The Chemical Toy Box

An Educational Demonstration Package

Prepared by the

Cleveland Section

of the

American Chemical Society

National Chemistry Week 1998

Overview

Did you know that chalk, glow-in-the-dark toys, and slime are all made of chemicals? Come and make some. Have fun exploring the science behind them. Being a chemist means never having to put away your toys!

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Acknowledgements

The National Chemistry Week (NCW) programs of the Cleveland Section ACS began in 1994 with an idea to put together a scripted program that could be performed at any local school or library. This idea has expanded to become the centerpiece of Cleveland Section's NCW activities, which has received national recognition from the American Chemical Society. In 1998, the Cleveland Section will perform fifty demonstrations.

A local section Organizing Committee coordinates this library/school hands-on demonstration program. This Committee develops a theme for the program; recommends, tests, and reviews activities and experiments; writes a script; collects supplies and materials; recruits sponsors and volunteers; contacts libraries and schools; and schedules individual shows. The Committee (as well as the rest of the Section's NCW activities) is overseen by the Cleveland Section's three NCW coordinators, Betty Dabrowski (chair), Marcia Schiele (co-chair), and Rich Pachuta (co-chair). Committee members include Fen Lewis, Shermila Singham, Lois Kuhns, Jason F. Khayat, Helen Mayer, Peggyann Moore, Paula Fox, and David W. Ball.

Asssembly of the fifty demonstration kits is a monumental task, with only donuts and pizza (provided by Cleveland Section Chair David Ball) as the payment. Volunteers for the Grand Assemby of Kits (abbreviated GAK) included Nick Baldwin, David Ball, Gail Ball, Donald Boos, Irene Cesa, Anna Cesa, Mark Cesa, Laura Cesa, Helen Dernar, Rita Dernar, Karen Dernar, Scott Donne, Betty Dabrowski, Paula Fox, Jason F. Khayat, Lois Kuhns, Fen Lewis, Helen Mayer, Peggyann Moore, Helen Moore, Rich Pachuta, Julie Rehm, Danielle Schiele, Nathan Schiele, Jessica Schiele, Jeremy Schiele, Marcia Schiele, Gwenyth Szabo, and Allison Winokur.

The foundation of this program has been the script, written so that the it can be performed easily at any school or library. This year's script, written by Helen Mayer, is based on the well-organized format set in past years by Susie Rolland and Mike Setter.

Our NCW efforts reach farther this year because of various sponsors who have donated money, materials, or services to the Cleveland Section specifically for National Chemistry Week. We are grateful to NASA Lewis Research Center, Reflex Analytical, Day-Glo, Battelle Memorial Institute, the Great Lakes Science Center, Cleveland State University, Ursuline College, General Electric/Nela Park, Dodd's Camera, Brooklyn Wal-Mart Photo Center, Cuyahoga Community College – Metro Campus, UCAR Carbon Company, and the Cuyahoga County Public Library – Independence Branch for their contributions and support.

Last and most important, thanks to all the volunteers who donate their time and expertise. Without the dozens of dedicated chemical professionals to lead these activities, there would be no Cleveland Section NCW program.

Overview

This year's National Chemistry Week demonstrations revolve around children's favorite objects—their toys. The chemistry behind some common toys is discussed. In addition, some simple chemical principles are illustrated using toys. The students will receive toys to take home, including:

- chalk
- UV-sensitive and phosphorescent beads
- heat-sensitive paper

Through the demonstrations, the students will learn:

- how to distinguish the three states of matter: solid, liquid and gas
- how to make "mock" chalk
- the properties of liquids using a density wand
- about polymers and gases using balloons
- how a Cartesian diver works
- how to make slime
- how color-change paints work
- the principles of fluorescence and phosphorescence
- how to make a rocket using Alka-Seltzer®

How Experiment Write-ups are Organized

Each experiment write-up is divided into seven different parts:

- Background and Set-Up Information for Demonstrators
- Materials for This Experiment - Students
- Materials for This Experiment - Demonstrators
- Experiment Demonstration Pre-Work Set-Up
- Demonstration Instructions
- Experiment Conclusions & Answers
- Additional Information If Needed

Demonstrator's Guide

Presentation Overview

This section describes the basic presentation technique used during the demonstrations. This is a guideline only as some experiments are different. Make sure you follow the instructions given in each experiment.

1. Introduce experiment.
2. Do your demonstration piece.

   Note: *Most experiments require you to perform the experiment to show the students what to do on their own.*

3. Have the students do their experiment.

   Note: *For some experiments your demonstration and the students hands-on work are nearly simultaneous. You are leading them as they perform the experiment.*

4. Some experiments will be done by all students. For others, there will be one "toy" that will be shared by all students at the table.

MAKE SURE TO FOLLOW ALL DIRECTIONS IN EXPERIMENTS

- The chalk experiment requires you to start it early in the program and finish it during the Toys That Glow experiment. Do not forget to return to this experiment before the program ends.
- Some experiments have special safety concerns due to the materials being used. These are listed in the section for that experiment.

Demonstration Check-Off List

The next few pages list suggested activities to complete for the program.

Activities To Do Before You Go To The Demonstration	✓ When Complete
Read through this packet to familiarize yourself with the experiments	❑
Collect the materials you need to bring with you to the demonstration: ➢ This packet ➢ Demonstration kit (*Optional: decorate the kit box as a toy box*) ➢ Extension cord ➢ 1 gallon jug for waste water collection ➢ 1 gallon jug of water (if none available at site) ➢ 1 roll of paper towels ➢ 2 or 3 Sharpie-type pens ➢ 1 pair of scissors (not your best ones!) ➢ 1 large garbage bag ➢ 1 pan with sides, like a pie, 8"x 8", or 9"x 13" ➢ 1 kitchen or hand towel ➢ Hand lotion, baby oil, glycerin, or cooking oil ➢ 1 plastic food container, such as a Rubbermaid®, Tupperware®, or margarine container, approximately 3 cup volume or larger ➢ Examples of toys (optional)	❑
Contact the children's librarian: ➢ Ask the room to be arranged with 6 tables around a front table ➢ Ask to have 5 chairs around each of the 6 tables ➢ Ask for all the tables to be covered with newspapers ➢ Ask for extra paper towels for each table ➢ Ask if they have a microwave, or some way to boil a couple of cups of water *Note: If the library cannot provide a way to boil water, bring boiling water to the library in an insulated container*	❑

Activities To Do When You Get To The Library	✓ When Complete
Introduce yourself to the children's librarian	❑
Ask the librarian how many students are pre-registered	❑
Confirm that there are 6 student tables and 1 demonstrator's table	❑
Confirm that all tables are covered in newspaper and have paper towels	❑
Set out the individual items for each experiment on the students' tables and the demonstrator's table	❑
Complete Demonstration Pre-Work Set-Up for all demonstrations: ➢ Opening Session ➢ Preparation of Chalk ➢ Density Wands ➢ Balloons ➢ The Cartesian Diver ➢ Slimy Stuff ➢ Color-Change Paints ➢ Toys That Glow ➢ Alka-Seltzer® Rockets *Note: This set-up is estimated to take 30 minutes.*	❑
Set out the literature (1-page hand-out on toys to make at home and *ChemMatters*)	❑

Activities To Do During The Demonstration	Timing
Welcome the students and parents as they enter the room	**-**
Stamp each student's hand with rubber stamp and fluorescent ink when they enter the room	2 min.
Ask each student to make a name tag by writing their names on the heat-sensitive paper with Sharpie-type marker. Help them pin the tags on.	2 min.
Assess number of students per table and adjust to 3 - 5 per table *Note: If you have extra tables, keep them empty.*	**-**
Complete the Opening Session introduction	5 min.
Perform demonstrations	*Total Time: 51 min.*
➢ Preparation of Chalk	10 min.
➢ Density Wands	2 min.
➢ Balloons	5 min.
➢ The Cartesian Diver	2 min.
➢ Slimy Stuff	15 min.
➢ Color-Change Paints	10 min.
➢ Toys That Glow	10 min.
➢ Alka-Seltzer® Rockets	10 min.
Complete the Closing Session information	1 min.

