The Joy of Toys:
A Hands-on Program

An Educational Demonstration Package

Prepared by the

Cleveland Section

of the

American Chemical Society

National Chemistry Week 2005

Overview

Take a peek in a child's toy box and you'll find chemistry at work... and play! From design and manufacture, to the materials they're made of, toys need chemistry! Join us for an hour of hands-on experiments to celebrate National Chemistry Week! While conducting hands-on experiments, students will learn about the properties of solids and liquids, such as density and solubility, how to make “mock” sidewalk chalk, how a Cartesian diver works, how color-change paints work, and how to make a rocket using Alka-Seltzer®

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Acknowledgments

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 2005, the Cleveland Section volunteers will perform over sixty demonstrations at libraries, schools, and other public sites. Continuing our relationship that started in 2001, the Cleveland Section will also be providing training and materials for Cleveland-area teachers, at the Cleveland Regional Council of Science Teachers' Fall Conference, so that they can conduct additional programs in their own classrooms.

This library/school program and other NCW events are the result of the hard work of many dedicated and talented volunteers. It all starts with our local section NCW Planning Committee. The Committee develops a theme for the program; recommends, tests, and reviews activities & experiments; writes a script; collects supplies and materials; prepares the kits; recruits sponsors and volunteers; contacts libraries and schools; and schedules shows. This Committee, as well as the rest of the Section's NCW activities, was overseen by the Cleveland Section's NCW coordinators for 2005 Lois Kuhns, Kat Wollyung and (behind the scenes) Paula Fox. Committee members include Mark Waner, Dan Tyson, Don Boos, John Pendery, Marcia Schiele, Shermila Singham, Rich Pachuta, Bob Fowler, Jesse Bernstein, Helen Mayer, Deanne Nowak and Betty Dabrowski. Additional credit and thanks is given to all of the many GAK (Grand Assembly of Kits) Day volunteers, including the John Carroll University ACS Student Affiliates, who gave up a Saturday in September to help count, measure, and assemble all of the necessary materials for our demonstration kits.

Our NCW efforts reach many children year because of various sponsors who have donated money, materials, and/or services to the Cleveland Section specifically for National Chemistry Week. We are especially grateful to the Martha Holden Jennings Foundation for a significant financial grant this year of $3000. We also thank NASA Glenn Research Center, John Carroll University, the Cuyahoga County Public Libraries, The Coca-Cola Company (Dayton, OH), Encon Inc. (Dayton, OH), Bericap, Inc., Cargill (Dayton, OH and Memphis, TN), Avery Dennison (Concord, OH), Kuhns and Associates, Thompson Raceway Park (Cleveland, OH) and other anonymous sponsors for their numerous contributions and support.

Last and most important, we thank 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.

How Experiment Write-ups are Organized

The materials and set-up of the demonstrations are located in the introduction section of this packet. Then, each experiment write-up is presented as follows:

- Background Information for Demonstrators
- Demonstration Instructions
- Experiment Conclusions
- Additional Information If Needed – You obviously do not need to cover all of this material with your students. Pick out what you are comfortable explaining.

Presentation Overview

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

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

   Note: Many 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 student's hands-on work are nearly simultaneous. You lead them as they perform the experiment.

4. Some experiments will be done by all students. For others, there will be one experiment that will be shared by all students at the table. In a few cases, only the demonstrator will perform the experiment. You are encouraged to get student helpers for the demonstrator-only experiments.

NO 'ACS TOY COMPANY' EXISTS AND NO CATALOG WILL BE PRINTED.

This script tells a story about the "Amazing Cleveland Section (ACS) Toy Company" giving these presentations in order to rank toys for their toy catalog. The tallying of student votes for their favorite toys and the possible temporary posting of these results on our website is simply for the joy and entertainment of the students participating in our demonstration programs.

MAKE SURE TO FOLLOW ALL DIRECTIONS IN EXPERIMENTS

Some experiments may have special safety concerns due to the materials being used. Any safety concerns are listed in the section for that experiment. Any MSDS's necessary would typically be found in the Appendix; however, there are none necessary for this year's program.

For information about the American Chemical Society's NCW safety guidelines, visit
www.acs.org/portal/Chemistry?PID=acsdisplay.html&DOC=ncw%5Csafetyguidelines.html

Demonstration Check-Off List

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

Activities To Do Before the Day of the Demonstration	**Completed ?**
Read through this packet to familiarize yourself with the experiments	❑
Contact Kat Wollyung at katkat@neo.rr.com or Lois Kuhns @ ch_kuhns@hotmail.com with any questions.	❑
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 and for extra paper towels for each table. Otherwise take newspaper and do this during setup. ❈ Ask about availability of demonstration materials from list of page 7 (ex. paper towels, newspaper) ❈ Make sure that the room is available before and after the program for set up and clean up. Set-up may take up to an hour.	❑
Collect the materials you need to bring with you to the demonstration. The materials list is on page 7.	❑

Activity To Do AT LEAST ONE DAY BEFORE the Demonstration	**Completed ?**
There are no specific experimental preparations to do before coming to this year's program. **However**, you may want to fill the Cartesian Diver bottles in advance to save time during the demonstration set-up. This kit provides 7 bottles (one bottle per student table and one for the demonstrator), but if you wish to provide a bottle for each student, you will need a total of 31 bottles. If desired, you can prepare all of the diver bottles in advance. Instructions are included on page 11. If you plan to give away 30 completed Diver Bottles, you will **definitely** want to prepare them in advance.	❑

Continued next page

Activities To Do When You Get To The Library	**Completed ?**
Arrive approximately 1 hour before demo time to allow for set up.	❑
Introduce yourself to the children's librarian.	❑
Ask the librarian how many students are pre-registered (designed for 30).	❑
Confirm that the tables and chairs are set up properly.	❑
Confirm that all tables are covered in newspaper and have paper towels.	❑
Obtain those supplies from list on page 7 if provided by library.	❑
Complete Demonstration Set-Up for all demonstrations: see "Activities to Do On-Site Prior to Demonstration" on pages 10-12. *Note: This set-up is estimated to take 30-45 minutes.*	❑
Set out the literature: *Celebrating Chemistry* newspapers and related handouts for this year.	❑
You may wish to set up an 'Exit' area to allow space for end-of-program activities: goggle return, literature distribution, and Toy-nament voting	❑

Activities To Do During The Demonstration	**Timing**
Welcome the students and parents as they enter the room.	-
Hand out goggles and help adjust to the correct fit (if necessary).	-
Assess number of students per table and adjust to 3 - 5 per table. Record the number of students and adults.	-

Continued next page

Activities To Do During The Demonstration (Continued)	Timing
Complete the Opening Session Introduction	4 min.
Perform demonstrations ❋ Experiment 1: Fortune-Telling Fish	<5 min.
❋ Experiment 2: Preparation of Chalk	10 min.
❋ Experiment 3: The Magic Paint-By-Numbers Coloring Book	10 min.
❋ Experiment 4: Cartesian Diver	<4 min.
❋ Experiment 5: Bubble Bottle	<5 min.
❋ Experiment 6: Density Wand	<4 min.
❋ Experiment 7: Magic Sand	5 min.
❋ Experiment 8: Alka-Seltzer® Rockets	10 min.
Hand out the voting papers as you complete the Closing Session information.	2 min.
Collect goggles & hand out literature while students vote for their favorite toy.	1 min.
Note: Times are approximate. During your program, you may choose to omit an experiment so that your program does not run over time. Plan ahead to determine which toy you might skip over or abbreviate; we suggest you do the Magic Sand and/or the Rockets as a demonstration rather than hands-on.	*Total Time: ~ 60 min.*

