

Chemical Outreach

Student Activity

What is this activity about?

Mamie Moy, the daughter of immigrant parents was the first person in her family to earn a college degree. Interested in all her subjects, Mamie's science teacher became her role model by encouraging everyone to be curious about nature and the world around them. The teacher's directive, "Just go out and do it," led Mamie into a career of chemistry and chemical education. Mentoring high school girls to carry out their passion for science and share it with others keeps Mamie active within the chemistry community today. The American Chemical Society recognized Mamie Moy's continuing involvement with students and the public by honoring her as the recipient of both the Helen M. Free Award for Public Outreach and the ACS Award for Encouraging Women into Careers in the Chemical Sciences.

Outreach activities within a community raises public awareness of the positive role chemistry plays in our lives. In this activity, you and members of your class or ChemClub™ will organize and perform a series of chemical demonstrations in a demonstration show. It will afford you an opportunity to communicate your knowledge and enthusiasm for science with another class, a community group such as Boy or Girl Scouts or an elementary or middle school group that you have selected. A community street fair also provides an excellent opportunity for outreach. The benefits of outreach programs are numerous. By working together to prepare your materials and perform the demonstrations, you will develop skills in communication, public speaking and team work. The show will give each student a chance to showcase his/her science skills and theatrical talents. By preparing and executing your selected demonstration, you will achieve a better understanding of chemistry concepts and safe practices. You will be able to excite the general public and increase their awareness of the impact science has within the schools, the community and individual lives. You may inspire younger students to take chemistry and continue in a science career. The possibilities are endless!

A chemical demonstration show may have a theme or just be a collection of selected demonstrations appropriate for the group you are addressing. The demonstrations suggested in this activity are arranged to create a "performance" atmosphere. Many of the reagents are household chemicals, but still require awareness of safety and disposal practices. Like all theatrical performances, your demonstration show will require preparation and rehearsal prior to the main event.

What Materials do I need?

Chemical splash goggles and a chemical-resistant apron must be worn by all demonstrators during pre-demonstration preparations, demonstrations, and clean-up.

A) Invisible Writing

Phenolphthalein 1% solution in isopropanol Cotton swabs

Spray bottle of glass cleaner with ammonia

Writing paper

B) Blow Out a Candle with CO₂

2-1 liter clear plastic soda bottles
Scissors
Coat hanger
Wire cutters

Matches
Vinegar
Baking soda (sodium bicarbonate)

C) GAK

8-ounce bottle of Elmer's Glue®
Warm water
1 teaspoon of Borax powder

Plastic cup
Plastic teaspoon
Mixing bowl

D) Orange Juice to Strawberry Float

Aquarium, large tray, or sink
2-L Beakers
600-mL Beakers
Stirring rod (large)
Alconox® Soap

3 M HCl
Methyl orange, 0.2%
Sodium bicarbonate (NaHCO₃)
Tap water

E) pH Rainbow Tube

0.1 M NaOH in plastic dropper bottle
0.1 M HCl in plastic dropper bottle
Deionized water
5% Universal indicator

Clear glass or plastic tube
(ID 1-3 cm; 40-80 cm long)
2 solid rubber stoppers to fit tube
Beaker (volume exceeds tube)

F) Red, White, and Blue

Aluminum foil
250-mL beakers
Glass stirring rod
Deionized water
Light-box (if available)

Phenolphthalein solution, 1%
MgSO₄·7H₂O (Epsom salt)
CuSO₄·5H₂O
Household ammonia

G) Water Shell Game

3 non-see through cups
Sodium polyacrylate polymer (found in baby diapers and "water-lock")
Pitcher or large beaker

H) Witches Potion

2-500 mL Beakers
4-250 mL Beakers
Deionized water

Phenolphthalein, 1% in isopropanol
Household ammonia
Vinegar

What procedure must I follow?