Activities To Do Immediately After The Demonstration	✓ When Complete
Transfer all liquids to the 1 gallon waste jug	❑
Transfer all solids to the garbage bag	❑
Remove newspapers from the tables and put in the garbage bag	❑
Give any left over literature to the librarian	❑

Activities To Do Once You Get Home	✓ When Complete
Pour waste liquid from 1 gallon jug down the drain	❑
Put garbage bag in the trash	❑
Clean and dry all vials	❑

Note: ***All materials are typical household products. They can be safely disposed of in the manner indicated above.***

Contents of Demonstrator's Kit (*For additional details, see the Appendix.)

Key: *Provided by demonstrator* Provided per kit

Opening Session

31 sheets of heat-sensitive paper
31 safety pins
1 stamp pad
1 or 2 rubber stamps
1 sealed pipette with colorless fluorescent ink
2-3 Sharpie type pens
scissors

Experiment 1: Preparation of Chalk

31 3-oz. white plastic cups labeled "C"
31 craft sticks
31 capped film canisters fill with plaster of Paris
1 dropper-top bottle of fluorescent Tempera paint
1 plastic teaspoon
1 piece of chalk
500 ml tap water

Experiment 2: Density Wands

7 density wands *(*See Appendix for details)*

Experiment 3: Balloons

5 balloons
1 empty, clear plastic soft-drink bottle, 16 oz
1 bamboo skewer
2 large rubber bands
1 plastic food container
1 kitchen towel
1 1/4 cup tap water, boiling hot
hand lotion, baby oil, glycerin, mineral oil, or cooking oil

Experiment 4: The Cartesian Diver

7 2-liter soft drink bottles
7 "divers" (pipettes with hex nuts)

14 L tap water

Experiment 5: Slimy Stuff

7 zipper-close plastic bags marked “slime”
7 craft sticks
7 small clear plastic cups with mark at 1/4 cup
7 clear plastic cups, 9 oz.
7 zipper-close plastic bags labeled “corn” (containing _ cup of corn starch)
7 plastic cups
2 disposable pipettes
1 50-ml vial of 4% borax solution with green food coloring
2 50-ml vials of gel glue solution
1 bottle marked “glob-borax” containing borax solution
1 large bottle containing white glue and water (appears pink in color)
scissors
2 cups tap water

Experiment 6: Color-change Paints

7 plastic cups marked “yellow”
7 plastic cups marked “changer”
7 plastic cups marked “red”
93 cotton swabs
31 pieces of white paper, 5.5” x 4.25”
1 vial of turmeric solution marked “yellow”
1 vial of changer solution
1 vial of phenol red solution

Experiment 7: Toys That Glow

31 bracelets made with UV-sensitive and phosphorescent beads
1 GE Blacklite Stik®
extension cord
optional: glow-in-the-dark toys supplied by demonstrator

Experiment 8: Alka-Seltzer® Rockets

6 empty transparent film canisters
2 Alka-Seltzer® (or generic-brand) tablets
1 empty pan with sides, such as a pie pan

1/2 cup tap water

Overall

1 gallon jug for waste water collection

1 plastic garbage bag for waste collection

1 roll of paper towels

30 copies Chem Matters magazines

1 large cardboard box

Set of instructions

Items for the Demonstrator to Provide

15 liters of tap water

1 1/4 cup boiling hot water (from library, or bring from home in an insulated container)

1 gallon jug for waste water collection

1 plastic garbage bag for waste collection

1 roll of paper towels

2-3 Sharpie-type pens

1 plastic food container, such as a Rubbermaid®, Tupperware®, or margarine container, approximately 3 cup volume or larger

1 kitchen towel

hand lotion, baby oil, glycerin, mineral oil, or cooking oil

scissors

extension cord

1 pan with sides, such as pie pan, 8 x 8" or 9 x 13" pan

glow-in-the-dark toys (optional)

newspapers (optional)

Items for the Demonstrator to Return

plastic vials, CLEANED

rubber stamps

GE Blacklite Stik®

ALL UNUSED MATERIAL

Activities to Do On-Site Prior to Demonstration

Opening Session

- Place the name tags, safety pins, and Sharpie-type pens in a convenient place so that the students can write their names as they arrive.
- Remove the stamp pad and ink from the bag marked "Tag/Stamps." Cut the tip off the pipette and dispense the ink onto the stamp pad.

  Note: Do this step as close to the students' arrival time as possible so the ink doesn't dry.

Experiment 1: Preparation of Chalk

- Add exactly 2 teaspoons of water to each cup labeled "C". Place 5 cups on each of the students' tables and one on the demonstrator's table.
- Place five craft sticks on each of the students' tables and one craft stick on the demonstrator's table.
- Place five film canisters filled with plaster of Paris on each of the students' tables and one on the demonstrator's table.
- Place one container of paint on the demonstrator's table.
- Place one piece of chalk on the demonstrator's table.

Experiment 2: Density Wands

- Place one density wand on each of the students' tables and one on the demonstrator's table. *Alternately, the demonstrator may wish to hand out the density wands during the program.*

Experiment 3: Balloons

To be done at home:

- Fill the bottle with about 1/4 cup boiling water. Stretch the balloon over the neck of the bottle. Let stand about 10 min. The balloon will reverse inflate into the bottle.

To be done at the demonstration site:

- Place the balloon/bottle assembly into a plastic container on the demonstrator's table.
- Boil water, or bring hot water to the library in an insulated container.
- Place the remaining balloons, the towel, the lotion or oil, the skewer, and the rubber bands on the demonstrator's table.

Experiment 4: The Cartesian Diver

- Prepare the "Cartesian Diver" bottles by filling the bottle with water as full as possible. Place each "diver" (pipette/nut unit) into a cup of water to determine where the diver floats. Fill or release water so that the diver floats at the top of the water. Place the diver in the soft drink bottle. ***Note: This step can be done at home.***

- Place one "Cartesian Diver" bottle on each of the students' tables and one on the demonstrator's table.