Activities To Do Immediately After The Demonstration	Completed?
Clean up as indicated in the **Clean Up** section (page 36).	❑
Tally the votes for each toy in the "Toy-nament".	❑
Complete the Demo Feedback Form (record number of adult & student participants)	❑
Give any leftover literature to the librarian *(library kits only)*.	❑
Place extra Fortune Fish, density wands and dry Cartesian divers along with rinsed & dry rockets (left uncapped) into the return mailing envelopes provided, and give them and the box of goggles to the librarian so that they can be returned to the branch at Fairview Park Regional by interlibrary mail. *(library kits only)*	❑

Activities To Do Once You Get Home	Completed?
Leave a message for Kat Wollyung at katkat@neo.rr.com with the following information: (1) attendance, (2) vote tallies, (3) other comments	❑

Supplies Required for Demonstration

Items for Demonstrator to Provide (or to request in advance from the librarian)

1 large garbage bag for solid waste collection

2 gallons of water, approximately (Note: It may be difficult to transport water from library restrooms or fountains with low spigots, so don't plan to use this method to obtain water unless you have investigated the water availability at your site. You may want to fill the Cartesian Diver bottles (Expt. 4) to within one inch of the very top before you arrive.)

1 roll paper towels (if none at site)

newspaper for covering 7 long tables with a few layers of paper (if none at site)

scissors (for cutting tips off pipettes) (Expt. 5)

<u>Notice</u>: If you will be performing multiple demonstrations on the same day, you will need to sanitize the goggles between demonstrations. You will also need:

small quantity of household bleach

wash bin or bucket

rags, old towels, or cotton paper towels for drying (soft so as not to scratch the goggles)

Items Provided in Each Demonstration Kit:

Note: Items needed for each demonstration that are to be provided by the demonstrator are listed in italics below the kit items for convenience/reference

General:

1 box containing kit contents

30 copies *Celebrating Chemistry* newspapers (if available from ACS)

30 copies each of 'Book List' and other take home materials

2 envelopes for returning supplies (addressed to Fairview Park Library) *(library kits only)*

1 box of goggles (30 child & 2 adult size, addressed to be returned to Fairview Park Library) *(library kits only)*

Experiment 1: Fortune-Telling Fish

31 Fortune-Telling Fish with "Chemistry Fortune" labels
7 paper towels
7 small Styrofoam or plastic plates

room temperature tap water (enough to dampen 7 paper towels)

Experiment 2: Preparation of Chalk

31 white plastic cups (3-oz.)
31 craft sticks
31 zipper-top sandwich bags containing plaster of Paris with Tempera paint powder
(one film canister-full of plaster with _ teaspoon Tempera paint powder)
7 plastic teaspoons
7 clear plastic cocktail-style cups marked "water"
(NOTE: The demonstrator's cup will also be used during the preparation for Expt. 4 - Cartesian Diver as well as during the presentation of Expts. 5 - Bubble Bottle. All 7 cups will be used again in Expt. 7- Magic Sand).
1 piece of sidewalk chalk
tap water

Experiment 3: The Magic Paint-By-Numbers Coloring Book

31 paint-by-number sheets pre-treated with Yamada universal indicator solution
7 individual packets of lemon juice (or _ cup)
1 bag of sodium carbonate (1/4 teaspoon, to be mixed in approx. 100ml (or _ cup) water)
1 clear plastic cup marked "Na_2CO_3" with line indicating approximately _ cup
7 portion or other small cups marked "1" for holding lemon juice solution
7 portion or other small cups marked "2" for holding water
7 portion or other small cups marked "3" for holding sodium carbonate solution
39 cotton swabs
7 strips of pHydrion paper
7 lists of pH and corresponding color of the indicator strips
tap water (approximately 3/4 cup)

Experiment 4: Cartesian Diver

7 empty plastic bottles with caps (16-oz to 2-liter, water or cleaned soft-drink)
(Note: You may wish to have additional bottles; a total of 31 bottles would be needed should you choose to give each student their own bottle along with the diver supplied in this kit.)
31 pipets with hex nuts (divers)
demonstrator's "water" cup *(from Expt. 2- Chalk)* for filling divers only
tap water to fill the bottles

Experiment 5: Bubble Bottle

1 20-oz. plastic bottle filled _-full with vegetable oil
1 sealed pipet containing food coloring

1 Alka-Seltzer tablet*
(*Note: The Alka-Seltzer pouch contains two tablets; break one tablet into approximately 6 pieces for this demonstration, and save the second tablet for the Alka-Seltzer Rockets, Experiment #8)
(Continued next page)
demonstrator's "water" cup *(from Expt. 2 - Chalk)* for filling bottle
tap water
scissors

Experiment 6: Density Wand

31 density wands
For your information--The wands contain the following in a soft drink bottle preform tube:
12.5 mL vegetable oil
12.5 mL clear corn syrup mixed 3:1 v/v with water
food coloring and glitter and/or stars

Experiment 7: Magic Sand

1 zipper-top bag of magic sand (double-bagged)
7 clear plastic 9-10 oz cups marked "sand"
1 coffee filter for cleanup
7 "water" cups *(from Expt. 2 - Chalk)*
7 plastic spoons *(from Expt. 2 - Chalk)*
tap water

Experiment 8: Alka-Seltzer® Rockets

7 empty clear film canisters (with caps that fit inside – easier to pop open as a rocket) with "weebles" to serve as a decorative "rocket pilot"
3 Alka-Seltzer® tablets
(~1/3 tablet per table; one tablet was packaged with Expt. 5 - Bubble Bottle)
1 blue tray or an empty pan with sides, such as a 9 x 13" baking pan (launch pad)
~1/2 cup tap water

Closing Session - "Toy-nament" Voting

30 voting papers
8 cups labeled with the names of the toy experiments

Items to be Returned through Inter-Library Mail (library kits only)

rockets, RINSED/CLEANED, leave open if not thoroughly dried
extra Cartesian divers (divers only, no bottles)
extra Density Wands
extra Fortune Fish

Activities to Do On-site Prior to Demonstration

General:

- Refer to pages 4 and 5 for items to verify room setup (6 student tables with 5 chairs each, one demonstrator table, all covered with newspaper, each with paper towels, etc. & obtain any supplies requested from librarian)

Experiment 1: Fortune-Telling Fish

- Place five Fortune-Telling Fish on each of the students' tables and one on the demonstrator's table.
- Wet the paper towels with tap water and wring out so the towels are damp, but not dripping. Fold each paper towel into fourths and place on a small plate.
- Place 1 plate on each of the students' tables and one on the demonstrator's table.

Experiment 2: Preparation of Chalk

- Place five white plastic cups and five craft sticks on each of the students' tables. Place one white plastic cup and one craft stick on the demonstrator's table.
- Place five zipper-top bags containing plaster of Paris with Tempera paint on each of the students' tables and one on the demonstrator's table.
- Fill 6 of the plastic cups marked "water" approximately 2/3-full with tap water. Place 1 cup on each of the students' tables.
- Then Fill the 7th plastic cup marked "water" nearly full with tap water. Place this cup on the demonstrator's table. (Note: If you have not already prepared the Cartesian Diver bottles (Expt 4), you should use this cup to fill the divers. During the demonstration program, you will be using approximately two spoonfuls of this water for this chalk experiment; the rest will be used for Expts. 5 – Bubble Bottle, and 7 - Magic Sand.)
- Place one plastic teaspoon on each of the students' and demonstrator's tables.
- Place one piece of chalk on the demonstrator's table.

