Throughout the guide, teaching tips are in red.

Activity Description & Estimated Class Time

During five 50-minute periods, students will investigate properties (physical appearance, solubility, conductivity, reactions with water, reaction with acid, pH, and reaction with iodine) of nine white powders. They will then use this data to solve a riddle based on unknown mixtures of the powders.

Objectives

Students will demonstrate knowledge and understanding of the following ideas and content:

- Different compounds have different measurable properties.
- Properties of compounds remain consistent, and can be used to identify them.

Students demonstrate this knowledge and understanding by collecting data on properties of some compounds, then using this information to solve a complicated riddle.

Correlations to North Carolina Science Standards

8.P.1.2 Explain how the physical properties of elements and their reactivity have been used to produce the current model of the periodic table of elements.

8.P.1.3 Compare physical changes such as size, shape and state to chemical changes that are the result of a chemical reaction to include changes in temperature, color, formation of a gas or precipitate.

Brief Science Background

Physical properties of matter are determined by the electrons of the atoms that make up that matter. These properties are a constant and consistent for each material, and can be measured. Combining materials in a chemical reaction produces a chemical compound. In a chemical compound, the components *do not* retain their individual properties. However, combining materials where no chemical reaction takes place produces a mixture. In a mixture, the components *do* retain their individual properties. Understanding this will help students solve the riddle of the mystery mixtures.

Part 1 — Properties of Powders (50-minutes)

Materials

Materials for groups of 4 students (2 pairs)

- 1 labeled cup, 3.5 oz, of baking powder
- 1 labeled cup, 3.5 oz, of sodium bicarbonate (baking soda)
- 1 labeled cup, 3.5 oz, of cornstarch
- 1 labeled cup, 3.5 oz, of Epsom salt
- 1 labeled cup, 3.5 oz, of flour
- 1 labeled cup, 3.5 oz, of powdered sugar

Materials Cont.

- 1 labeled cup, 3.5 oz, of salt
- 1 labeled cup, 3.5 oz, of sugar
- 1 labeled cup, 3.5 oz, of sodium carbonate (washing soda)
- 9 small scoop spoons, one for each cup of powder
- toothpicks for stirring
- 1 wash bottle
- acetic acid solution (vinegar) in a 1 oz cup
- 1 labeled dropper bottle of iodine solution
- droppers

Materials for pairs of students:

- 1 Chem Plate
- 1 conductivity tester
- 1 labeled dropper bottle with water
- pH paper test strips

Materials for each student

- 1 photocopy of the reaction chart BLM 1(supplied by teacher)
- science notebook (supplied by teacher)

Preparation

Make copies of BLM 1

1. Fill and label all of the 3.5 oz cups of powders. Make up sets of labeled cups for each table (group of 4). Each set includes 1 labeled cup of each of the following:
   - baking powder
   - sodium bicarbonate (baking soda)
   - cornstarch
   - epsom salt
   - flour
   - powdered sugar
   - salt
   - sugar
   - sodium carbonate (washing soda)

2. Fill and label dropper bottles with water, iodine solution, and vinegar.

Procedure

Students work in pairs to test the properties of the white powders.

The order of chemical tests depends on class time available. It is most efficient and informative to go test-by-test so that the teacher can discuss the setup and significance of each test. Going test-by-test also helps clarify interpretations of test results so that the class can agree. This way, students can compare results of the same tests for different compounds. For example, soluble compounds may dissolve in as little as 1 drop of water or as much as 20 drops of water. Similarly, students can compare the relative conductivity of various solutions by the relative brightness of the conductivity test bulb.

If you have 90 minutes of class time, it is expedient to run batteries of tests sequentially. For example, you could start with the water reaction test (using 1 drop of water), then use the same samples for the solubility test and simply keep track of how many more drops are added. You can then use the solubility test wells for the conductivity test (the wells need at least 10 drops of water). Finally, you can check pH in these same wells. Tests for the acid and iodine reactions change reagents, and therefore need to be done on separate samples.