Experiment 5: Slimy Stuff

- Transfer 4 pipette aliquots (2 ml each) of gel glue solution into 7 plastic bags marked "slime". Seal bag securely. Place one bag on each of the students' tables and one on the demonstrator's table.
- Place the vial of borax solution and a disposable pipette on the demonstrator's table.
- Empty 7 bags marked "corn" into the seven 9-oz plastic cups. Place one cup on each of the students' tables and one on the demonstrator's table.
- Fill the 7 small clear plastic cups up to the 1/4 cup mark with water. Place one cup on each of the students' tables and one on the demonstrator's table.
- Place a craft stick on each of the students' tables and one on the demonstrator's table.
- Prepare "glob" by pouring the bottle marked "glob-borax" into the bottle containing the white glue and water. Cap the bottle and shake vigorously for 5-10 min until the sides of the bottle become clean. *Note: This step can be done the night before at home.*
  Note: If the "glob-borax" solution has precipitated, shake it before using.
- Pour a small amount of glob into each cup. Scissors can be used to cut the material. Leave the demonstrator's portion in the large bottle to show how easily cut the material is during the demonstration.

Experiment 6: Color-Change Paints

- Distribute the turmeric solution evenly among the 7 plastic cups labeled "yellow". Place one cup on each of the students' tables and one on the demonstrator's table.
- Distribute the changer solution evenly among the 7 plastic cups labeled "changer". Place one cup on each of the students' tables and one on the demonstrator's table.
- Distribute the phenol red solution evenly among the 7 plastic cups labeled "red". Place one cup on each of the students' tables and one on the demonstrator's table.
- Place 15 cotton swabs on each of the students' tables. Place three cotton swabs on the demonstrator's table.
- Place 5 sheets of paper on each of the students' tables. Place one sheet of paper on the demonstrator's table.

Experiment 7: Toys That Glow

- Plug the GE Blacklite Stik® into the extension cord. If it is safe to do so, plug it into the wall during preparation. If not, note where the wall outlet is for future reference.

Experiment 8: Alka-Seltzer® Rockets

- Fill each film canister about 1/4 full with water. Cap and place one on each of the students' tables.

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- Place 1/3 of an Alka-Seltzer® tablet on each of the students' tables.
- Place the empty pan with sides on the demonstrator's table.

Upon Arrival

Background and Set-Up Information For Demonstrators

- The students will receive a name tag and get their hands stamped as they enter the room.
- The name tag is made of heat-sensitive paper, and will be discussed in the Color-Change Paints experiment.
- The ink for the stamp is fluorescent, and will be discussed in the Toys That Glow experiment.

Materials For This Experiment - Students

- 30 sheets of heat-sensitive paper (one per student)
- 30 safety pins (one per student)
- 2 – 3 Sharpie-type pens

Materials For This Experiment - Demonstrators

- one sheet of heat-sensitive paper (with your name on it)
- one stamp pad
- one or two rubber stamps
- one sealed pipette with colorless fluorescent ink
- scissors

Pre-Work Set-Up

Do the following:

- ➢ Place the name tags, safety pins, and Sharpie-type pens in a convenient place so that the students can write their names as they arrive.
- ➢ Remove the stamp pad and ink from the bag marked "Tag/Stamps." Cut the tip off the pipette and dispense the ink onto the stamp pad.

Note: Do this step as close to the students' arrival time as possible so the ink does not dry.

Perform the Experiment Upon Arrival of the Students

Do the following:

- ➢ As the students arrive, stamp their hand or name tag with the rubber stamp and fluorescent ink. *Note: If the students ask what is happening, tell them that this is similar to getting stamped at an amusement park, and they will find out more about the chemistry of the ink later.*
- ➢ Ask each student to write their name on the heat-sensitive paper and pin it on.

An alternative: Give the librarian the heat-sensitive paper, the pins, and the pens and ask him or her to have the students make a name tag as they line up for the program.

Opening Discussion

Introductions

Do the following:

- Introduce yourself as a chemist.
- Introduce the American Chemical Society as the largest organization in the world devoted to a single profession.
- Introduce National Chemistry Week - what it is and why we do it.

(Hint: it is a nationwide event put on by volunteers like you to let non-chemists know about chemistry and how chemistry and chemists influence their lives.)

What is Chemistry and Chemicals?

Do the following:

- Explain that chemistry is the study of everything around them.
- Ask for volunteers to name some chemicals. Then ask more volunteers to name something that isn't a chemical.
- Remind students that all toys are made from chemicals.

Note: If demonstrator brought toys from home, this is a good time to show them.

> ***Remember: everything around us is a "chemical".***
> *Be very careful in correcting the students. Encourage their participation while explaining that anything they name really is a chemical.*

What Do Chemists Do?

- Ask the participants to tell you what a chemist does, what a chemist looks like.

Note: Be prepared for some strange and funny answers. Try not to laugh, cry, or get offended.

- Tell them BRIEFLY and in simple terms what you do as a chemist.

Note: This should last no more than 1 minute. Remember to leave the physical chemistry lecture and the "big" chemistry words at home!

- Tell them that chemists use their knowledge to answer questions about the world around them. This is very exciting, as they will soon see.

Demonstrator's Guide

Demonstration Introduction

Get Students Enthused about the Demonstration

Ask the following:

- Have you ever wondered how toys were made?
- Would you like to make your own toys? Remind students that if they follow the directions carefully, they will have some toys to take home at the conclusion of the demonstration.
- Tell them that being a chemist means never having to put away your toys!

Set the Story of The Chemical Toy Box

Do the following:

- Tell the story:

Have you ever spent a rainy Saturday afternoon cooped up in the house with nothing to do? In our story, there are two children, about your age, named Matt and Sarah, who are at home bored on a Saturday afternoon. Let's follow them as they open...The Chemical Toy Box.

Introduce the Items on the Tables

Do the following:

- Tell them that the objects on their tables will allow them to help discover the chemical toy box along with Matt and Sarah.
- Tell them not to touch anything until told to do so. Remind them never to taste or smell anything, as if they were in a laboratory.
- Tell them that they will learn to make toys that can be also made at home using the handouts provided at the end of the demonstration.

Experiment 1: Preparation of Chalk

Background and Set-Up Information For Demonstrators

Experiment Purpose & General Methodology

- The concept of solids will be introduced with the preparation of chalk.
- The paint used for this experiment is fluorescent and will be discussed in Experiment 7, Toys That Glow.

Materials For This Experiment - Students

- 30 3-oz. white plastic cups labeled "C" (one per child)
- 30 craft sticks (one per child)
- 30 capped film canisters filled with plaster of Paris (one per child)

Materials For This Experiment - Demonstrators

- one 3-oz. white plastic cup labeled "C"
- one craft stick
- one capped film canister filled with plaster of Paris
- water
- one dropper-top bottle of fluorescent paint Tempera paint
- one plastic teaspoon
- one piece of chalk

Preparation of Chalk Pre-Work Set-Up

Do the following:

- Add exactly 2 teaspoons of water to each cup labeled "C". Place 5 cups on each of the students' tables and one on the demonstrator's table.
- Place five craft sticks on each of the students' tables and one craft stick on the demonstrator's table.
- Place five film canisters filled with plaster of Paris on each of the students' tables and one on the demonstrator's table.
- Place one container of paint on the demonstrator's table.
- Place one piece of chalk on the demonstrator's table.