Experiment 3: The Magic Paint-By-Number Coloring Book

- Place 5 paint-by-number coloring sheets on each student table and one on the demonstrator's table.
- Open one lemon juice packet into each portion cup marked "1". To prevent spilling, the cups should be filled _ to _ -inch deep.

- Add about _ to _-inch of water into each of the 7 portion cups marked "2".
- Dump the contents of the bag containing the sodium carbonate into the cup marked "Na_2CO_3". Add water to the marked line (approximately _ cup) and mix thoroughly.
- Add about _ to _-inch of the sodium carbonate solution into each of the 7 cups marked "3".
- Place one of each portion cup (1, 2 and 3) onto each of the student and demonstrator tables.
- Place 6 cotton swabs on each student table (2 per cup) and three on the demonstrator's table.
- Place the 7 pieces of pHydrion paper and list of pH and corresponding colors on the demonstrator's table. Do not distribute them amongst the tables yet as they may get wet.

Experiment 4: Cartesian Diver

- Prepare the "Cartesian Diver" bottles by filling the bottles with water to about 1 inch from the very top. **You will save vast amounts of time if you do this before you come to the site. Prepare at least 7 complete bottles and divers for the program.** You may choose to completely prepare one set-up for each student, or simply distribute the rest of the dropper/hex nut divers to the students to take home.
- Squeeze each diver and lower into the water cup (from Expt. 2) to partially fill the diver. Place each "diver" (pipet/nut unit) into the water to determine where the diver floats. Remove water if it sinks or add a few more drops if it floats too high. It should **just** float with the top at the surface of the water. **You may also do this before you come to the site if you wish.**
- Place the diver in the soft drink bottle and cap the bottle.
- Repeat the above two steps for the other divers and bottles. Make at least 7 Cartesian Divers for the program; you may make more to distribute to the students as you wish.
- Replenish the water in the demonstrator's water cup for Expt. 2.
- Place all the "Cartesian Diver" bottles on the demonstrator's table.

Experiment 5: Bubble Bottle

- Place the plastic bottle containing vegetable oil, the sealed pipet containing food coloring, and the scissors on the demonstrator's table.
- Pre-break one of the Alka-Seltzer tablets into approximately 6 pieces. The pieces will be used in this experiment and should be left on the demonstrator's table. The remaining tablet will be used in Expt.8 – Rockets.
- Note: The demonstrator's water cup from Expt. 2 – Chalk – will be used here as well.

Experiment 6: Density Wands

- Place 5 density wands on each of the students' tables and one on the demonstrator's table. *Optional: The demonstrator may wish to hand out the density wands during the program.*

Experiment 7: Magic Sand

- Distribute the sand evenly between the seven cups marked "sand" but do not place on the student tables until you do the experiment.
- Note: Students will reuse "water" cup and spoons from Expt. 2 - Chalk for this experiment.
- Place the coffee filter on the demonstrator's table.

Experiment 8: Alka-Seltzer® Rockets

- Fill each film canister about _-full with water. Cap and place one on each of the students' tables and one on the demonstrator's table.
- Break the three Alka-Seltzer® tablets into thirds. It is recommended that you keep them on the demonstrator's table.
- Place the tray on the demonstrator's table. (The tray is not IN the kit box; these were distributed along with the kit box.)

Closing Session - "Toy-nament" Voting

- Place the 30 pieces of voting papers on the demonstrator's table.
- Place the 8 voting cups (labeled with the names of the toys) on a table with the literature to be handed out to the students at the end of the program.
- You may wish to set up an 'Exit' area to allow space for end-of-program activities: goggle return, literature distribution, and Toy-nament voting

Opening Discussion

Introductions

Do the following:

- Introduce yourself as a chemist (or state your interests in chemistry), and 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 it has improved our everyday life.)*

What is Chemistry and Chemicals?

Do the following:

- Explain that chemistry is the study of everything around them.
- Ask volunteers to name some chemicals. Then ask more volunteers to name something that isn't a chemical.

> ***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.
- 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.

Introduce the Items on the Tables

Do the following:

- 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.

- *Note: Some of the items in the demonstration are actual food items. Remind students throughout the demonstration not to eat or drink anything!*

Introduce the Items on the Tables and Distribute Goggles (if needed)

Do the following:

- Tell the students that various items have been gathered for them on their table.
- Tell them not to touch anything until instructed to do so.
- Most of the items can be found around the house. *Remind them never to taste or smell anything, as if they were in a laboratory!*
- Tell the students that even though most of our items are relatively harmless today, we will still be good chemists and take the safety precaution of protecting our eyes.
- Put on a pair of the adult-sized goggles. If you have an assistant, ask them to do the same.
- Distribute the goggles (if you haven't already done so) and help the students put them on. Adjust the straps as necessary. (Note: These goggles are sanitized each year and prior to each demonstration.)

Introduce Today's Presentation: "The Joy of Toys"

Tell the students the following:

This year's theme for National Chemistry Week is "The Joy of Toys".

- When we hear the word "chemical" in the news, it is often in a story about a 'bad' or 'dangerous' chemical spill, or how a chemical has been found to be harmful to our health. But this isn't always the case! Chemistry can be good for us and FUN too!
- Have the students try to name a few FUN 'chemical toys'. [GAK, slime, silly putty, wall walkers, model clay, glow sticks, glow in the dark toys… to name a few.]
- Tell the students that we will be using the scientific method to guide us in our investigation of various items associated with chemistry-related toys. We will make observations, form a hypothesis (a guess as to how or why something works), use experiments to test our hypothesis, and then evaluate the results of the experiment to accept or reject the hypothesis.

- Millie and Amadeus are two friends who plan to open a new toy company—The A.C.S. Toy Company. The A.C.S. stands for the "Amazing Cleveland Section." They are trying to find the best toy to be the center of their catalog cover. They have narrowed their choices down to eight possible toys but have asked for your help to make their final decision.
- Incidentally, these are two important names. Millie's name refers to the prefix 'milli' m.i.l.l.i. (spell it out) as in milliliter and milligram which are important units of measurement in chemistry. Amadeus refers to a famous scientist Amadeus Avogadro who helped us learn

another important chemical unit, the mole, which is a word used for the very large number 6.023×10^{23} similar to the way we use the word 'dozen' to represent the number 12.

- Millie and Amadeus ask that you vote on your favorite toy at the end of this program. We are sort of holding our own "Toy-nament"! So let's get started!

Experiment 1: Fortune-Telling Fish

Experiment Purpose & General Methodology

- The concept of water absorption will be introduced through the action of cellophane Fortune-Telling Fish.
- The experiment is done by each student and should take less than 5 minutes to complete.

Introduce the Experiment

Tell the students the following:

- The first product in our "Toy-nament" claims to give your ***chemistry*** fortune (in honor of National Chemistry Week, of course) when you simply place it in your hand.
- Is it magic? Let's experiment with it and find out!

Perform Experiment Simultaneously with the Students

Do the following:

- Have each student take his/her Fortune-Telling Fish out of its plastic sleeve and place it on the palm of his/her own hand.
- Observe what happens (the fish curls up and moves around). After observing the fish's motion, have the students place their fish on the table so they can uncurl.