Part I: Pre-demonstration Preparation

- I) Select a member of the team to be the Master of Ceremonies (MC). The MC will welcome the guests, provide introductions and interludes, and will keep the show on track. A student or the teacher may perform this role.
- II) Form individual groups of 2-3 students and select a demonstration to perform.
- III) Each group must carefully read the demonstration including the safety practices, assemble the materials and practice the demonstration several times prior to the day of the show.
- IV) Develop a dialogue to use with the audience as you perform your demonstration. Many people view chemistry as being "magic." Consider incorporating this technique into your dialogue. Demonstration may also be accompanied with a popular and relevant song. Be creative.
- V) Practice, practice, practice your demonstration and dialogue! For suggestions, view the video clip of the demonstration that is in the preparation section.
- VI) Obtain a box and place all your demonstration materials in it. Label the box with your names and demonstration title.

A) Invisible Writing

- 1) One end of a cotton swab is dipped into the 1% phenolphthalein solution. The swab is held by the dry end. For large signs, use a paint brush.
- 2) A "secret" message is written on the paper with the wet end of the cotton swab. As the isopropanol evaporates, all traces of the message will vanish.
- 3) Sample "secret" messages may be "Chemistry is cool!" "WOW" "Applause, Please." Use a pencil to write your message on the back of the paper so that you can identify the proper message during your demonstration. Prepare a sign such as "That's all Folks!" to end the show.

B) Blow Out a Candle with CO₂

- 1) Cut off the top of each of the plastic soda bottles to make inexpensive cylinders. Keep the two funnels (tops of the bottles) for another project or drop them into a recycling bin.
- 2) Make a candle holder out of the coat hanger. The object is to lower the lighted candle into the soda bottle (your new cylinder) without burning yourself. See the photo for a picture of the candle holder.



<http://www.stevespanglerscience.com/>

C) GAK

This demonstration requires no pre-demonstration preparation other than collecting materials.

D) Orange Juice to Strawberry Float

Weigh 50 g sodium bicarbonate and 50 g Alconox™ and put in a container with lid or a Baggie™. The solids may be mixed in the container.

E) pH Rainbow Tube

This demonstration requires no pre-demonstration preparation other than collecting materials.

F) Red, White, and Blue

- 1) Put 5 drops of phenolphthalein solution into the first beaker. This should be done very shortly before the demonstration, since it will evaporate quickly. If this happens, the color change will not occur.
- 2) Dissolve approximately 5 crystals of magnesium sulfate heptahydrate and approximately 3-5 mL of water in the second beaker.
- 3) Dissolve 3 pea-sized copper sulfate crystals in approximately 3-5 mL of water in the third beaker.
- 4) Wrap the cups with aluminum foil to enhance the curiosity of the audience.

G) Water Shell Game

Set up before hand one cup (the one you will pour water into at the end) with a scoop of sodium polyacrylate polymer.

H) Witches Potion (Prepare the glasses just prior to the start of the show)

- 1) Prepare 4 glasses and label them: #1,#2,#3,#4
In #1 and #3 put 5 drops of phenolphthalein
In #2 and #4 put 5 drops of ammonia
If you prepare these ahead of time, then be sure to stack them, one inside the other, with an empty one inside the top one. This prevents your drops from evaporating.
- 2) In one of the large containers put 20 drops of vinegar. Fill the other large container with water.

Part II: The Show

Upon arrival at the site of the show, set up all materials.

Master of Ceremonies welcomes the crowd and introduces the demonstrators as a group.

Demonstration #1 is introduced. The Invisible Writing demo makes a good beginning, but there is no specific order of demos that must be followed.

- 1) Use the **Invisible Writing** demo as the Welcome. Spray the "Welcome" sign, then the "Please applaud" sign. The audience will catch on quickly. Tell a short story and spray signs that are key components of the story. At the end, entertain questions from the audience.

http://chicagoacs.net/statefair/CD-2010/experiments/invisible_writing.html

The MC should spray the "**Applause, please**" sign as the demonstrators exit and before introducing the next demonstration.

