Mystery Mixtures

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, 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.

Correlations to NC Science Standards

PS.8.1.4 Construct an explanation to classify changes in matter as physical changes (including changes in size, shape, and state) or chemical changes that are the result of a chemical reaction (including changes in energy, color, formation of a gas or precipitate).

Learning Targets

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.

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 Powder

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
- 1 labeled cup, 3.5 oz, of salt
- 1 labeled cup, 3.5 oz, of sugar

Materials Cont.

- 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 labeled dropper bottle with water
- pH paper test strips
- 1 student instruction sheet (SD 1)

Materials for each student

- 1 photocopy of the reaction chart SD 2(supplied by teacher)
- science notebook (supplied by teacher)

Preparation

Allow for 1 hr.

1. Make copies of SD 1 & SD 2
2. 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)
3. Fill and label dropper bottles with water, iodine solution, and vinegar

Procedure

1. Using SD 1, students work in pairs to test the properties of white powders.
2. 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. Discuss each test procedure with students before turning them loose. Tests are as follows:
   - **Visual inspection:** Examine the compound. Describe in detail how it looks.

Procedure Cont.

- **Reaction with water:** Use the water dropper bottle to add 1 drop of water to the compound. 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:** Use the water dropper bottle to add 5 additional drops of water to the compound. Use a toothpick to stir. Stir in another 5 drops up to a maximum of 25 drops. Describe in detail what does or does not happen. 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.
- **pH:** Use the same solution to check pH. Dip an end of the pH 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 1 small 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. Student teams should put a small level scoop of the compound into a separate well and then add a drop of iodine solution to the compound. Note any reaction. Students should discover the following:
    - Baking powder, cornstarch, and flour give a 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.
- **Reaction with acetic acid:** Student teams should put one small level scoop of the compound into a separate well, add 1 drop of acetic acid solution (vinegar) to each well, and look for a reaction. Sodium bicarbonate, baking powder, and sodium carbonate all react with the acid to produce bubbles.

Content Connection

After all tests are complete, display SD 3 so all students can compare this chart with their results. Discuss these results as a class and make any updates. 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
- 5 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
- student activity sheet (SD 5)

Preparation

Allow for approx. 1 hr.

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.

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

Procedure

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 five 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

Procedure cont.

which is which. The worker hands you a list of the mixtures:

- four + sodium bicarbonate
- flour + sodium carbonate
- flour + baking powder
- cornstarch + salt
- sugar + sodium bicarbonate

1. 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?
2. Project SD 4 and discuss which tests might be useful to find out what is in the mixtures?
3. Allow students to test the mixtures and record all information on SD 5.

Content Connection

1. Project SD 4 and have students explain in 3-4 sentences which two powders their mystery mixture was made of. They must reference the data they collected. Some students may need the sentence starter: I think Mystery Powder ___is made from ___. My main reasons for thinking this are ___ and ___. I know this because my data chart says ___.
2. Reveal the identity of the mystery mixtures.

Student Instructions

Do one compound at a time.
Use a clean scoop for each different compound. Do not cross contaminate.

1. **Visual Test** - Put a scoop of your first compound into well #1. Examine the compound. Describe in detail how it looks.

2. **Reaction with Water** - Add one drop of water to the compound. Describe in detail what does or does not happen.

3. **Solubility Test** - Add 5 additional drops of water to the compound. Use a toothpick to stir. Stir in another 5 drops up to a maximum of 25 drops. Describe in detail what does or does not happen.

4. **pH Test** - Use the same solution to check pH. Dip an end of the pH strip into the Chem Plate well. Compare the color of the paper to the scale on the container. Write down the pH. <7 is an acid, 7 is neutral, >7 is a base.

5. **Reaction with Iodine** - Put a scoop of your compound into well #2. Add one drop of iodine to the compound. Describe and record the results. Focus on color.

6. **Reaction with Acetic Acid (vinegar)** - Put a scoop of your compound into well #3. Add one drop of acetic acid to the compound. Describe and record the results.

Repeat steps 1-6 with a second compound using wells 5-7. Be sure to use a clean scoop and a new pH strip.

Repeat steps 1-6 with a third compound using wells 9-11. Be sure to use a clean scoop and a new pH strip.

After you complete all tests for the three compounds, use the wash bottle of water to rinse out your plate. Use a paper towel to dry it. Repeat the six tests with the next three substances. Continue until all substances have been tested.

SD 2

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

SD 4

Flour + sodium bicarbonate (baking soda)

Flour + sodium carbonate (washing soda)

Flour + baking powder

Cornstarch + salt

Sugar + sodium bicarbonate (baking soda)

SD 5

	Visual inspection	Reaction with water	Solubility with water	pH	Reaction with iodine	Reaction with acetic acid
Mystery Mixture 1						
Mystery Mixture 2						
Mystery Mixture 3						
Mystery Mixture 4						
Mystery Mixture 5						