  Have the students consider their fortunes:

Chemistry Fortune-Telling Fish (written by Marcia Schiele)

Place fish flat in your hand; its movements will indicate:

Moving Tail	You love "tales" of famous chemists and their experiments.
Moving Head	You love using your brains to plan experiments and figure things out.
Moving Head & Tail	You like the hands-on approach to learning about chemistry.
Curling Sides	You react happily when you hear the word "chemistry".
Turns Over	You flip for chemistry.
Motionless	You can sit for hours and watch crystals grow.
Curls up Entirely	You love everything about chemistry.

- Ask the students: "Do you think the fish can really tell your fortune?" (Hopefully, the resounding answer is "No", or at least "I don't think so.")
- Then let's try to figure out why the fish reacted the way that they did when we placed it in our hands.

- Ask the students: "What is it about our hands that could cause the fish to curl up?" (Answers will probably include heat and moisture (from sweaty palms?))
- Let's start with moisture. We can test this idea by placing the Fortune-Telling Fish on a damp paper towel.
- Have the students locate the plate with the damp paper towel and place their fish on it. Observe what happens. (The fish will curl up again.)
- Does it matter which side of the fish you put on your hand or the damp towel? The side with the faint design or the plain side? (Answer: No, it doesn't; the fish will curl either way.)
- Next, have the students place their fish on top of its plastic sleeve. Place the plastic sleeve (with the fish on top) onto the damp paper towel. Observe what happens. (The fish should not curl up or move.)
- Ask the students: "What do these experiments tell us?" (Answer: The fish curls up and moves due to moisture.)

Conclusions

Tell the students the following:

- The Fortune-Telling Fish is made from cellophane. The surface of cellophane is hygroscopic, which means it will readily absorb water
- The side of the fish that is touching your hand (or the damp paper towel) absorbs more water than the side towards the air and it begins to swell and expand (like a dry sponge swells when it gets wet). The expansion on one side causes the ends of the fish to curl up and move away from your hand.
- When the plastic sleeve was placed between the fish and the moisture-source (the damp paper towel), the plastic sleeve blocked the moisture from being absorbed so the fish did not curl up.
- You may take your Fortune-Telling Fish home with you. Keep it in the plastic sleeve so it doesn't get lost!
- **NOTE**: If the fish get overly wet they will start to degrade! These special fish need very little water to work and do not like to actually get wet!

Additional Information If Needed: Technical Background

- What about the effect of heat? To test the effect of heat without moisture, place the fish on top of its plastic sleeve and place the sleeve (with the fish on top) on the palm of your hand. Even though there is heat from your hand, the fish does not curl up.

- Reference: *Teaching Chemistry with Toys, Activities for Grades K-9;* by Jerry Sarquis, Mickey Sarquis, and John P. Williams; Terrific Science Press: Miami University Middletown, Middletown, Ohio, 1995; pp. 83-85.

Experiment 2: Preparation of Chalk

Experiment Purpose & General Methodology

- The concept of solids, liquids, and gases as well as chemical reactions, will be introduced with the preparation of chalk.
- This experiment will be done by each student and will take approximately 10 minutes to complete.

Introduce the Experiment

Tell the students the following:

- On to our next contestant! You've all seen and probably played with sidewalk chalk *[the demonstrator should hold up the piece of chalk at this point]*.
- The next product in our "Toy-nament" is chalk, but not just any old chalk. Our product is a chalk that you make yourself!
- Ask the students: "Do you know how chalk is made or where it comes from?"
- First, let's consider its properties! Chalk must be hard enough to stay together so we can hold it in our hands, but soft enough to make a mark on the sidewalk or chalkboard.
- 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).
- <u>Solid</u> - molecules are fairly close together so material can be moved whole, like a rock or a stick.
- <u>Liquid</u> - 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.
- <u>Gas</u> - 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 most materials can be divided into these three categories.
- Ask the students "Is chalk a solid, liquid, or gas?" (Hopefully, they 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 to us, 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 Experiment Simultaneously with the Students

Do the following:

- Transfer the plaster of Paris from the zipper-top sandwich bag to the white plastic cup. Let the students know that Tempera paint powder has been added to the plaster to give our chalk some color.
- Have the students take turns adding two plastic teaspoons-full of water from the cup marked "water" to their cups containing the plaster.
- Using the craft stick as the stirrer, have each student mix the contents of their cup until it is smooth.

  Note: The mixture should have the consistency of thick pudding. If the mixture is too dry, have the student add more water, one teaspoonful at a time, and mix thoroughly. If the mixture is too runny, there is no need to take any action (it may just take longer for the chalk to begin to harden).
- Tap the cup on the table to remove air bubbles.
- The demonstrator should collect the craft sticks and empty plaster bags in the waste bag.
- The demonstrator may also want to collect the water cups and spoons if there is a concern about accidental spillage.
- Place the mixture aside to begin to harden while doing the other demonstrations (allow a minimum of 30 minutes).
- *Note: Each student will be able to take their own piece of chalk home. Students should wait until the next day (or until the chalk has hardened) before removing it from the plastic cup.*
- *Note: Inform the students that this chalk is especially good for writing on sidewalks, but will NOT work on chalkboards.*

Conclusions

- "Real" chalk is made from a chemical called **calcium carbonate**. Calcium carbonate is found in rocks (marble and calcite), sea shells, and egg shells. Calcium carbonate is used in toothpaste as an abrasive and it is also the major ingredient in Tums antacid tablets.
- The chalk that we made is similar to regular chalk, but we used plaster of Paris. Plaster of Paris contains **calcium sulfate** (from calcinated gypsum).
- There is a **chemical reaction** between the calcium sulfate and the water that causes the hydrated calcium sulfate crystals to link together and harden. The water does not simply evaporate to form the chalk; through a chemical reaction, the **liquid** water becomes part of the **solid** chalk.

➢ The reaction between the calcium sulfate and the water is an exothermic reaction which gives off heat. If we check our cups later, we may be able to feel a little bit of warmth through the bottom of the cup.

❋ Tomorrow, your chalk will be fully cured and you can pop it out of the plastic cup and use it!

❋ *Note: Inform the students again that this chalk is especially good for writing on sidewalks, but will NOT work on chalkboards*.

Additional Information if Needed: Technical Information.

- 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, a very soft mineral composed of calcium sulfate dihydrate with the chemical formula $CaSO_4{\cdot}2H_2O$. 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 structure is made up of sheets of Ca^{2+} and SO_4^{2-} ions held together by hydrogen bonds in the water molecules. The grip between these sheets is easily broken, so plaster is fairly soft.

The reaction to make chalk is:

$CaSO_4 \bullet 1/2\ H_2O + 1.5\ H_2O$ -------> $CaSO_4 \bullet 2\ H_2O$

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 3: Magic Paint-By-Number Coloring Book

Experiment Purpose & General Methodology

- The concepts of acids, bases and neutral substances and their effect on indicators will be introduced in this coloring activity.
- Each student will get their own page to color but will share the chemical solution 'paints'.
- This experiment should take about 10 minutes to complete.

Introduce the Experiment

Tell the students the following:

➢ Almost everyone enjoys art class in school and also enjoys coloring or painting at home. Some of us are good artists and paint freehand, while and others of us enjoy simple paint-by-number drawings. Our activity does not require any great artistic ability, but the results will be magical.