Preparation of Chalk

Introduce the Experiment

Tell the students the following:

- Matt pulls out a piece of chalk from his toy box [the demonstrator should pull out the chalk at this point]. He begins to draw on the chalkboard. He notices that chalk is hard enough to stay together, but soft enough to make a mark on the board.
- Matt asks Sarah if she knows how chalk is made.
- Ask the students "Have you ever wondered where chalk came from?
- Ask the students if they know the difference between solids, liquids, and gases (older students may know the answers, but younger ones may need help with the definitions).
  - Solid - molecules are fairly close together so material can be moved whole, like a rock or a stick.
  - Liquid - molecules are further apart, so the material has no shape of its own. It must be moved in a container, and takes the shape of the container. Water is the most familiar liquid.
  - Gas - molecules are very far apart. Gases have no shape at all, and they fill up all the space in which they are put. Air is the most familiar gas.
- Remind students that all materials can be divided into these three categories.
- Ask the students "Is chalk a solid, liquid, or gas?" (they hopefully will respond with the correct answer!)
- Chalk is made from a chemical called calcium carbonate. Calcium carbonate is found in rocks. We do not have any calcium carbonate available, so we will make chalk from a common household material called plaster of Paris, which is also used for making plaster casts.
- We will make some chalk that you can take home at the end of the demonstration!

Perform the Preparation of Chalk Simultaneously With the Students

Do the following:

- Slowly and with stirring, add the plaster of Paris from the film canister to the plastic cup containing the water. Use the craft stick as the stirrer.
- Mix until the water and the plaster of Paris become homogenous.

  Note: If the moistened plaster of Paris is too thick, add a few drops of water from the bottle. If the moistened plaster of Paris is too thin, add more plaster of Paris from an extra film canister.

- The demonstrator should add a few drops of paint to each student's cup.

  Optional: Tell the students that if they do not mix well, they will have swirls in their final chalk. This is an example of a nonhomogenous mixture.

- Tap the cup on the table to remove air bubbles.
- The demonstrator should collect the craft sticks in the waste bag.
- Place the mixture aside to harden while doing the other demonstrations (Allow 30 minutes minimum.)

  Note: Each student will make a piece of chalk to take home.

  Note: This chalk is especially good for writing on sidewalks, but will not work on chalkboards.

Additional Information If Needed: Preparation of Chalk Technical Background

- Chalk is calcium carbonate, $CaCO_3$, which is a soft form of limestone. Natural deposits are found in Iowa, Texas, Arkansas, and Great Britain. Other sources of calcium carbonate are sea shells, egg shells, marble, and calcite. Calcium carbonate is used in toothpaste.
- Plaster of Paris is calcinated gypsum. Gypsum is found in rock and can be formed artificially as a by-product in an old method of producing phosphoric acid.
- When hydrated, plaster of Paris forms interlocking crystals which expand in volume. This characteristic of swelling upon curing makes it ideal for making plaster casts.
- The reaction to make chalk is:

$CaSO_4 \cdot 1/2\, H_2O + 1.5\, H_2O$ -------> $CaSO_4 \cdot 2\, H_2O$

This is an exothermic reaction, or a reaction that gives off heat. An optional exercise is to have the children feel the cup about 15 minutes into the demonstration.

Experiment 2: Density Wands

Background and Set-Up Information For Demonstrators

Experiment Purpose & General Methodology

- The students will examine the density wands.
- The students will learn principles about liquids, including density and solubility.

Materials For This Experiment - Students

- 6 density wands, prepared prior to the demonstration (one per table)

For your information--The density tubes contain the following in a plastic vial, taped shut:

7 mL mineral oil

7 mL clear corn syrup with food coloring

glitter and/or stars

Materials For This Experiment - Demonstrators

- 1 density wand

Density Wands Pre-Work Set-Up

Do the following:

➢ Place one density wand on each of the students' table and one on the demonstrator's table.

**Alternately, the demonstrator may wish to hand out the density wands at the appropriate time during the program.*

Density Wands

Introduce the Experiment

Tell the students the following:

➢ After making the chalk, and while waiting for it to dry, Matt and Sarah had nothing to do again. But they were curious children, so Sarah went back to the chemical toy box and picked up a wand (pick up demonstrator's wand).

Perform the Density Wand Experiment Simultaneously With the Students

Do the following:

Note: There is only one wand per table. Let each student have a turn to observe.

- Ask the students to pick up the wands from their table and to turn it over several times. What do they observe? [Some observations that may not be obvious include: (a) the glitter is near the middle of the tube, and (b) there is a bubble that slowly moves up the tube as it is turned over, carrying the glitter with it.]
- Is the material inside a solid, liquid, or gas? (Remind them of the definitions if necessary.) [Answer: all of the above--liquid, gas bubble, solid glitter or stars.]
- How many liquids are there? [Answer: two that do not dissolve.]
- Can you give an example of two liquids that do not dissolve in each other? [If they cannot, prompt for bottled salad dressing made of oil and vinegar.]
- Tell the students that the liquids dissolve or do not dissolve based on chemical structure. There are two types of liquids: those that dissolve in water, and those that dissolve in oil. Oil and water do not mix (like an oil spill on a puddle.)
- In our tubes, the two liquids are oil and corn syrup. Corn syrup dissolves in water. Remember, when you drink pop, which is mostly water and corn syrup, the two liquids do not separate in your glass.
- Ask one student at each table to shake the tube for 5 seconds (count the seconds out loud). Observe what happens. [Answer: the two liquids do not mix, and the air bubble will slowly work its way to the top.]
- What color liquid is on top? Is it always the same or does it change every time the tube is turned over? [Answer: it is always the same.]
- Liquids that do not dissolve are arranged in order of density or weight of the liquid. The heavier one will be on the bottom, and the lighter one on top. Our tubes contain oil and corn syrup. Which one is on top? [Answer: oil is less dense, so it is on top.]

Additional Information If Needed: Density Wands Technical Background

- Toys such as fairy wands and some kaleidoscopes are based on density differences.
- The density wands can also be used to demonstrate viscosity. Viscosity is a measure of a liquid's resistance to flow. The higher the viscosity, the slower it flows, like grease or ketchup. Water has a lower viscosity, so it flows very easily. In this density wand, the viscosity of the corn syrup is higher than that of the oil.
- Oils are long chains made up of CH_3-$(CH_2)_x$-CH_3.
- Corn syrup contains a mixture of simple and complex sugars. The general chemical formula for sugars, which are carbohydrates, is $(CH_2O)_x$.

Experiment 3: Balloons

Background and Set-Up Information For Demonstrators

Experiment Purpose & General Methodology

- The principles of gases will be demonstrated using balloons.
- The demonstrator will show the students how to poke a sharp stick though the balloon without popping it, illustrating the properties of polymers.

Materials For This Experiment - Students

- None. This experiment will be done by the demonstrators only.

Materials For This Experiment - Demonstrators

- 5 balloons
- 1 1/4 cup water, boiling hot (from library, or bring from home)
- 1 empty, clear plastic soft-drink bottle, 16 oz.
- 1 plastic food container, such as a Rubbermaid®, Tupperware®, or margarine container, approximately 3 cup volume or larger
- 1 kitchen towel
- 2 large rubber bands
- Hand lotion, baby oil, glycerin, mineral oil, or cooking oil
- 1 bamboo skewer

Balloons Pre-Work Set-Up (to be done at home)

Do the following:

- Fill the bottle with about 1/4 cup boiling water. Stretch the balloon over the neck of the bottle. Let stand about 10 min. The balloon will reverse inflate into the bottle.

Balloons Pre-Work Set-Up (to be done at the library)

Do the following:

- Place the balloon/bottle assembly into a plastic food container on the demonstrator's table.
- Boil water, or bring hot water to the library in an insulated container.

