



What's in the Bottle?

Use chemistry to identify a mystery liquid

Lesson Plan

Description: Visitors test five known chemical solutions and use those results to identify an unknown chemical.

Audience: Hands-on activity for families and children ages 8 and up

Length: 20 minutes

Learning Objectives

Visitors learn:

- Comparing properties of an unknown compound to properties of known compounds can help identify the unknown compound.
- There are a variety of common results of chemical reactions, including color change, precipitation of a solid, and bubbling caused by generation of a gas.

Visitors develop skills related to chemistry and science, including:

- Systematically investigating a problem
- Analyzing data
- Communicating and discussing experiment results

Learning Standards

National Science Education Standards

1. Science as Inquiry
 - K-4: Abilities necessary to do scientific inquiry
 - K-4: Understanding about scientific inquiry
 - 5-8: Abilities necessary to do scientific inquiry
 - 5-8: Understanding about scientific inquiry
 - 9-12: Abilities necessary to do scientific inquiry
 - 9-12: Understanding about scientific inquiry
2. Physical Science
 - K-4: Properties of objects and materials
 - 5-8: Properties and changes of properties in matter
 - 9-12: Chemical reactions

Background Information

The main goal of any experiment is to answer a question or solve a problem. The problem can be as simple as finding out what kind of metal is in a piece of jewelry or as complex as determining what chemicals control the various processes in a living organisms. The problem for this activity is to identify an unknown chemical.

In this case, the chemicals can be differentiated with some very simple tests. Visitors are given five known chemical solutions. The first task is to test the five known chemicals with a set of reagents and note the results. Visitors then are given an unknown sample, identical to one of the five known solutions. Visitors test the unknown compound and compare the results to those for the known compounds. Based on the pattern of results, they will be able identify the unknown compound.

This activity uses chemicals in solution. A *solution* is a homogeneous mixture of a solute (either a solid or a gas) dissolved in a solvent. In this activity, various solids are dissolved in water.

The chemical solutions are combined with reagents. A *reagent* is a substance used to react with another substance.

Some of the chemicals and reagents react with each other. A *reaction* is when a chemical change takes place. In this activity, visitors can observe reactions that create *bubbles*, *color changes*, and *precipitates*. A *precipitate* is a solid that settles out of a solution.

Chemicals and reagents

The five chemicals used in the activity are:

- **Sugar** solution (10% by weight)
- **Citric acid** solution (10% by weight)
- **Sodium sulfate** solution (10% by weight)
- **Hydrogen peroxide** solution (3% by weight)
- **Baking soda** solution (10% by weight)

The chemicals are identified using the following reagents:

- **Phenol red** is an acid base indicator that turns yellow below pH 7 (acid) and red above pH 8 (base).
- **Calcium chloride** is used to detect sulfate ions in a solution. The calcium ions from the calcium chloride react with sulfate ions to form a cloudy, white precipitate of calcium sulfate.
- **Vinegar (acetic acid)** reacts with sodium bicarbonate to produce carbon dioxide bubbles.
- **Potassium iodide** can be used to detect hydrogen peroxide. A purple-brownish color indicates relatively high concentrations of peroxides and yellowish colors indicate low concentrations.

Materials

For each pair of visitors

- Set of five labeled dropper bottles filled with the known chemicals
 - Sugar solution (10% by weight)
 - Citric acid solution (10% by weight)
 - Sodium sulfate solution (10% by weight)
 - Hydrogen peroxide solution (3% by weight)
 - Baking soda solution (10% by weight)
- Set of four labeled dropper bottles filled with the test reagents
 - Phenol red pH indicator (CAUTION: this will stain your skin and clothes)
 - Calcium chloride solution (10% by weight)
 - White vinegar
 - Potassium iodide solution (10% by weight)
- Dropper bottle filled with one of the unknown chemicals (labeled 1, 2, 3, 4, or 5)
- Laminated activity grid
- Results worksheet (optional)
- Pencil
- Safety glasses for each visitor
- Paper towels (to wipe worksheet and clean spills)

For the presenter

- One set of the materials at the visitors' workstations
- Waste container

Sources

- Citric acid, sodium sulfate, phenol red indicator, calcium chloride, and potassium iodide are available through scientific suppliers, including Flinn Scientific (www.flinnsci.com).
- Safety glasses are available through Flinn and other scientific suppliers.
- Sugar, hydrogen peroxide, baking soda, and vinegar are available at grocery stores.

Notes to the Presenter

CAUTION: Always supervise visitors during this activity. Be sure visitors wear safety glasses and don't let them taste any chemicals (even drinks).

Set Up

Set up takes approximately 30 minutes.

(Set up will take longer the very first time you do the activity.)

Make the activity grids:

1. Print or photocopy the grid onto pale blue, green, or pink paper. The colored background makes the white precipitates show up. (Don't use white or yellow paper—the precipitates will be difficult to see.)
2. Laminate the sheets or enclose them in plastic sheet protectors. Phenol red will stain some laminates and sheet protectors; if this occurs, try another kind.