➢ There are ordinary coloring books that require you to use crayons or markers to create a colored picture. There are also very special coloring books that by applying water to the picture the colors appear.

➢ Our coloring activity is a little bit of both. See if this contestant in the "Toy-nament" is your favorite. Remember you will be voting for your favorite toy at the end of today's program.

➢ Ask the students if they can name any acids. Any bases?

➢ Tell the students that acids have many free hydrogen ions. The letter H represents hydrogen, which is the source of a measurement term called pH which is used to rank how acidic or how basic something is. Point out that many foods are acidic like orange juice and vinegar.

➢ Tell them that most bases have many hydroxide ions; they are ions composed of one oxygen and one hydrogen atom ion or -OH. Point out that cleaners, antacids, and baking soda are basic.

➢ Most neutral things have the same number of hydrogen ions and hydroxide ions. Ask the students if they know the name of the compound that is made up of two hydrogen atoms and one oxygen atom, HOH or H_2O (*water)*. It has an equal number of hydrogen ions (H+) and hydroxide ions (-OH) and has a neutral pH.

➢ Explain that many acid-base indicators are dyes that can come from plants. They exhibit different colors depending on the acidity or basisity (pH) of the solution to which they are added. Different indicators turn different colors because their molecules behave differently when put in acids or bases or neutral substances. Our indicator is actually a mixture of several different indicators and so it can change many different colors depending on the pH of the solution.

➢ Ask the students to look at (but not touch, taste, or smell) the 3 portion cups and ask them to guess which one is the acid? Which one is neutral? Which one is basic? *They shouldn't be able to answer, so explain that our coloring activity will help them to decide.*

Perform Experiment Simultaneously with the Students

Do the following, leading the students:

➢ Tell the students that our cotton swabs will be our paint brushes for today. It may be impossible to stay within the lines of our picture areas, but that's okay, we just want to see the different colors from the different paints in our experiment.

➢ Have the students put two cotton swabs into each portion cup and distribute the cups along the table. Tell them that each portion cup has one of our three 'paints' for today; two people can paint with the same color using the two cotton swabs. Remind them NOT mix the swabs between two different cups.

➢ Ask two children with the portion cup marked "1" to color some of the areas marked 1 on their paint-by-number picture. The child with the portion cup marked '2' can color some of the areas marked '2' on their paint-by-number picture. And children with the portion cup marked '3' can color some of the areas marked '3' on their paint-by-number picture.

➢ After about 30 seconds, have the students carefully pass the cups and their matching cotton swabs to other students. Tell the students not to worry if they have not finished coloring in all of the spaces; they can finish it later.

➢ After another 30 seconds, carefully pass the cups again so that everyone has had a chance to work with all three 'paints'.

➢ Ask the students what they observe. *(The three 'paints' give three different colors. '1' is red, '2' is green, and '3' is blue.)*

➢ Now, ask if they can determine which chemical is acidic, basic or neutral? *(No. We see color changes, but that doesn't tell us which solution is acidic, neutral or basic.)*

➢ Tell the students that we have one more test for them to complete as part of the conclusion.

➢ Ask the students if they have ever seen acid/base test strips (give them the hint that their parents might use them for the swimming pool or to test garden soil).

➢ Distribute the pHydrion paper. Have one student tear the paper into three even pieces and give two of them to his/her fellow students.

➢ Ask those three students each take one of the 3 different 'paint' solutions and its cotton swabs and test the pH of the liquid by lightly touching the cotton swab on the pHydrion paper. Ask the students the color observed when touching the number '1' solution on the pH paper? '2'? '3'?

- Pass out the color list for the pH paper to the students.
- Explain that we chemists and other scientists measure how acidic or basic something is using a pH scale with values from 1 to 14. Neutral compounds have a pH value of 7. More acidic items have pH values closer to 1 while more basic items have pH values closer to 14.
- Explain to the students that they can match the color of each pHydrion paper from the cups '1', '2' and '3' to the color list and determine the pH of the solution to identify the acidic, neutral, and basic substances.
- Ask them to identify by number which chemical they used as paints was an acid, which was a base and which was neutral. [Our three cups are: 1 is red /acidic/lemon juice, 2 is green/neutral/water, 3 is blue/basic/washing soda.

Conclusions

Tell the students the following:

- The paper they colored was treated with an indicator solution before they received it. Their paint-by-number paper and the pH paper both contain indicators or molecules that change color when exposed to acid, neutral or basic solutions.
- Our 'paints' are made from household chemicals. The students were able to see color changes when they applied these household chemicals to our indicator-treated paper. Our acid is lemon juice, our neutral is water, and our base is sodium carbonate (or washing soda, used in water treatment). Our "magical" coloring books aren't magical – they're SCIENCE!
- Let the students know they will be able to take their paper home with them.

Additional Information If Needed: Technical Background

- Sodium carbonate, soda ash, or washing soda is: Na_2CO_3
- Students can make their own indicators at home by cooking some red cabbage, red beets, radish skins, blueberries or any highly colored skin. These will change colors as well. Many "recipes" for natural indicators may be found on the web.
- For the grown-ups: pH stands for potential or power of Hydrogen. According to the Compact Oxford English Dictionary, the "p" stands for the German word for "power", *potenz*, so pH is an abbreviation for "power of hydrogen". pH = -log[H+] It is the logarithm of the reciprocal of hydrogen-ion concentration in gram atoms per liter and provides a measure on a scale from 0 to 14 of the acidity or alkalinity/basisity of a solution (where 7 is neutral, greater than 7 is acidic and less than 7 is basic). The pH scale was defined because the enormous range of hydrogen ion concentrations found in aqueous solutions make using H^+ molarity awkward. For example, in a typical acid-base titration, $[H^+]$ may vary from about 0.01 M to 0.0000000000001 M. It is easier to write "the pH varies from 2 to 13".

Experiment 4: Cartesian Diver

Experiment Purpose & General Methodology

- The Cartesian Diver illustrates the principles of air pressure.
- This experiment will be done at each table and should take <5 minutes to complete. Each student will later be given a diver (and instructions) to make their own Cartesian diver at home.

Introduce the Experiment

Tell the students the following:

- On to our next contestant in the "Toy-nament"!
- Hold up the demonstrator's Cartesian Diver and tell the students that this toy is called a Cartesian Diver. We'll see what makes them fun and discuss how they work.
- Ask the students what would happen if they were to drop a penny and a cork into water? [*the penny sinks and the cork floats*]
- Ask them why this happens. [*they may say one is heavier than the other*]
- Ask what would happen if you had a 1 pound piece of Styrofoam and put it into a bucket with a penny? The penny would still sink but the styrofoam would float so mass is not a very good way to decide if something floats or sinks.
- There is a property of matter called density. Who knows what "density" means? [*mass/volume*]. Density is a comparison of the weight (mass) and size (volume) of an object. Density is a measurement of the amount of mass (or matter or "stuff") is contained in a certain volume (or amount of space). In a general sense, something that seems heavy for its size is said to be more dense.
- The density of water is 1 gram per milliliter (or cubic centimeter). Objects with a density more than water sink and those with a density less than water would float.
- Then ask them which of the objects, a penny or cork have a density more than water? [*penny*] A density less than water? [*the cork*]
- Now let's look at a toy that is based upon density.