[View a video](#) that demonstrates how to write your secret message and spray your signs.

2) Blow Out a Candle with CO₂

This is an exciting demonstration because most audiences are not used to "seeing" a colorless gas being "poured."

- 1) Attach a candle to your "coat hanger" candle holder. Light the candle and lower it into one of the empty soda bottle cylinders. This proves that the candle does not go out when you lower it into the container.
- 2) Remove the candle and blow it out.

- 3) Pour approximately 3 ounces of vinegar into the cylinder and add one tablespoon of baking soda. The mixture will immediately begin to fizz and bubble. It's important that you do not pick up the cylinder - just leave it on the table.
- 4) After all of the bubbling has stopped, light the candle and slowly lower it into the soda bottle cylinder. The candle will go out. Relight the candle and try it again. Carefully observe the place in the cylinder where the candle goes out. The cylinder is filled with an invisible gas called carbon dioxide and this gas extinguishes the flame.
- 5) Light the candle and lower it into the second soda bottle cylinder. Just as you observed at the start, the candle should not go out because there's a sufficient amount of oxygen in the cylinder. Remove the candle and blow it out.
- 6) Pick up the cylinder with the invisible carbon dioxide gas and slowly pour the gas into the second cylinder. This is tricky because you're pouring an invisible gas! Just make sure that you don't pour any of the liquid into the second container.
- 7) Light the candle and lower it into the container that used to have the carbon dioxide gas - the candle should stay lit - proving that all of the gas is now gone. Immediately lower the candle into the second container... and the candle goes out!

[View a similar demonstration](#)

The MC should spray the " Applause, please" sign.

3) GAK

- 1) Empty an 8 oz. bottle of Elmer's Glue into a mixing bowl.
- 2) Add 1-2 drops of food coloring
- 3) In a plastic cup containing 1/2 C warm water, add a teaspoon of Borax Powder and stir.
- 4) While stirring the glue, add a small amount of the Borax solution to the bowl. Continue adding the Borax and mix with your hands until you get the slime to the consistency you like.
- 5) Play with it. Make a ball or shape it into an object. Invite a member of the audience to "feel" the slime. Pass a glob of slime among the audience members.

[Click here](#) and then on the "Video" tab to view a video of making GAK

The MC should spray the " Applause, please" sign.

4) Orange Juice to Strawberry Float

- 1) Add 300 mL of tap water to a 2-L beaker
- 2) Add the sodium bicarbonate and Alconox to the 2-L beaker. Stir the solution until most of the solid dissolves.
- 3) Add 100 mL of 0.2% solution methyl orange indicator to the beaker
- 4) Add approximately 270–280 mL of 3 M hydrochloric acid to a 600-mL beaker.
- 5) Place the beaker containing acid and the beaker containing the solution in a large tray or aquarium.
- 6) All at once, add the acid to the beaker containing the orange solution and watch the foaming begin.

[View a video](#) of the Orange Juice to Strawberry Float Demonstration

The MC should spray the " Applause, please" sign.

5) pH Rainbow Tube

If available, the presenter could wear a rainbow tie-dyed lab coat and chemical splash goggles.

- 1) Stopper one end of the tube and fill the tube to within 3-4 cm of the top with a solution of universal indicator in water.
- 2) Add a few drops of HCl to the tube, secure a stopper in the end and invert the tube.
- 3) Remove the upper stopper and add an equal number of drops of NaOH to the tube. Replace the stopper and invert again then hold the tube horizontally. Observe.

[View a video](#) of this demonstration

The MC should spray the " Applause, please" sign.

6) Red, White, and Blue

Upon introduction, a patriotic song may be played while the demonstrators are setting up.

- 1) Place a white background behind the three prepared beaker and place the beakers on a light-box if one is available.
- 2) Pour the ammonia solution into each beaker keeping the volume hidden by the aluminum foil.
- 3) Lift the aluminum foil to reveal the red, white and blue colors.

