, Bassam, "Canned Heat: Alcohol Gels," in Chemical Demonstrations, vol. 3, University of Wisconsin Press, 1989, pp. 360-1.

Making fire with flint and steel
http://members.aye.net/~bspen/fire.html

How safety matches work
http://www.sciencenet.org.uk/database/Technology/Original/t00085d.html OR
http://www.bartleby.com/81/14725.html

Colored Flames
Harry Potter Chemistry

"He took a pinch of glittering powder out of the flowerpot, stepped up to the fire, and threw the powder into the flames. With a roar, the fire turned emerald green . . ."
Harry Potter and the Chamber of Secrets, p. 47.
"…a group of haggard-looking Ministry Wizards point[ed] at the distant evidence of some sort of a magical fire that was sending violet sparks twenty feet into the air."."
Harry Potter and the Goblet of Fire, p. 87.

What you need:
- Petri dishes or evaporating dishes
- flame-proof tray
- about 250 mL denatured (ethyl) alcohol
- a few grams each, chlorides of the following metals: copper(II), lithium, potassium, sodium, strontium, calcium
- few grams boric acid
- spectroscopes

Related topics:
solar and stellar spectra

fireworks

emission spectroscopy

atomic structure

periodic table

Safety and Disposal Notes:
Ethyl alcohol is very flammable and burns with an almost invisible flame. Denatured alcohol has additives that make it toxic (and terrible tasting) to ingest. Denatured alcohol is 95% ethyl alcohol and 5% water, so it is less flammable than methyl alcohol. Be sure to wipe up any spilled alcohol solutions, extinguish any flame sources, move electrical appliances away from your display area. Allow flaming dishes to burn out, then dispose of solid residues in trash or down the drain. Dishes will remain hot for some time.

General idea:
Works best as a demonstration, and better still with lights turned down or off. Set fire to shallow containers of alcohol mixed with inorganic solids. Enjoy the colored flames, some of which change color as the solution burns. Students can see spectral lines of the burning salt solutions and identify unknowns by their flame colors.

What to do:
- Prepare solutions with denatured alcohol and as much metal salt or boric acid as will dissolve. Make just enough for your demonstrations rather than planning to store solutions.
- Set Petri or evaporating dishes on a flame-proof tray. Pour a shallow layer of the alcohol solution in each dish.
- Ignite alcohol with a match or lighter.
- Turn out the room lights. Oooooh, aaaaaah!
- Point spectroscopes at the colored flames and look for distinctive lines for each element.

References:
A periodic table with colored illustrations of element spectra:
http://chemlab.pc.maricopa.edu/PERIODIC/He.html

An Encarta article on spectroscopy:
http://www.encarta.msn.com/index/conciseindex/03/003F1000.htm

Organic chemistry flame tests using a copper wire to detect halide ions:
http://ull.chemistry.uakron.edu/organic_lab/beil/

physics of light sources:
http://acept.la.asu.edu/PiN/rdg/color/source.shtml

how fireworks work:
http://www.wf.net/~lcrump1/
OR http://www.howstuffworks.com/fireworks.htm

how atoms work:
http://www.howstuffworks.com/atom7.htm/

Flinn Scientific, Inc. has a CHEMFAX entitled Oooh! Aaah! Style Flame Tests using methyl alcohol. Webpage http://www.flinnsci.com/homepage/chem/mysdemo5.html describes a green flame demo using a Bunsen burner.

Flash Paper
Harry Potter Chemistry

"There was a soft, crackling noise, and a shivering light filled the compartment. Professor Lupin appeared to be holding a handful of flames."
Harry Potter and the Prisoner of Azkaban, p. 83.

What you need:
- flash paper purchased from a magic shop
- matches, lighter, or hot plate
- tongs
- Pyrex petri dish

Related topics:

Explosives
Flame chemistry

Safety and Disposal Notes:
Be sure to practice LETTING GO of flaming flash paper. Be careful not to toss flaming flash paper toward flammable materials, including your own hair and clothing.

General idea:
Flash paper looks like ordinary paper, but it burns very quickly, leaving hardly any smoke or ash. This paper is essentially cellulose nitrate, which has been prepared by soaking paper in nitric and sulfuric acids. The process dissolves away most of the lignin in the paper. Cellulose nitrate burns completely because there is enough oxygen in the molecular structure to convert everything to gaseous products (CO, CO_2, H_2O, and N_2).

Although you can make flash paper, handing concentrated acids is not a task for a home laboratory! In Minnesota, you must be at least 18 years old to buy flash paper at a magic store, because it is considered an explosive.

What to do:
- PLEASE DO NOT TAKE ANY FLASH PAPER AWAY WITH YOU!
- Move away from any combustible materials. Remove fleece garments or fuzzy sweaters. Be aware that your hair is flammable also!
- Twist a narrow strip of flash paper to a point at one end.
- Hold the flash paper by the pointed end.
- Light the untwisted end of the paper with a match or lighter. Toss the paper upward and LET GO OF IT QUICKLY!!
- Alternatively, you can light flash paper on a Pyrex petri dish.

References
Shakhashiri, Bassam, "Combustion of Cellulose Nitrate (Guncotton)," in Chemical Demonstrations, vol. 1, University of Wisconsin Press, 1983, pp 43-45.

Dr. Bob's Magic Shop http://www.magicstor.com/files/flash.htm
You can mail order flash paper from this site, but you pay a large hazardous materials fee.

Lots of flash paper accessories: http://www.tannenmagic.com/cart/cat72.html