- Place the remaining balloons, the towel, the lotion or oil, the skewer, and the rubber bands on the demonstrator's table.

Balloons

Introduce the Experiment

Tell the students the following:

- When we last met Matt and Sarah, they were playing with density wands and learning about liquids.
- But Matt felt he had learned enough about liquids, and went back to the toy box. He reaches in and pulls out a balloon left over from his last birthday party. [The demonstrator should pull out an empty balloon at this time]. He wonders what to do with it.
- Sarah observes that you can blow up the balloon with air [The demonstrator should do this.] Is air a solid, liquid, or gas? Why? Is the plastic that balloons are made from a solid, liquid, or gas?
- Matt blows up the balloon and lets it go [The demonstrator should also let go of the balloon.] Why does the balloon behave this way? [Answer: The plastic of the balloon is pushing against the gas inside it and, given the chance, the balloon will push out the gas. That is why we have to tie a balloon at the end if we want to keep it blown up.]
- Sarah wonders about the properties of gases. Let's help Sarah understand gases better.

Perform the Balloons Experiment as a Demonstration

Part I - Gases and Air Pressure

Do the following:

- Show the students the bottle/balloon unit. Tell the students that the balloon was inverted inside the bottle on purpose. The liquid inside the bottle is water.
- Pour about 1 cup of boiling water into the plastic food container.
- Place the bottle/balloon unit in the water. Cover the top half of the battle/balloon unit with a kitchen towel for insulation. Use the rubber bands to hold the bottle in place. Wait and watch as the balloon flips outside the bottle and inflates slightly.

Note: This may take several minutes. In the meantime, perform Part II, Skewering the Balloon without Puncturing.

- Ask the students to comment on the inflation of the balloon causing it to go from the inside of the bottle to the outside.
- Ask the students what would happen if the air inside the bottle were cooled. Add cold water to the plastic food container and watch what happens. [The balloon should reverse inflate inside the bottle, just as it appeared before we added the hot water.]

- Tell the students that air is a mixture of different gases. Air pressure is all around us. The air pressure is different depending on elevation; the air pressure at sea level is different than on top of a mountain. Divers must consider the difference in air pressure under water for safety considerations.
- The air pressure inside the plastic bottle increased as the temperature increased. This caused an expansion inside the balloon which "popped" out of the bottle. The air needed to occupy more space as heated molecules move faster and further, so the balloon was pushed outward.
- Similarly, when the bottle was cooled, the air inside the bottle cooled also. The air molecules needed to occupy less space, so the balloon reverse inflated inside the bottle as the outside air pushed on it. A negative pressure, or a partial vacuum, was created inside the bottle while the outside air pressure remained constant.

Part II - Skewering the Balloon without Puncturing. This experiment is done by the demonstrator.

Do the following:

- Blow up a balloon to the size of a small honeydew or a large cantaloupe.
- Put a small amount of lotion or oil on the skewer.
- Slowly, but forcefully, twist and push the skewer through the balloon at a thick section near the knot. The balloon should not pop. [This takes some practice.]

Note: Skilled demonstrators may wish to poke the skewer through the thick section near the top.

- Tell the students that the balloon did not pop because balloons are made of long molecules called polymers. When the stick is put into the balloon slowly and near the thick part, the polymer molecules bend and deform, letting the stick in. If the stick is pushed in quickly, the polymer molecules break, and the balloon bursts [demonstrate this by popping the balloon with the skewer].

Additional Information If Needed: Balloons Technical Background

- Other examples of the usefulness of air pressure include special balloons that can be used to lift heavy objects, and keeping automotive tires inflated to support a car and its cargo.
- In Part I, we demonstrated Gay-Lussac's Law: at a constant pressure, the volume of a confined gas is proportional to its abolute temperature.
- Toy balloons are made of polymers (usually a form of rubber latex).

Experiment 4: The Cartesian Diver

Background and Set-Up Information For Demonstrators

Experiment Purpose & General Methodology

- The Cartesian Diver illustrates the principles of air pressure.

Materials For This Experiment - Students

- 6 2-liter soft drink bottles
- 6 "divers" (pipettes with hex nut)

Materials For This Experiment - Demonstrators

- 1 2-liter soft drink bottle
- 1 "diver" (pipette with hex nut)
- Tap water

The Cartesian Diver Pre-Work Set-Up

Do the following:

- Prepare the "Cartesian Diver" bottles by filling the bottle with water as full as possible. Place each "diver" (pipette/nut unit) into a cup of water to determine where the diver floats. Fill or release water so that the diver floats near the top of the water. Place the diver in the soft drink bottle. ***Note: This step can be done at home.***
- Place one "Cartesian Diver" bottle on each of the students' tables and one on the demonstrator's table.

The Cartesian Diver

Introduce the Experiment

Tell the students the following:

- Sarah decides to go back to the toy box to find another toy. She pulls out a bottle that is filled with water and has a small diver floating in it . [Demonstrator should pick up Cartesian Diver bottle.] She observes how the diver falls as she presses the bottle and rises after she lets go. Sarah wonders how this toy works.

Perform the Cartesian Diver Simultaneously With the Students-

Do the following:

- Ask the students to pick up the bottles on their tables. Inform them that in our experiment, the diver has been replaced by an eyedropper. The toy is called a "Cartesian Diver" after Rene Decartes, a famous French philosopher and mathematician, who first described the phenomenon.
- Ask the students where the eyedropper is. [Answer: It should be near the top of the bottle at this point.]
- Ask the students to squeeze the bottle. What happens? [Answer: The eyedropper sinks.]
- Ask the students what happens when they let go of the bottle. [Answer: The eyedropper rises.]
- Ask the students if this is what they expect to happen? [Answers may vary.]
- Have each student at the table have a chance to squeeze the bottle.

Cartesian Diver Conclusions

Do the following:

- Tell the students that this experiment works because there is a bubble of air inside the eyedropper. When the closed bottle of water is squeezed, the air bubble becomes smaller (the pressure on the bottle compresses the air bubble--air is more compressable than water) and the eyedropper sinks. When the bottle is released, the bubble is large again, and the eyedropper rises.

Additional Information If Needed: Cartesian Diver Technical Background

- A more technical explanation involves buoyancy. A submerged body like the diver is subject to a buoyancy force that is equal to the weight of the fluid displaced by the body, according to Archimedes' principle. This is why a big ship floats; its total weight equals the weight of the water it displaces.
- When the Cartesian Diver bottle is squeezed, the air bubble in the eyedropper becomes smaller, and the eyedropper displaces less water. The buoyancy is less, so the eyedropper sinks. When the bottle is released, the air bubble in the eyedropper returns to its original size and the eyedropper displaces more water, becoming more buoyant.
- The concept of buoyancy makes a submarine sink or rise by using tanks that can be filled with water or air.
- The concept of buoyancy can also be used to explain why eggs (and humans) float in salty water but not in fresh water. The density of the salt water is higher, so the weight of displaced water will be higher, and the buoyancy force will be higher also.

Experiment 5: Slimy Stuff

Background and Set-Up Information For Demonstrators

Experiment Purpose & General Methodology

- Some materials are easily classified as solids or liquids. Others, like the polymers in this demonstration, are harder to classify.
- The students will make two types of "slime". The demonstrator will provide an additional type of slime. The students will compare the three types of slimy stuff.