Perform the Experiment Simultaneously with the Students

Do the following, leading the students:

- Ask the students to pick up the bottles on their tables. Inform them that in our experiment, the diver is the top of a dropper with a small weight (brass nut) attached. The toy is called a

"Cartesian Diver" after Rene Descartes, a famous French philosopher and mathematician, who first described the phenomenon.

- Ask the students where the dropper 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.

Conclusions

Tell the students the following:

- First we need to remember some properties of liquids and gases. Ask the students their differences. Then tell the students that liquids flow but have a fixed volume and have molecules which are relatively close to each other. Gases have no shape or volume and can be compressed or expanded because their molecules are far apart from each other. Because the liquid molecules are already very close together, you cannot squeeze (compress) a liquid to make it smaller, but since the gas molecules are far apart, you can squeeze a gas to compress it. When we squeeze the diver bottle, the volume (amount of space taken up) of the water does not change, but the volume of the gas does get a little smaller. Thus the water from the bottle is pushed into the diver to take up the extra space.

- If we consider the diver assembly to consist of the dropper (pipet bulb), the hex nut and the air and water inside, then as we squeeze the bottle, we force more water up into the assembly dropper (because the air pocket inside the bulb is compressible). This adds to the mass of the assembly without changing the volume, thus increasing the assembly's density.

- When the diver's density increases, it soon becomes greater than the density of the surrounding water, and the diver sinks. When the pressure is released, the compressed air pocket inside the bulb pushes the extra water back out, and the diver assumes its original density and floats back up to the surface.

- Fish keep themselves from either sinking or floating to the surface by using muscles to squeeze or relax a small sac (with a small air bubble inside) in their bodies. By squeezing the sac smaller, the fish will sink. By relaxing their muscles, the sac increases in size, displaces more water, and a fish will begin to rise to the surface. Man uses this same principle to control the buoyancy of a submarine. By pumping water in and out of tanks stored in the submarine, a submarine can be made to rise and sink.

- You will each receive a Cartesian Diver of your own to take home. [If each child received a bottle you will have no further work. If only 7 of the divers were used in the program we HIGHLY RECOMMEND that you remove the diver from the filled bottles and give each child a diver. There will be no complaints then that someone got more than another student!]

Additional Information If Needed: Technical Background

- Whether an object floats or sinks in a fluid depends on whether that object's density is less than or greater than the density of the fluid.
- D = m/V. Thus, if you add to the mass of an object without changing its volume, the object's density increases. You can also increase the density of an object by keeping the mass constant while you decrease the object's volume.
- Boyle's Law: as the pressure on a gas sample is increased, it gets compressed into a proportionately smaller volume.
- Whereas gases are easily compressible, liquids and solids are not.
- 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.
- There are really two ways to view this phenomenon. One is discussed above. On the other hand, consider the assembly to consist of the bulb, the hex nut and the air inside, but not the water -- it is part of the surrounding fluid. When we squeeze on the bottle, it compresses the air pocket and thus decreases the total volume of the assembly. Since the mass remains constant, the assembly's density increases.

Experiment 5: Bubble Bottle

Experiment Purpose & General Methodology

- The students will learn about properties of liquids, such as density and solubility, as well as chemical reactions that produce a gas.
- This experiment will be done as a demonstration for the group. It can be repeated several times.

Introduce the Experiment

Tell the students the following:

- Have you ever seen a lava lamp - the kind with the thick goo moving almost magically through the water-like liquid in a glowing lamp? You've probably seen them in novelty stores or gift shops.
- The lava lamps you can buy in the store are based on the fact that oil and water don't mix.
- We can make a version of our own from oil and water!

Perform Experiment as a Demonstration for the Students

Do the following:

- Show the students the bottle and tell them that it contains vegetable oil.
- Take the cap off the bottle and pour water from the "water" cup to nearly fill the bottle, leaving some room at the top. Have the students observe what happens. (*The oil and water don't mix; the water is on the bottom, the oil is on top*.)
- Cut open the sealed pipet and add about 10 drops of food coloring to the bottle (or more, to make the water a very deep color). Have the students observe what happens. (*The food coloring sinks through the oil but does not change the color of the oil. It only makes the water colored*.)
- Take a small piece of the Alka-Seltzer tablet and drop it into the bottle. (Smaller pieces work better than larger ones. If necessary, add a second piece.) Hold up the bottle so all can see, and/or walk around the room so each table can get a chance to see the "lava lamp-like bubble bottle" close-up.
- If desired, repeat the demonstration with another small piece of the Alka-Seltzer tablet.
- When finished, put the bottle aside in a safe place where it won't get knocked over. WARNING: Do NOT put the cap back on the bottle until the entire Alka-Seltzer tablet has dissolved and there are no more bubbles forming (otherwise, carbon dioxide gas may build up in the bottle and it may jet out upon its next opening)!

Conclusions

Tell the students the following:

➢ When we added the water to the bottle containing the oil, the water sank to the bottom without mixing with the oil. Just like in Italian salad dressing, the oil and water don't mix. The water sinks to the bottom because it is denser than the oil. As mentioned in the previous experiment, density is a comparison of the weight (mass) and size (volume) of an object. In a general sense, something that seems heavy for its size is said to be denser.

➢ The food coloring mixed only with the water, not the oil, because it is more like the water. "Like dissolves like." Liquids that mix well with each other, such as the water and food coloring, are said to be "*soluble"* in one another since they form an even *solution*. Liquids that don't mix well are called 'insoluble' since they do not form an even solution, such as the water and oil.

➢ The Alka-Seltzer tablet reacted with the water to make tiny bubbles of carbon dioxide gas. These bubbles are much less dense than the water and oil so they rose through the oil, carrying along with them a few drops of the colored water. When the bubbles reached the top of the oil, the bubbles popped, releasing the gas into the air. Without the carbon dioxide bubbles to make it less dense, the colored water drops sank back down to the bottom of the bottle. (The carbon dioxide bubbles were like floatation devices for the water drops… without them, the drops sank back down to the bottom of the bottle.)

➢ As some of the colored water drops sink back down to the bottom of the bottle, new gas bubbles are forming, rising through the oil, and taking new drops of colored water with them. The reaction will continue until the Alka-Seltzer tablet has been fully used up.

Additional Information If Needed: Technical Background

Excerpts from *Lava Lites: A Chemical Juggling Act*, by Mike McClure, first appearing in the April 1997 edition of ChemMatters, also available at chemistry.org.
"In 1963, Craven Walker, an English engineer, invented a "display device", which consisted of a glass vessel containing water and mineral oil. When illuminated by a light bulb in the lamp base, the oil would nearly jump off the bottom, rising and falling in weird patterns that were fascinating and relaxing to watch, especially if the liquids were brightly colored. Whether Walker's invention was a carefully planned experiment or a serendipitous discovery is not known. What we do know is that two American entrepreneurs bought the marketing rights for the lamp at a German trade fair soon after its invention. By 1965 Haggerty Enterprises of Chicago, a company specializing in novelty products, had begun production, and Walker's device had a new name—the Lava Lite Lamp."

"The exact recipe used in commercial lamps is a carefully guarded secret. Haggerty Enterprises will only admit that 13 mysterious chemicals are carefully blended to produce those goopy lava shapes. Although we may not know Haggerty's secret formula, we do know that the basic components are oil and water along with a slew of specially selected chemicals to improve safety, appearance, and performance."