[View a variation](#) of the Red, White, and Blue demonstration.

The MC should spray the " Applause, please" sign.

7) Water Shell Game

This demonstration is especially entertaining while playing the song, "The Hustle" by Van McCoy.

- 1) Pour about 1/2 cup of water into cup containing the sodium polyacrylate polymer.
- 2) Slowly move cups around so students can easily tell where the water cup is.
- 3) Ask a student to select a cup NOT containing water. Invert this cup over student's head.
- 4) Remove cup from game and have another student pick from remaining two cups. Invert over student head.
- 5) When last remaining student balks at having water cup inverted over his head turn cup upside down over your head. No water comes out!

The MC should spray the " Applause, please" sign.

8) Witches Potion

- 1) Line up the prepared glasses in numerical order. Have the two large containers on the side.

- 2) Choose 5 volunteers, 4 witches and someone to read the poem. Hand each volunteer a copy of her/his part of the poem with instructions.
- 3) Starting with the large container of water in the demonstrator's hand, ask the "reader" to begin reading the poem.

Read: (Volunteer Reader)

"Four witches made quite a commotion.
When I invited them to create a potion.
Into four glasses went the magic brew,"

STOP

Demonstrator: Fill each glass 1/4 - 1/2 full with water. All will be clear.

Read:

"And into a rage the first witch flew:
She shrieked (*Witch #1 shrieks*), "There's no magic in this drink
To cast a spell, it must be pink!"
The second witch laughed (*Witch #2 laughs*), "The pink is here.
Pour your brew in--the color will appear!"

STOP

Have Witch #1 pour her water into the glass of Witch #2. The phenolphthalein will react with the ammonia and turn bright pink, indicating the presence of a base.

Read:

"The third witch shrieked, (*Witch #3 shrieks*) 'We need more!'
And gave her brew to Witch number Four."

STOP

Have Witch #3 pour her water into the glass of Witch #4. The phenolphthalein will react with the ammonia and turn bright pink, indicating the presence of a base.

Read:

"Now there are two glasses of pink,
But no one asked me what I think!
I'll invoke my powers to make it clear-
'Be Gone Pink!' 'Watch it disappear!!'"

STOP

Demonstrator pours both glasses with the pink solution into the glass container with vinegar. The acid will neutralize the base and the liquid will be clear again.

END

The MC should spray the " Applause, please" sign.

*The show is over and the MC may spray the sign that says, "That's all Folks."
Entertain questions from the audience about the chemistry of the demonstrations.*

What safety precautions and disposal actions must I take?

- 1) Chemical splash goggles and chemical-resistant apron must be worn during all pre-demonstration set-up, demonstration, and clean-up.
- 2) The audience must be far enough back from the demonstration area to avoid accidental splashes and spills.

A) Invisible Writing

- 1) Never spray ammonia products towards anyone's face or eyes.
- 2) Cotton swabs, and used paper can be discarded in the trash.
- 3) Return the phenolphthalein solution and glass cleaner to your teacher.

B) Blow Out a Candle with CO₂

- 1) Be careful not to burn yourself when working with the lit candle.
- 2) The vinegar/baking soda mixture can be poured down the drain.
- 3) Plastic cylinders can be recycled or saved for future demonstration shows.
- 4) Return the matches and candle to your teacher.
- 5) The candle holder can be saved for future demonstrations or discarded.

C) GAK

Do not pour the used GAK down the drain. Rather place in a plastic storage bag and discard in the trash.

D) Orange Juice to Strawberry Float

Hydrochloric acid (3 M) is moderately toxic by ingestion and inhalation; it is corrosive to body tissues, especially to the eyes. Methyl orange solution (0.2%) is slightly toxic by ingestion. Alconox[®] and sodium bicarbonate are irritants, especially to the eyes. This demonstration rapidly generates a foamy mixture that may spray in all directions. Along with chemical splash goggles and chemical-resistant apron, acid resistant gloves should be worn.