Materials For This Experiment - Students

- 6 zipper-close plastic bags labeled "slime" (one per table)
- 6 craft sticks (one per table)
- 6 small clear plastic cups with mark at 1/4 cup (one per table)
- 6 clear plastic cups, 9 oz. (one per table)
- 6 zipper-close plastic bags labeled "corn" containing _ cup cornstarch (one per table)
- 6 plastic cups (one per table)
- Tap water

Materials For This Experiment - Demonstrators

- 1 zipper-close plastic bag labeled "slime"
- 2 disposable pipettes
- 50 ml vial of 4% borax solution with green food coloring
- 2 50-ml vials of gel glue solution
- 1 craft stick
- 1 small clear plastic cup with mark at 1/4 cup
- 1 clear plastic cup, 9-oz.
- 1 zipper-close plastic bag labeled "corn" containing _ cup cornstarch
- 1 plastic cup
- 1 bottle marked "glob-borax" containing borax solution
- 1 large bottle containing white glue and water (may appear pink in color)
- Scissors
- Tap water

Slimy Stuff Pre-Work Set-Up

Do the following:

- Transfer 4 pipette aliquots (2 ml each) of gel glue solution into 7 plastic bags labeled "slime". Seal bag securely. Place one bag on each of the students' tables and one on the demonstrator's table.
- Place the vial of borax solution and a transfer pipette on the demonstrator's table.
- Empty 7 bags marked "corn" into the seven 9-oz plastic cups. Place one cup on each of the students' tables and one on the demonstrator's table.
- Fill the 7 small clear plastic cups up to the 1/4 cup mark with water. Place one cup on each of the students' tables and one on the demonstrator's table.
- Place a craft stick on each of the students' tables and one on the demonstrator's table.
- Prepare "glob" by pouring the bottle marked "glob-borax" into the bottle containing the white glue and water. Cap the bottle and shake vigorously for 5-10 min until the sides come clean.

Note: If the "glob-borax" solution has precipitated, shake it before using.

Note: This step can be done the night before at home.

- Pour a small amount of glob into each cup. Scissors can be used to cut the material. Leave the demonstrator's portion in the large bottle to show how easily cut the material is during the demonstration.

<u>Slimy Stuff Demonstration</u>

Introduce the Experiment

Tell the students the following:

- Matt goes back to the toy box and pulls out some slime. He enjoys playing with the green squishy material, not to mention annoying his sister by placing it on some of her favorite toys. Sarah reminds him that there are several types of slimy stuff that can be made at home. She wonders if they are classified as solids or liquids. Let's make some slimy stuff and find out.

Perform the Slimy Stuff Simultaneously With the Students

Part I - Preparation of Slime

Do the following:

- Ask the students to open up the snack size plastic bag with the gel glue. The demonstrator will add one pipette of borax solution to each bag.
- Ask the students to close the plastic bag securely. Squish the bag with fingers to mix.

Part II – Preparation of Oobleck

Do the following:

- Pour the water from the small clear plastic cup into the cup with the cornstarch. Mix with a craft stick for about one minute.
- Ask the students to poke the mixture with a craft stick quickly, then slowly. Ask them to try to pull the stick out quickly.

Part III – Glob

Do the following:

- Demonstrate pouring the glob into a cup and cutting it. Ask the students to feel the glob in the cups on their tables.

Note: If glob gets on the students' clothes or hands, rubbing it quickly will make it "solidify" and easy to remove.

Slimy Stuff Conclusions

Tell the students the following:

- Ask the students to look at each of the slimes. Are they solid, liquid, or gas? Why? [These materials are not easy to classify. These slimes are polymers called non-Newtonian fluids. They has properties of both liquids and solids. They become more solid as you put more pressure on it.]
- Note that "glob" flows like a liquid, but it has to be cut (or pulled quickly) to be separated, similar to a solid.
- Other substances that have properties of both liquids and solids include Jello® and shaving cream.

Additional Information If Needed: Slimy Stuff Technical Background

- "Slime" is made from gel glue (polyvinyl alcohol) and borax. Borax in water yields the borate ion. When glue and borax are mixed, they form a cross-linked polymer, with the borate ion acting as a "bridge." "Slime" is similar to the commercial product with the same name.
- "Oobleck" is made from cornstarch and water. It has complex properties due to the water flowing between the cornstarch molecules. When pressure is applied, liquid water is driven out of the spaces between the molecules and temporarily solidifies the substance. Quicksand has properties similar to oobleck.

- "Glob" is made from Elmer's® glue (polyvinyl acetate) and borax. Like "slime," the borate ion is cross linked with the polymer. This type of material is sold commercially as Gak®.
- The most famous commercially-available slimy material is Silly Putty®. Silly Putty® is a silicone polymer, originally made in 1941 in an unsuccessful attempt to manufacture a silicone-based synthetic rubber.
- Slime and glob can be disposed of in the garbage. Oobleck can be washed down the sink

Experiment 6: Color-Change Paints

Background and Set-Up Information For Demonstrators

Experiment Purpose & General Methodology

- The students will learn the principles behind color-change paints.
- The students will learn that color changes are used for a number of different toys and materials, including the heat-sensitive paper used for their name tags.

Materials For This Experiment - Students

- 18 plastic cups (three per table—one each marked "yellow," "red," and "changer")
- Turmeric solution ("Yellow")
- Changer solution
- Phenol red solution
- 30 cotton swabs (3 per student)
- 30 pieces of white paper, 5.5" x 4.25" (1 per student)

Materials For This Experiment - Demonstrators

- 3 plastic cups, one each marked "yellow," "red," and "changer"
- 1 vial of turmeric solution ("Yellow")
- 1 vial of changer solution
- 1 vial of phenol red solution
- 3 cotton swabs
- 1 piece of white paper, 5.5" x 4.25"

Color-Change Paints Demonstration Pre-Work Set-Up

Do the following:

- Distribute the turmeric solution evenly among the 7 plastic cups labeled "yellow". Place one cup on each of the students' tables and one on the demonstrator's table.
- Distribute the changer solution evenly among the 7 plastic cups labeled "changer". Place one cup on each of the students' tables and one on the demonstrator's table.
- Distribute the phenol red solution evenly among the 7 plastic cups labeled "red". Place one cup on each of the students' tables and one on the demonstrator's table.

- Place 15 cotton swabs on each of the students' tables. Place three cotton swabs on the demonstrator's table.
- Place 5 sheets of paper on each of the students' tables. Place one sheet of paper on the demonstrator's table.

Color-Change Paints Demonstration

Introduce the Experiment

Tell the students the following:

- Sarah grew tired of playing with slime after Matt put some in her chair when she was not watching and she sat in it. She was ready to play with a more fun toy than Matt was playing with, so she went back to the toy box. She retrieved several color-change markers and began writing on a piece of paper. Then she used another marker to write over the color, and watched with wonder as the color changed.
- Have you ever used markers like Crayola® Changeables™ color markers and wondered how they work? Would you like to play with color-change paints?

Perform the Color-Change Paints Demonstration Simultaneously With the Students

Part I – Color Change Paints

Do the following:

- Ask the students to dip one cotton swab into the "yellow" solution to paint a small picture. Do the same with the "red" solution. Use a different cotton swab for each solution.
- Wait until each student has yellow and red paint on their pieces of paper.
- Show the students how to change the color by dipping another cotton swab into the "changer" solution and painting over the other colors.