"When a lava lamp is turned on, an ordinary 40-watt bulb illuminates and warms the contents of the glass globe. The solid paraffin melts, changing into a thick molasses-like liquid. As the temperature increases, the blob of paraffin expands, like a soap bubble. When the paraffin's volume goes up, its density decreases; and when the density of the paraffin falls just below the density of water, an interesting phenomenon happens. Struggling to float in the surrounding water, an expanding pillar of brightly colored gunk squishes upward. Usually a glob of paraffin breaks loose, wobbles into a sphere and rises like a hot air balloon to the top of the globe. As it rises, the paraffin releases some of its heat to the surrounding water and cools. When this happens, the lava shrinks and its density increases. Soon the blob becomes denser than water and sinks slowly back to the bottom where the cycle begins again."

Experiment 6: Density Wand

Experiment Purpose & General Methodology

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

Introduce the Experiment

Tell the students the following:

- We are now up to the sixth contestant in our "Toy-nament".
- Remember, will not vote until after we have seen all eight toys.
- We will be combining ideas we have learned from the Cartesian Diver and Bubble Bottle in this next toy.

Perform Experiment Simultaneously with the Students

Do the following:

- Ask the students to pick up their 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 in one another*.]
- 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 vegetable oil and corn syrup. Corn syrup dissolves in water. Remember, when you drink soda 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 vegetable oil and corn syrup. Which one is on top? [*Answer: Oil is less dense, so it is on top*.]
- Inform students that they make take their wand home with them but do not open them or they will make a mess and their parents will be very unhappy and make them clean it up!

Additional Information If Needed: 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 vegetable oil.
- Oils are long chains made up of CH_3-$(CH_2)_x$-CH_3 or CH_3-$(CH_2)_x$-$(CH{=}CH)_y$-CH_3. The structure of oils is not similar to water, thus the two compounds don't mix well.
- Corn syrup contains a mixture of simple and complex sugars. The general chemical formula for sugars, which are carbohydrates, is $(CH_2O)_x$. The oxygen/hydrogen structure in carbohydrates hydrogen bonds to the oxygen/hydrogen structure in water – "like dissolves like".

Experiment 7: Magic Sand

Experiment Purpose & General Methodology

- The hydrophobic properties of "Magic Sand" will be investigated.
- The experiment is done at each table and should take less than 5 minutes to complete.

Introduce the Experiment

Tell the students the following:

- *Remember you will be voting for your favorite toy at the end of this "Toy-nament"!*
- The seventh product in our "Toy-nament" claims to give sand "magical" properties.
- When we play at the beach, we build sandcastles and make sculptures from sand. Sand sinks in water, and when mixed with a lot of water it acts more like a liquid than a solid. In this activity, you will observe how another type of sand, called "magic sand," behaves when mixed with water.
- Is it magic? Let's experiment with it and find out!

Perform Experiment Simultaneously with the Students

Do the following:

- Distribute the cups of magic sand to one student at each table. Ask them not to touch the substance yet.
- Ask them what they think the word **hydrophobic** means. Hint: Ask them to define "phobic" (fear of). They may know other phobias, like claustrophobic or arachnophobic (fear of spiders). Tell them "hydro" means water (as in fire hydrant or dehydrated).
- **Slowly** pour a **small** amount of the Magic Sand into the cup marked water *(from Expt. 2)*. Instruct the students to follow your example and place only a small amount of sand into the cup. Alternatively, you may want to use the spoon to gently sprinkle the sand into the cup.
- Ask them for their observations. The sand floats on top if only a little is put in.
- Now SLOWLY pour all of the Magic Sand into the cup and show how it makes shapes and will keep those shapes.
- Take the spoon *(from Expt. 2)* and remove some of the sand to show that it is still dry.
- Decant the water into the cup marked magic sand to show that the rest of the sand is still dry.
- Do the process a second time.

➢ Note: You can do the 'clean-up' filtering of the sand as part of the demo (if time permits) to show the students that the sand is indeed dry.

Conclusions

Tell the students the following:

➢ We all know that regular sand gets wet because you experience this when you go to the beach in the summer. Regular sand has atoms on its surfaces that are attracted to water. Magic sand is regular sand that has been treated with another chemical that hates water [hydrophobic]. That is why the sand can be in water and still feel dry.

➢ Ask the students what other hydrophobic materials they encounter in everyday life. [*Answers: raincoat, wax on car, oil, etc.*]

➢ Collect both cups immediately after the experiment.

Cleanup – Note: You can do the filtering step as part of the program, if desired, to show the students that the sand is indeed dry

After the program do the following:

- ➢ Place the coffee filter over a container (whatever is available) and decant as much water as possible from the magic sand. The filter will collect the fine, floating pieces of sand.
- ➢ Dispose of the water.
- ➢ You may return the sand to the baggie but please dry the sand completely on paper towels or newspaper overnight. Wipe the baggies completely dry as well.
- ➢ Place the dry sand into the dry baggie and then into the second baggie.
- ➢ We would ask you to share the dried sand with your friends and/or families or librarian.

Additional Information If Needed: Technical Background

- Regular sand is mostly silicon dioxide that is formed in grains. The surface of the grains contains polar OH groups that are easily attracted to the polar OH bond of water. Therefore, beach sand is hydrophilic or water-loving.
- Water wets or adheres to beach sand and flows freely between the grains. Sand is denser than water and sinks. Sand mixed with a lot of water acts more like a fluid than a solid. The sand/water mixture slides, slumps, and resists construction attempts.
- The special sand used in this experiment is commercially known as Magic Sand™, Astro Sand™, or Mystic Sand™. The instructions suggest putting water in a large glass bowl and sprinkling in a small amount of magic sand. Instead of sinking, like beach sand, the magic sand

will float and form a "sand raft". By sprinkling more and more magic sand onto the sand raft, the raft can be made to plunge to the bottom. The magic sand does not appear to be wet but to be surrounded by a silvery layer looking like plastic film. This silvery layer is the curved surface of a large air bubble that surrounds the magic sand.

- Magic sand is ordinary beach sand treated with the vapors of trimethylhydroxysilane, $(CH_3)_3SiOH$, the active ingredient in ScotchGuard™. When the grains of sand are exposed to the trimethylhydroxysilane, a chemical reaction takes place forming water and the bonding of the trimethysilane compound to the silica particles. Following this treatment, the exterior of the sand grains contain methyl groups that are insoluble in water or hydrophobic. The Magic Sand is very attracted to nonpolar molecules such as oil and will appear "wet" with the oil. Magic sand is made from regular sand (silicon dioxide) that has been dyed and coated with tiny particles of pure silica, and exposed to a special chemical treatment making it hydrophobic. Hydrophobic means, "scared of water", so a hydrophobic chemical is one that will not combine easily with water. Oil is a common example of a hydrophobic chemical. If you pour some oil in a cup of water, it will float on the surface. Magic sand behaves the same way, except it sinks! The coating on the outside of the magic sand pushes the water away. Take the magic sand out of water and it is perfectly dry!

Experiment 8: Alka-Seltzer® Rockets

Experiment Purpose & General Methodology

- The students will use a reaction between Alka-Seltzer® and water to propel a film canister.
- The demonstrator and one student from each table will set off one rocket. *Optional. If running out of time, the demonstrator may wish to launch only one rocket as a demonstration. Or, if room space and safety permits, have two students launch at a time, from opposite sides of the launch pad.*

Introduce the Experiment

Tell the students the following:

- We have finally come to the last entry into Millie's and Amadeus' quest for the best toy for the front page of The A.C.S. Toy Company's catalog.
- We will vote right after we do this experiment.
- Ask students to define a gas. [*no definite volume or shape*]
- Ask students to name a few gases they have heard about. [*carbon dioxide, carbon monoxide, methane, hydrogen, oxygen, nitrogen they may have learned in school or in the news*]
- Ask the students if they can think of a toy that uses a gas! [*they may say air rifles, potato guns*]
- Ask how these types of toys work. [*air is compressed and when released provides the force necessary to propel an object forward*]
- In this experiment, we will make a rocket that we can launch using a gas.