E) pH Rainbow Tube

- 1) Wash any spilled acid or base with plenty of water.
- 2) Solution in tube can be flushed down the drain with an excess of water.

F) Red, White, and Blue

Follow your teacher's directions for disposal of chemicals.

G) Water Shell Game

The cup containing the polyacrylate gel can be discarded in the trash.

H) Witches Potion

All solutions can be flushed down the drain.

How is this activity related to my knowledge of science/chemistry?

You are responsible for understanding the chemistry of your demonstration so that you can answer any questions your classmates, teacher, and audience may ask.

How can I extend my learning with this activity? (Extensions)

Create a new demonstration show with a new set of demonstrations.

Chemical Outreach

Teacher's Guide

Concepts:

- Chemical reactions
- pH and acid-base indicators
- Production of CO₂ and its properties
- Polymers and cross-linking
- Precipitation reactions
- Student presentation skills

Background:

The teacher will instruct the students to :

- *Form groups of 2-3*
- *Select a demonstration for each group*
- *Set up an audience (elementary class, scout troop, middle school class or even within their own class)*
- *Gather together the materials needed*
- *Practice the demonstration*
- *Explain the chemistry behind the demonstration*
- *Perform the show*

Chemistry:

A) Invisible Writing

Phenolphthalein is an "indicator" that is colorless in its normal or acid state. When exposed to a base, such as the ammonia in the glass cleaner, it turns deep pink, which is its basic state. Since the ammonia can evaporate off the paper, the reaction is reversible, and the phenolphthalein reverts to its colorless state. Re-spraying the dried, invisible message will make the pink color re-appear.

B) Blow Out a Candle with CO₂

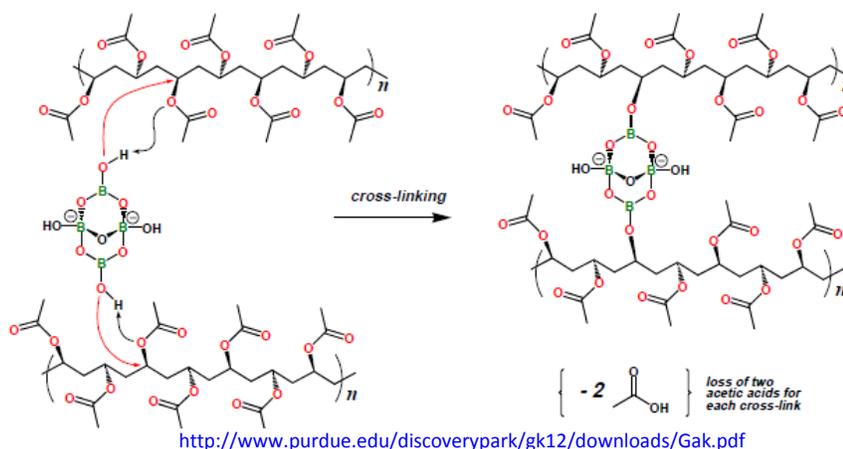
Carbon dioxide gas can extinguish a fire. It does this by reducing the amount of oxygen in the air around the burning object. Since carbon dioxide has a density greater than air, it flows to the bottom of the cylinder filled with air by pushing the air up and out of the cylinder. Pouring a gas is like pouring a liquid. This property makes it easy to fill containers with carbon dioxide and to pour carbon dioxide from one container to another.

The reaction between the vinegar and baking soda to produce carbon dioxide is:



C) GAK

GAK is a polymer. Acetate groups in Elmer's glue cross-linking with B-OH groups in borax molecules to form polymers. Because of the cross-linking, GAK behaves like a rubbery solid called an elastomer.