Part I Conclusions - Color Change Paints

Tell the students the following:

- These color-change paints are based on the concept of acids and bases. Whether a substance is an acid or base is based on the structure of the compound. Acids taste tart, like lemons or vinegar. Bases feel slippery and taste bitter, like soap or detergent.
- Some compounds are called indicators. Indicators change color when the solution they are in changes from an acid to a base. Chemists use indicators to tell if a solution is an acid or a base.

- The yellow paint is made from turmeric in alcohol solution. Turmeric is a spice that cooks use to add flavor to food and to give mustard a deep yellow color. Turmeric contains a pigment that is an acid/base indicator.
- When the changer solution, which is a base, is added to the yellow turmeric solution, the indicator in the turmeric changes color to maroon.
- The red paint is made from phenol red in water. Phenol red is also an acid/base indicator.
- When the changer solution, which is a base, is added to the phenol red solution, the phenol red changes color to hot pink.

Part II – Heat-Sensitive Paper

Do the following:

- Ask the students to put their hands on the name tag and observe what happens.

Part II Conclusions - Heat-Sensitive Paper

Do the following:

- Tell the students that their name tags are made with heat-sensitive paper.
- The name tag color changes due to a chemical reaction that requires heat. The heat from a hand is enough for the reaction to occur. In the case of the color-change paints, we needed to mix two chemicals for the color reaction to occur.

Additional Information If Needed: Color-Change Paints Technical Background

- Commercial color-change markers are based on pH and redox reactions. We demonstrated the use of pH indicators in this experiment.
- Commercial color-change markers are sold in sets. The colored markers contain the dye, water, glycol (used as a hemectant, or a substance that retains mosture), a nonsudsing detergent (used as a wetting agent, a substance that inreases the rate at which a liquid spreads across a surface), and citric acid (used to maintain the low pH). The color-change wand contains a solution made from water, glycol, a nonsudsing detergerent, a reducing agent such as sodium sulfite or sodium metabisulfite, and a base such as sodium hydroxide.
- In our demonstration, the changer solution is washing soda.
- The heat-sensitive paper works at temperatures above 75°F.
- The heat-sensitive paper contains color-changing microcapsules. The microcapsules are composed of melamine formaldehyde (the same material as Formica®). The microcapsules

are filled with a lipid (fat) such as methyl stearate and a dye that is barely visible when the lipid is liquid, but is bright when the methyl stearate solidifies. The paper actually contains two dyes, one a permanent ink and other other a color-changing pigment. For example, if a red permanent ink is mixed with a blue color-changing pigment, it will appear purple when cool. When heated, the blue color melts away, turning the purple to red.

Experiment 7: Toys That Glow

Background and Set-Up Information For Demonstrators

Experiment Purpose & General Methodology

- Many fun toys, especially those sold for Halloween, are "glow-in-the-dark." We will use these toys to demonstrate two forms of luminescence--fluorescence and phosphorescence.
- The demonstrator will use a black light to demonstrate a fluorescent hand stamp, the fluorescent paint in the chalk that the students made, and ultraviolet (UV)-sensitive and phosphorescent beads.

Materials For This Experiment - Students

- 30 bracelets made with UV-sensitive and phosphorescent beads on a phosphorescent string (one per student)
- Hands stamped at beginning of demonstration
- Chalk from experiment #1.

Materials For This Experiment - Demonstrators

- One GE Blacklite Stik® (UV long wave)
- Extension cord
- One bracelet made with UV-sensitive and phosphorescent beads on a phosphorescent string
- Chalk from experiment #1
- Optional--Glow-in-the-dark toys supplied by the demonstrator

Toys That Glow Pre-Work Set-Up

Do the following:

- ➢ Plug the GE Blacklite Stik® into the extension cord. If it is safe to do so, plug it into the wall during preparation. If not, note where the wall outlet is for future reference.
- ➢ Place all bracelets on the demonstrator's table.

Toys That Glow

Introduce the Experiment

Tell the students the following:

- Matt got very interested in color changes after the last experiment. He wanted to know more about toys that change color. He went back to the toy box and pulled out a glow-in-the-dark action figure.
- Matt noted that this figure glowed the same green color as the stars on the ceiling in Sarah's bedroom.
- Ask the students to name some glow-in-the-dark toys. [They should not need prompting for answers.]
- Ask the students if they were interested in finding out about why they glow.

Perform the Toys That Glow Demonstration Simultaneously With the Students

Part I – Hand Stamps

Do the following:

- Pick an assistant to control the lights. For demonstrators who are working alone, this could be the librarian, a parent, or one of the students.
- When the lights are off, turn on the GE Blacklite Stik®. Ask for a student volunteer, and illuminate his or her hand.

Optional: At this point, the demonstrator may wish to illuminate the hands of all the students. A very long extension cord is helpful.

- Tell the students what they are seeing is a phenomenon called fluorescence. When some atoms or molecules absorb energy, they will emit photons or light, which we see as "glow." The black light provides the energy required for the molecules in the stamp ink to glow.
- Fluorescence is a short-lived phenomenon. Show the students how quickly the glow fades when the black light is turned off.

Part II – Concluding the Preparation of Chalk Experiment

Do the following:

- Turn on the Blacklite Stik® and illuminate the chalk, which will glow.
- In this case, the color is visible under normal room light. Although it is a brighter color than normal paint, there is not enough energy present to make it really glow. Under the higher energy of the black light, the paint fluoresces.

- Again, note that the phenomenon is short-lived by moving the chalk away from the black light.
- Tell the students that the bright "neon" colors used for toys, clothing, paper, etc., are made from fluorescent inks. These "neon" dyes will glow brigher under black light.
- Fluorescent compounds are also added to some white clothes, white paper, and laundry detergents to make them appear whiter. This can be demonstrated by illuminating a child wearing white clothes.
- Note that the chalk does not glow in the dark.

Part III – UV-Sensitive and Phosphorescent Beads

Do the following:

- Hand each student a bracelet. When the room lights are on, turn on the Blacklite Stik® and illluminate the bracelet. Focus the students attention on the phosphorescent beads which will glow green. Turn off the Blacklite Stik® and the room light. The beads will remain glowing.
- Tell the students that the glow-in-the-dark phenomenon is called phosphorescence. Phosphorescence is like fluorescence in that the energized species emit photons or light. Unlike fluorescence, phosphorescence lasts longer, even after the energy source (the black light) is turned off.
- Phosphorescent materials are added to the "glow-in-the-dark" toys. Regular light (as well as black light) energizes the material, which continue to glow even after the room lights are turned off.
- Turn off the room lights and turn on the Blacklite Stik® . Note how the phosphorescent beads glow brighter when energized.
- Turn off the Blacklite Stik® and turn on the room lights. Note that some beads are changing colors. This happens because the beads contain UV-sensitive dyes.
- Tell the students that a black light is not needed to change the colors on their bracelet. Bright sunlight (which contains UV light) will also made the colors appear. Remind them that the phosphorescent beads will glow in the dark after being exposed to ordinary room light.

Additional Information If Needed: Toys That Glow Demonstration Technical Background

- Teeth and recently bruised areas of the skin that show no surface damage also exhibit fluorescence.
- Invisible inks are sometimes used in money and postage stamps to detect counterfeiters.