Perform Experiment Simultaneously with the Students – one rocket at a time

Do the following, leading the students:

- Place the tray or empty pan with sides on the **floor**, centrally located, but as far away from the students' tables as possible. This pan will become the launch pad. The rockets can fly a many feet high, so do not launch from a desk or tabletop. Also, do not launch directly below light fixtures in which the rockets may become caught.

CAUTION: THE ROCKETS ARE DANGEROUS. A MISFIRED ROCKET COULD HIT A PERSON IN THE EYE. ALL GOGGLES MUST BE WORN.

Note: Keep all spectators at least 10 feet away from the launch pad. Do not point the canister at yourself or anyone else. Wear goggles at all times.

- Have one student from each table come to the launch pad with the film canister (which is about _-full of water).
- Hand each student with the film canister, the 1/3 Alka-Seltzer tablet.
- Tell them that, one at a time, they will (1) add their piece of Alka-Seltzer tablet to their canister, (2) replace the lid into/onto the canister as quickly as possible, (3) turn the rocket over to place the rocket lid-down on the launch pad, and (4) step away from the launch pad. Have the students *repeat these instructions verbally* before starting. Alternately, launch your rocket first, and explain the steps as you proceed.
- **Ask everyone to stand back. Be sure all goggles are on**. Have one of the students approach, and launch the first rocket. Count down while waiting for the launch.
- Explain conclusions below. Repeat with the other rockets, one at a time. Have fun!
- *Optional. If running out of time, the demonstrator may wish to launch only one rocket as a demonstration. Or, if room space and safety permits, have two students launch at a time, from opposite sides of the launch pad.*

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 soda 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, and the body of the canister is propelled upward.

Additional Information If Needed: 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 - Voting for Favorite Toy in "Toy-nament"

➢ It is finally time for you to vote for your favorite toy and help Millie and Amadeus make their big decision.

➢ Pass out the voting papers to each student. Tell the students that they should place their voting paper into the cup marked with the name of the toy that was their favorite.

➢ Remind the students that they can take home their Fortune Fish, sidewalk chalk, Cartesian diver, density wand and paint-by-numbers paper.

➢ Remind the students to check our website for updates in the scoring for their favorite toy in the "Toy-nament" as other students at other locations will be voting as well throughout National Chemistry Week. Our website address is http://www.csuohio.edu/cleveland_acs/ncw.htm

➢ Thank the students and parents for coming to this year's demonstration and learning about the chemistry of toys.

➢ Have students come up to the voting area, one table at a time, to 1) vote, 2) turn in their goggles, and 3) pick up their take-home sheets & *Celebrating Chemistry* newspapers.

Clean up

After the students leave, clean up the room

➢ Return items borrowed from the library to a librarian. Give any leftover literature to the librarian.

➢ Collect the film canister "rockets" and rinse well with water. Shake off as much water as possible or, if time permits, dry them as well as possible with paper towel. Place them into one of the gallon-sized zipper bags (since they will still be wet), and seal the bag. Place this into the large yellow mailing envelope (labeled to Fairview Park library); do not seal the envelope yet.

➢ If you have leftover Cartesian divers (divers only; no bottles), please remove any water and shake dry or wipe. Place in the experiment's quart zipper bag and add these to a mailing envelope.

➢ If you have any leftover Density Wands please place them in a gallon-sized zipper bag and add them to a mailing envelope.

➢ If you have any leftover Fortune Fish, please add them to a mailing envelope.

➢ Complete the Feedback Form, place it into a mailing envelope, and seal both envelopes.

➢ Combine water and other liquid-waste in a gallon jug or bucket. This liquid waste can be put down the sink safely with running water.

➢ All solid waste can be collected in the large garbage bag and thrown into the regular trash.

- If you are performing another demonstration for this year's National Chemistry Week, sanitize the goggles between demonstrations with a dilute bleach solution as instructed in the written directions found on the inside cover of the goggle container. Be sure to dry them with soft cloth or soft paper towels to prevent scratching.
- If you are finished performing your demonstration(s) for this year, place the used goggles into their box. Please stack them without twisting or crushing. (There is no need to clean them when you are through; our committee will clean them for the next year and/or for other programs.)
- Give the mailing envelope of saved supplies as well as the box of goggles to the children's librarian with instructions to put it them in the interlibrary mail to Fairview Park Library.

At home:

E-mail Kat at Katkat@neo.rr.com with:

1. The number of students and adults at your program
2. The tally for each toy in the Toy-nament
3. Any comments you have to improve our programs in the future.

Appendix

A. Material Safety Data Sheets

None necessary.

Note: All materials can be purchased at local stores or through educational suppliers.

B. Kit Contents – Supplemental List of Solutions and Special Supplies

The following is detailed information that can be used to recreate this demo kit in the future:

Experiment 1 - Fortune Fish are available from Oriental Trading catalog, website address: www.orientaltrading.com or other novelty stores.

Experiment 2 - Plaster of Paris is available from hardware/home stores; Tempera paint powder can be purchased from art & craft or teacher supply stores.

Experiment 3 –Please note that any coloring-book style picture can be adapted and used for this experiment; add the number "1", "2" and "3" in various sections of the picture and photocopy onto plain paper. Note: If you choose to print the picture on your own computer printer, make sure that you are not using water-soluble ink. Indicator should be applied to the paper and then allowed to dry completely before use. Universal indicator can be purchased as a solution from chemical supply companies such as Flinn Scientific whose website is www.flinnsci.com. The recipe may be created by preparing the solution as follows: (Yamada Universal Indicator recipe

To prepare 1000 mL indicator, dissolve the following amounts in 500 mL ethanol:

- 0.025 g Thymol Blue
- 0.060 g Methyl Red
- 0.300 g Bromothymol Blue
- 0.500 g Phenolphthalein

Neutralize the solution (to green) with 0.05 M NaOH and dilute to 1000 mL with water.
The colors one gets are

pH 10: violet	pH 9: indigo	pH 8: blue	pH 7: green
pH 6: yellow	pH 5: orange	pH 4: red	

Experiment 4 - Diver is made from the top of a disposable pipet with a brass nut attached; nut can be glued in place with waterproof glue if fit is not tight enough.

Experiment 5 - No special instructions or materials needed.

Experiment 6 - Substances used to make density wands may vary. Note: Mineral oil does not work as well as the food coloring does not completely separate from it. Also, using vegetable oil 1:1 with corn syrup (without water) does not dissolve the food coloring as well. Bottles/vials used should seal well and/or be taped well to prevent leaking.

Experiment 7 - "Magic Sand" is also known as "Mystic Sand" or "Space Sand" and can be found at toy stores or on the Internet.

Experiment 8 - Transparent, white film canisters from "Fuji" work best since the cap pops off easily under pressure. Pom-pom pilots can be purchased from novelty stores such as Oriental Trading or can be made from felt or foam feet, pom-pom, and wiggle eyes purchased in craft stores.