Prepare the chemicals and reagents:

- Prepare the sugar, citric acid, sodium sulfate, baking soda, calcium chloride, and potassium iodide solutions by dissolving 10 grams of solid in 100 ml water.
 - Sugar solution (10% by weight)
 - Citric acid solution (10% by weight)
 - Sodium sulfate solution (10% by weight)
 - Baking soda solution (10% by weight)
 - Calcium chloride solution (10% by weight)
 - Potassium iodide solution (10% by weight)
- Pour the chemicals and reagents into labeled dropper bottles.
 - Bottles of known chemicals should be labeled “Sugar”, “Citric acid”, “Sodium sulfate”, “Hydrogen peroxide” and “Baking soda”
 - Bottles of reagents should be labeled “Phenol Red”, “Calcium chloride”, “Vinegar” and “Potassium iodide”
- Bottles of unknown chemicals should be labeled “Unknown 1”, “Unknown 2”, “Unknown 3”, “Unknown 4” and “Unknown 5.” Each bottle should contain one of the known chemicals.

Tip: It's easier visitors if you color-code the labels for the known chemicals, reagents, and unknown chemicals. For example, you could make all the labels for the known chemicals red, the reagents blue, and the mystery chemicals yellow.

Program Delivery

Welcome visitors. Explain that they will be working in pairs or groups of three, and divide them among the workstations. Explain to parents that this is a family activity, and they should work with their children.

I need your help! Earlier today I was making up a batch of chemical solutions for this program, but I was interrupted. When I went back to my work, I realized I hadn't labeled any of my solutions, and now I don't know which one is which!

At first I was afraid I'd have to dump them all out, which would be a waste. Then I realized that I could get all of you to help me! So I made up another set of chemicals to compare to the unknown ones, and today we're going to figure out which is which!

Your job is to take five known chemicals, and do some tests on them. You will mix them with reagents (other chemicals) to find out how each reacts with each reagent. Then you'll get one of the unknown chemicals, and do the same thing. By comparing the results, you'll be able to identify your unknown chemical.

At the end, we'll all compare results, and I'll be able to label all my unknown chemicals!

Is everyone wearing safety glasses? *Make sure everyone is wearing safety glasses.*

Here's how we're going to do it. You all have laminated grids on your table. *Hold up a grid.*

You also have a set of known chemicals. *Hold up bottle/set with label showing.*
and a set of reagents. *Hold up bottle/set with label showing.*

Finally, you each have one unknown chemical that is the same as one of the five known chemicals.
Hold up bottle.

You have to figure out which one it is!

Using the grid

To figure out the unknown chemical, you're going to put drops of the chemicals and reagents on the laminated sheet. The sheet is a grid, with columns and rows. *Hold up sheet and indicate columns and rows.*

First, you're going to work down the columns. In each column, you're going to put one drop of one of the chemicals. *Demonstrate.*

You'll do this for all of the known chemicals. For now, leave the last column—the unknown chemical—empty. *Indicate last column.*

After you're done with columns, you'll work across the rows. In each row, you're going to put one drop of each of the reagents. In the first row, you'll put a drop of phenol red in each square. Put the drop right on top of the other drop, like this. *Demonstrate.*

You'll do this for all four of the reagents.

Remember to leave the last square of each row empty (where the mystery solution is going to go).

Checking for reactions

As you fill in the grid, you'll be looking for chemical reactions. Some of the reagents will react with some of the chemicals. (A reagent is something that causes a reaction.)

The reactions you should look for include:

- bubbles
- color change
- precipitate, which is a cloudy solid



Testing and comparing the unknown chemical

When you're all done with the known chemicals, you're ready for the fun part: testing the mystery solution! You'll put a drop of the mystery chemical in each square of the column, and then add a drop of the correct reagent to each square.

By comparing the results for the mystery chemical with the results you got for the known chemicals, you'll be able to identify the unknown chemical!

Optional: Use the results sheet: Which other column has the same the pattern? That's your chemical! Write it on your results sheet. Hold up results sheet.

When you're done, you can try another mystery chemical. Just use a paper towel to wipe clean the mystery chemical column, and start another one.

When everyone has done at least one mystery chemical, we'll compare results and see if we can identify all five.

Keep your safety glasses on while you work. If you spill, use the paper towels to clean it up.

Circulate, helping visitors who need assistance. After most visitors have completed the grid, get everyone's attention.

Let's compare results! Who had Mystery Bottle #1? What was in it? Continue through all the unknowns. If you like, you can write the results on a whiteboard. If you had visitors use the results sheet, they can check their answers.

Expected reaction results:

	1 Sugar	2 Citric acid	3 Sodium sulfate	4 Hydrogen peroxide	5 Baking soda	6 Unknown ???
A Phenol red	orange	yellow	red	yellow	red	
B Calcium chloride	colorless	colorless	white precipitate	colorless	colorless	
C Vinegar	colorless	colorless	colorless	colorless	bubbles	
D Potassium iodide	colorless	colorless	colorless	brown bubbles	colorless	

Clean Up

- Pack up and store durable equipment.
- Laminated sheets can be wiped off with a paper towel, to be used again. Paper towels can be discarded in the trash.

Credits

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What's in the Bottle?

Name _____

Bottle 1 _____

Bottle 2 _____

Bottle 3 _____

Bottle 4 _____

Bottle 5 _____

What's in the Bottle?

1

2

3

4

5

6

Sugar

Citric
acid

Sodium
sulfate

Hydrogen
peroxide

Baking
soda

???

A

Phenol red

B

Calcium
chloride

C

Vinegar

D

Potassium
iodide