- About 85% of fluorescent lamps are glass tubes that are filled with mercury vapor. The inner walls are coated with a luminescent substance called a "phosphor" consisting of calcium halophosphate doped with manganese and antimony ions. The antimony ions emit blue light and the manganese ions emit yellow light, with the combined emission appearing white. Altering the amounts of manganese and halogen ions (like fluoride) gives a range of colors from cool to warm white. Fluorescent lights require less energy than incandescent lamps which create heat to produce light. The other 15% of fluorescent lamps use triphosphors containing rare-earth ions.
- Fluorescence and phosphorescence are forms of luminescence. Luminescence involves the emission of light by means other than combustion, and thus occur at lower temperatures than combustion. Luminescence involves absorbing energy at certain wavelengths, and then emitting this energy as light. This is accomplished by electrons getting excited and jumping from inner orbitals of the atoms to outer orbitals. When the electrons fall back to their original state, a photon of light is emitted. If the light lasts for a short time, it is called fluorescence; if it lasts for a long time, it is called phosphorescence. The wavelength of light emitted has less energy (longer wavelength) than the one absorbed.
- The UV-sensitive beads are <u>not</u> a luminescent phenomenon.
- Luminescent objects contain phosphors in which UV light is absorbed and the energy is transfered to activators that luminesce. Glow-in-the-dark toys contain phosphors like zinc sulfide with rare earth elements as activators. Red or blue glowing toys may contain an alkaline earth sulfide.
- Timex uses zinc sulfide doped with copper ions for its glow-in-the-dark watch faces.

Experiment 8: Alka-Seltzer® Rockets

Background and Set-Up Information For Demonstrators

Experiment Purpose & General Methodology

- The students will use a reaction between Alka-Seltzer® and water to propel a film canister.
- Each table will set off one rocket; there is no demonstrator rocket.

Materials For This Experiment - Students

- 6 empty transparent film canisters with lid that fits inside (one per table)
- 2 Alka-Seltzer® tablets (1/3 tablet per table)

Materials For This Experiment - Demonstrators

- One empty pan with sides, such as a pie pan, an 8 x 8" or a 9 x 13" baking pan
- Water

Alka-Seltzer® Rockets Experiment Pre-Work Set-Up

Do the following:

- Fill each film canister about 1/4 full with water. Cap and place one on each of the students' tables.
- Place 1/3 of an Alka-Seltzer® tablet on each of the students' tables.
- Place the empty pan with sides on the demonstrator's table.

Alka-Seltzer® Rockets Experiment

Introduce the Experiment

Tell the students the following:

- The afternoon was almost over, and the rain stopped. Matt was excited about the rain stopping, so he went back to the toy box and got one of his favorite toys to play with that his mother would not let him play with inside the house. Matt reached into the toy box to get a rocket that he could launch outside.
- In this experiment, we will make a rocket that we can launch.

Perform the Alka-Seltzer® Rocket Experiment One Rocket at a Time

Do the following:

- Place the empty pan with sides on the **floor** as far away from the students' tables as possible. This pan will become the launch pad.
- Ask one student from each table to come to the launch pad with the film canister and the 1/3 tablet.
- Ask one student at a time to add the tablet to the film canister and snap on the lid as quickly as possible.
- Ask the student to place the film canister on the launch pad, lid down. **Ask everyone to stand back**. Count down while waiting for the launch.

> **CAUTION: THE ROCKETS ARE DANGEROUS. A MISFIRED ROCKET COULD HIT A PERSON IN THE EYE.**
>
> *Note: Keep all spectators at least 10 feet away from the launch pad. Do not point the canister at yourself or anyone else.*

- Repeat the launch with the other tables, one rocket at a time.
- *Optional. If running out of time, the demonstrator may wish to launch only one rocket as a demonstration.*

Alka-Seltzer® Rockets Conclusions

Tell the students the following:

- The ingredients in an Alka-Seltzer® tablet react with water to form a gas called carbon dioxide (CO_2). Carbon dioxide is the gas people exhale and plants use. It is also the gas that forms the fizz in pop.
- Remember, in the definition of gases, gases expand to take up all available space.
- The carbon dioxide exerts pressure on the closed film canister. The weakest part of the canister is where the lid and canister body meet. When the pressure builds, the lid pops off. The body of the canister is propelled upward.

Additional Information If Needed: Alka-Seltzer® Rockets Technical Background

- Alka-Seltzer® tablets contain sodium bicarbonate (baking soda), citric acid, and acetylsalicylic acid (aspirin). When mixed with water, the base (sodium bicarbonate) reacts with the acids, forming sodium citrate, sodium acetylsalicylate, and carbon dioxide.

- The sodium citrate is the buffering agent that acts as the antacid.

Closing Session

Close Demonstration

- Tell the students that chemistry makes their toys fun.
- Tell the students that they can make their own toys at home using the handouts provided.
- Remind the students that they can take home their chalk, their bracelet, their name tag, and the picture they made in the color-change paints experiment.
- Hand out the 1-page sheet containing instructions to make toys at home and a book list. Also hand out *ChemMatters*.
- Thank the students for coming and help us explore the Chemical Toy Box.

Appendix

Opening Session

Heat-sensitive paper - available from science education supply companies such as Educational Innovations (www.teachersource.com) or Steve Spangler Science (www.stevespanglerscience.com).

Stamp-pad - made from the lid to a disposable plastic container with a square of heavy felt attached. Alternately, a disposable plastic dessert plate could be used.

Colorless fluorescent ink - "invisible" ink that is visible under UV light; similar to inks used at amusement parks and other venues to stamp hands for re-entry.

Experiment 1: Preparation of Chalk

Fluorescent Temerpa paint - dry Tempera paint can be substituted for the liquid paint; when used dry, it can be added directly to the plaster.

Experiment 2: Density Wands

Density Wands - containing the following in a plastic vial, taped shut:

7 mL mineral oil
7 mL clear corn syrup with food coloring
glitter and/or stars

Experiment 3: Balloons

No additional details needed.

Experiment 4: The Cartesian Diver

"Diver" - prepared from a disposable plastic pipette, cut approximately _ - _" below the bulb with a tight-fitting hex nut attached.

Experiment 5: Slimy Stuff

Corn starch - approximately _ cup of corn starch is needed per table.

Gel glue solution - pre-mixed, 1 part gel glue and 2 parts water

Borax solution - typically a saturated solution, can be prepared by adding 1 tablespoon borax to _ cup warm water. Borax is available in grocery stores, with the laundry supplies.

White glue and water solution - approximately _ cup Elmer's glue and 1/3 cup water. Other brands of glue may also work, but might give different results.

Experiment 6: Color-change Paints

Turmeric solution - prepared by mixing _ to _ teaspoon turmeric (spice) with _ cup water.

Changer solution - 1 teaspoon washing soda in _ cup water. Washing soda is available in grocery stores, with the laundry supplies.

Phenol red solution - undiluted, available from laboratory or swimming pool supply companies.

Experiment 7: Toys That Glow

UV-sensitive and phospohorescent beads are available from science education supply companies such as Educational Innovations (www.teachersource.com). Beads may also be available at some craft/hobby stores.

Experiment 8: Alka-Seltzer® Rockets

Film canisters - "Fuji" brand film canisters work best.

Alka-Seltzer tablets - generic-brands may also be used.