1. Keep a dedicated scoop in each cup to be used with that cup only. Explain that cross contamination can confuse results, and it is critical to keep everything clean and separate. Preview each test before turning the students loose. Recap results after each test. Tests are as follows:

   - Visual inspection: Just looking at or smelling samples (but not touching or tasting them) can tell you a lot.
   - Reaction with water: Ask how each of the compounds might react with a drop of water. Place a small level scoop of each compound in separate wells of the Chem Plate. Use the water dropper bottle to add 1 drop of water to each sample, one at a time. Note any reaction. Only baking powder will bubble. (It contains both an acid and a carbonate base that react in the presence of water to produce gas).
   - Solubility in water: Ask students what they think "solubility" means. Is it "all or nothing?" How might someone find differences in solubility between compounds? Continue questioning until students come up with a way to compare amounts of water (e.g., counting drops) needed to dissolve equal amounts of different compounds. They'll need to limit amounts of compounds to a single level small scoop. They may refine this procedure. For example, rather than proceed by single drops, it's quicker to add 5 drops, stir, and then stir in another 5 drops up to a maximum of 25 drops. Through their investigations, students should discover the following:
     - Cornstarch and flour are not soluble.
     - Powdered sugar dissolves very quickly but produces a residue that does not dissolve because it contains cornstarch to prevent caking. (Do not tell the students this, but let them discover it themselves. If no one notices, you will have to tell them, because the cornstarch will influence a later test.)
     - Baking powder will look insoluble because it contains cornstarch, but some of its ingredients are soluble.
     - The other compounds are more or less soluble in 5 to 25 drops of water per level small scoop.

- Conductivity: Water solutions of some compounds (ionic compounds) can conduct electricity. Before doing these tests, discuss with students what it means to conduct electricity. Could you light a bulb connected to a battery through a conductor? What are some conductors? They will probably think of metal, but maybe not liquids, so give some examples (e.g. battery acid or saltwater). Could you light a bulb connected to a battery through a liquid conductor? Ask which compounds students predict will conduct in solution. Students can test the dry powders, which should not conduct, before testing the powders in water.

  Demonstrate the technique for testing conductivity. First, test the tester by touching the clean wires to see if the bulb lights. Show how to connect the battery properly. To avoid confusing results due to contamination, dip wire ends in clean water and dry with a paper towel between tests. Test the tester again between trials. For storage after you're done, disconnect batteries from bulbs and be sure wire ends are clean. **Wire ends may need to be cleaned with sandpaper. Some of the solutions corrode wire.** The flour, cornstarch, powdered sugar and sugar solutions will not conduct. The others will conduct and there may even be a noticeable difference in the brightness of the light with highly conductive solutions being brightest.

- pH: The same solution used for conductivity can be used to check pH. Students can use a toothpick to put a drop of solution on the test strip or they can dip an end of the strip into the Chem Plate well. Test paper can be conserved by using half a piece for each test. The color should be checked with the scale chart soon after dipping in the well. Most solutions are around neutral (6 to 7). Baking powder and sodium bicarbonate have a pH around 8 or 9 and sodium carbonate has a pH around 10 or 11.

- Reaction with iodine: You'll only have 1small dropper bottle of iodine and 1 small cup with acid per table of 4 students (2 teams of 2), so the pairs of students will have to switch off using the iodine and the acid. One pair can test with iodine while the other tests with acid, and then they can switch and compare results.

  Students might know that iodine turns dark blue, purple, or black in the presence of starch. It is a good example of a reaction that produces a color change. Ask students to predict which compounds they think will turn color with iodine.

  Student teams should put small level scoops of compounds into separate wells and put a drop of iodine solution on the samples. They need to record all results in their notebooks. Students should discover the following:

  - Baking powder, cornstarch, and flour give an unequivocal positive reaction, turning deep purple.
  - Powdered sugar gives a faint positive reaction because it has a little cornstarch in it to prevent caking, but regular granulated sugar does not.
  - Sodium bicarbonate, Epsom salt, table salt, and granulated sugar yield a negative starch test; they may turn pale yellow to orange.
  - Sodium carbonate turns the iodine solution clear.

  Confirm results with the whole class and ask what these results tell them about baking powder and powdered sugar. Someone may want to check the label on the box, and if so, let them.

- Reaction with acetic acid: Ask the students about the types of things that react with acids. Might any previous results give clues as to which compounds will react with acid? What kind of reaction might you expect?

  Student teams should put one small level scoop of each compound in separate wells, add 1 drop of acetic acid solution (vinegar) from the cup with a dropper to each well, and look for a reaction. Sodium bicarbonate, baking powder, and sodium carbonate all react with the acid to produce bubbles.

Wrap-Up

The class should agree on results after each test. After all tests are complete, display BLM 2 so all students can compare this chart with their results. These results are critical information for the next part of the activity.