D) Orange Juice to Strawberry Float

The sodium bicarbonate reacts with the hydrochloric acid in a neutralization reaction to produce sodium chloride, water and carbon dioxide gas according to the following equation:



Methyl orange is an acid–base indicator that turns from a yellow-orange color at pH 4.4 to a red color at pH 3.0. The initial basic solution has a deep orange color. The intensity of the yellow-orange solution is due to the high indicator concentration. Upon adding the acid, the pH drops and a strawberry red color forms. One of the products of this neutralization reaction is carbon dioxide gas, which is rapidly produced and becomes trapped in the soap bubbles. Over 13 liters of CO_2 gas are produced in this reaction, resulting in an abundance of soap bubbles.

E) pH Rainbow Tube

Universal indicators can be used to illustrate a whole range of pH conditions (usually because they are made up of a mixture of different indicators, all of which change at different pHs). As an acid is diluted, its pH increases -- but never beyond 7.0. Likewise, as a base is diluted, its pH decreases -- but, again, never less than 7.0. Buffers are solutions that are resistant to pH changes.

F) Red, White, and Blue

- 1) The red coloration is due to the presence of an indicator, phenolphthalein, in an ammonia base.
- 2) The white coloration is due to a precipitate that forms when MgSO_4 reacts with aqueous NH_3 . $\text{Mg}(\text{OH})_2$ is the insoluble white product.
- 3) The blue coloration is due to a complex ion that forms when Cu^{2+} ions react with aqueous ammonia. The formula for the complex ion is $\text{Cu}(\text{NH}_3)_4^{2+}$

G) Water Shell Game

Sodium polyacrylate polymer expands as much as 600% by slowly absorbing water. A little powder, cleverly hidden on the bottom of a non see-through cup, will absorb water poured into the cup. When the cup is later inverted the water is gone!

H) Witches Potion

The color changes from colorless to pink are due to pH changes as the vinegar and ammonia are mixed. Phenolphthalein is pink in the presence of a base and colorless at pHs of 7 and below.

Safety and Disposal:

Please review current Material Safety Data Sheets for additional safety, handling, and disposal information. Remind students to wear chemical splash goggles and chemical-resistant aprons.

A) Invisible Writing

Properly labeled phenolphthalein bottles can be stored in a flammables cabinet. Glass cleaner contains ammonia and can be stored with other ammonia products.

B) Blow Out a Candle with CO₂

Remind students to be careful not to burn themselves when working with the candle.

C) GAK

Remind students not to pour the used GAK down the drain as it will clog it.

D) Orange Juice to Strawberry Float

Review all federal, state and local regulations that may apply, before proceeding with disposal. The resulting mixture may be diluted with water, neutralized, and flushed down the drain with excess water.

E) pH Rainbow Tube

Wash acid and base spills with excess water. Contents of demonstration tube can be flushed down the drain with excess water.

F) Red, White, and Blue

Review all federal, state and local regulations that may apply, before proceeding with disposal. The resulting mixture may be diluted with water, neutralized, and flushed down the drain with excess water.

G) Water Shell Game

The cup that contains the gel can be discarded with solid trash.

H) Witches Potion

It is safe to flush solutions down the drain with excess water.

How is this activity related to my knowledge of science/chemistry?

Students should have a good understanding of their demonstration. They should be able to adequately answer any questions asked.

Extensions:

Select songs or musical selections to accompany the demonstrations.
Create a new demonstration show with a new set of demonstrations.

References:

http://chicagoacs.net/statefair/CD-2010/experiments/invisible_writing.html
<http://www.nclark.net/OrangeJuice.pdf>
<http://www.science-house.org/index.php/ctc/70-red-white-and-blue-i-demonstration-experiment-13>
<http://www.stevespanglerscience.com/experiment/invisible-fire-extinguisher>
<http://dwb4.unl.edu/chemistry/beckerdemos/BD024.html>
<http://www.stevespanglerscience.com/experiment/00000039>
<http://www.njacs.org/demowsg.html>