Part 2 — Mystery Mixtures

Materials

Materials for groups of 4 students (2 pairs)

- 1 covered cup, 3.5 oz, of mystery powder 1
- 1 covered cup, 3.5 oz, of mystery powder 2
- 1 covered cup, 3.5 oz, of mystery powder 3
- 1 covered cup, 3.5 oz, of mystery powder 4
- 1 covered cup, 3.5 oz, of mystery powder 5
- 1 covered cup, 3.5 oz, of mystery powder 6
- 6 small scoop spoons, one for each cup of powder
- dropper bottle with water
- toothpicks for stirring
- 1 wash bottle
- acetic acid solution (vinegar) in a 1 oz cup
- 1 labeled dropper bottle of iodine solution
- droppers

Preparation

Mix and fill mystery mixtures in 3.5 oz cups. Each group of 4 students needs a cup of each mixture. Make mixtures of the following in a 1:1 ratio, a cup of each ingredient should yield enough mixture for all classes. Store these.

- flour + sodium bicarbonate (baking soda) – labeled mystery powder 5
- flour + baking powder – labeled mystery powder 2
- flour + sodium carbonate (washing soda) – labeled mystery powder 6
- cornstarch + sugar – labeled mystery powder 4
- cornstarch + salt – labeled mystery powder 3
- sugar + sodium bicarbonate (baking soda) – labeled mystery powder 1

Procedure

1. Tell students: You have just become the CEO of the Half-Baked Cookie Company. On your first day on the job, you walk through the plant munching on a macaroon, and see six large tanks of what might be cookie ingredients pushed aside and labeled with question marks. You ask a worker what the tanks are. The worker says the last CEO had the mixtures made to save time. The idea was to mix dry ingredients first to have them ready for the batter. Unfortunately, the ex-CEO wrote the mixtures on a dollar bill, and his 8th grade child bought a soda from the vending machine with that dollar. The vats are now "mystery mixtures" that have sat for a year. It's known what the mixtures are, but no one knows which is which. The worker hands you a list of the mixtures:
   - four + sodium bicarbonate
   - flour + sodium carbonate
   - flour + baking powder
   - cornstarch + sugar
   - cornstarch + salt
   - sugar + sodium bicarbonate
2. You scurry back to your office, remembering that in 8th grade you learned how to figure out what's in each tank. That's why you get the big bucks. What's your plan?
3. Project BLM 3 and let the students plan tests for a few minutes. After they've had time, ask what they've planned. Which tests might be useful to find out what is in the mixtures?
4. The degree to which you walk the students through the testing process depends on the class, but try to make the students do the work. One way would be to have all the students do a test of their choice, and then ask: a) why did they choose that test and b) what do they think the results showed? Given a few examples, they will be able to devise and conduct a test plan that will identify the mystery powders.

Wrap-Up

1. Project BLM 3 and discuss students' ideas of which mixture is which.
2. Reveal the identity of the mystery mixtures.
3. Ask students to explain the steps they took to solve the riddle and how each test helped them solve the riddle.

BLM 1

	Visual inspection	Reaction with water	Solubility with water	Conductivity	pH	Reaction with iodine	Reaction with acetic acid
Baking powder							
Baking soda							
Cornstarch							
Epsom salt							
Flour							
Powdered sugar							
Salt							
Sugar							
Washing soda							

	Reaction with water	Solubility with water	Conductivity	pH	Reaction with iodine	Reaction with acetic acid
Baking powder	bubbles	insoluble, though some soluble ingredients	positive	8-9	dark purple	bubbles
Baking soda	none	soluble 20-25 drops	positive	8-9	stays yellow or orange	bubbles
Cornstarch	none	insoluble	none	6-7	dark purple	none
Epsom salt	none	soluble 5-10 drops	positive	6-7	stays yellow or orange	none
Flour	none	insoluble	none	6-7	dark purple	none
Powdered sugar	none	soluble 5-10 drops with residue	none	6-7	turns slightly purple	none
Salt	none	soluble 5-10 drops	positive	6-7	stays yellow or orange	none
Sugar	none	soluble 5-10 drops	none	6-7	stays yellow or orange	none
Washing soda	none	soluble 15-20 drops	positive	10-11	turns iodine solution clear	bubbles

BLM 3

Flour + sodium bicarbonate (baking soda)

Flour + sodium carbonate (washing soda)

Flour + baking powder

Cornstarch + sugar

Cornstarch + salt

Sugar + sodium bicarbonate (baking soda)