

Kitchen Solids Survey: Build an Identification Key

Investigation question: Eight white solids from the kitchen look nearly the same. Which simple tests sort them apart, and can a key built from the whole class's data name a powder nobody has seen before?

Classroom field investigation

Groups of 4

2 sessions

Setup 5 · Activity 85 · Cleanup 10 min

MS-PS1-2 · practice

Scientific purpose

Students take a fixed test protocol home (or to a kitchen station) and run four tests on eight common white solids: a water test for solubility, a vinegar test for a reaction, an evaporation test to recover what dissolved, and a magnified look at the grains. Back in class the results are pooled, disagreements are settled with evidence, and the class builds an identification key, a flow chart of yes/no tests, which is then used to name a mystery powder the teacher supplies. The lab gives students a real reason to standardize a procedure and shows that solubility and reaction tests separate substances that sight cannot.

Why this helps students with this chapter

Students meet eight look-alike powders they already trust in their own kitchens, so the puzzle feels real and the materials are free. Collecting data in many kitchens produces honest disagreement (was the baking soda 'dissolved' or 'cloudy?'), which forces the class to talk about controlled conditions and about how much solid water can hold. Building a key is a different kind of thinking from matching to a table: students decide which test to ask first, and they discover that one test splits the set in two while another barely helps.

Standards connections

MS-PS1-2 (practice, solubility data as identifying evidence, plus a first before-and-after observation (the vinegar fizz) that signals a reaction): Students collect and interpret solubility data to identify substances, which is the data-analysis practice of the PE, and the vinegar test asks them to compare what is present before and after two substances interact, which is a small, qualitative version of the PE's before-and-after reasoning. Lesson 12 does the full version, so the role is practice.

Roles (rotate each session)

- **Protocol keeper:** In session 1 checks that every group member can state the exact amounts and times, and in session 2 flags any home result that did not follow the protocol.
- **Pooler:** Collects the group's four home sheets into one group tally for each solid and test, and reports it to the class table.
- **Key builder:** Leads the group in choosing the order of tests for the identification key and draws the flow chart.

- **Mystery tester:** Runs the water and vinegar tests on the teacher's mystery powder at the class station and walks the result through the key.

Materials

Item	Quantity	Per	Note
Field sheet with the protocol and the data table	1	student	
Home kit list: table salt, granulated sugar, baking soda, baking powder, flour, cornstarch, Epsom salt, powdered sugar	1 level teaspoon of each per test	student	Students use what their kitchen has; the class station holds a full set for anyone who cannot test at home.
White vinegar	about 30 mL	student	
Measuring teaspoon and half-cup measure (or a 120 mL mark on a cup)	1 each	student	
Clear cups or glasses	8	student	Rinse and reuse; label with tape.
Dark plate or black paper for the evaporation drops	1	student	
Hand lens, or a phone camera on zoom	1	student	
Class station set of the eight solids in labeled containers plus the mystery powder	1 set	class	
Clear cups, teaspoons, vinegar, droppers and water for the class station	1 set	class	
Large sheet or whiteboard space for the pooled class table and the key	1	class	

Estimated cost: 10 to 15 per class (an estimate; A class station set of the eight solids (most under \$2 each, Epsom salt about \$4) and a bottle of vinegar about \$2; home testing uses what families already have, and the station covers anyone without.)

Safety

- Use only the eight listed food solids. Never test cleaning products, medicines, garden chemicals or any unlabeled powder, even one that looks the same.
- Do not eat or taste any test sample, even though the solids are food; the cups and spoons have touched vinegar and each other.
- Vinegar stings eyes; keep it away from the face and rinse with water if it splashes. Wash hands after testing.
- An adult should know the testing is happening. Label every cup, keep cups out of reach of small children and pets, and pour everything down the sink with running water when done.
- Baking soda plus vinegar foams up; use only ten drops on a pinch of powder on a plate, never in a closed container.

- At the class station the mystery powder is a food solid, but students treat it as unknown: no tasting, no sniffing, goggles on.

Teacher preparation and setup

1. Send a note home a week ahead listing the eight solids, the vinegar, and the safety rules; make clear that the class station is available for anyone who prefers to test at school.
2. Build the class station: eight labeled containers of the solids, vinegar in a dropper bottle, a stack of clear cups, teaspoons, a 120 mL marked cup, paper towels.
3. Choose the mystery powder (Epsom salt is a good first choice: dissolves clear, no fizz, dries to needle-shaped crystals; baking soda is a good second, since it fizzes with vinegar) and put it in a container labeled only X.
4. Run the protocol yourself on all eight solids so you know what each test gives in your water; hard tap water can make baking soda look slightly cloudy.
5. Prepare the pooled class table on the board: eight solids down the side, four tests across, with space for 'number of students reporting' under each result.

Investigation design

Independent variable	Which white solid is being tested.
Dependent variable	The result of each test: behavior in water, fizz with vinegar, residue after evaporation, appearance of the grains.
Controlled	1 level teaspoon of solid in 120 mL of room-temperature tap water, stirred 60 seconds; 10 drops of white vinegar on a pinch of dry solid; Drops dried overnight on a dark surface; Same hand lens or zoom for every solid
Trials	Every student tests each solid once; the class pool gives many repeats of each test, and disagreements are resolved by checking the protocol or retesting at the station.
Comparison	Results across kitchens for the same solid; the mystery powder's results against the class key.

Student procedure

1. Session 1 (class, about 20 minutes): read the protocol together and practice it on two solids at the station so everyone has seen 'dissolves clear', 'cloudy' and 'fizz' once. Write the four tests and their exact amounts on the field sheet in your own words.
2. At home or at the station, Test 1 (water): put 1 level teaspoon of the solid into 1/2 cup (120 mL) of room-temperature tap water and stir for 60 seconds. Record: dissolves clear, cloudy, settles to the bottom, or fizzes. Keep the cup for Test 3.
3. Test 2 (vinegar): put a pinch of the dry solid on a plate and add 10 drops of white vinegar. Record whether it fizzes (bubbles of gas) or not.
4. Test 3 (evaporation): with a spoon, place two or three drops of the clear liquid from Test 1 on a dark plate or black paper and let them dry overnight. Record what is left: cube-shaped crystals, needle-shaped

- crystals, a white powder or crust, a glassy or sticky film, or nothing.
5. Test 4 (magnified look): look at a pinch of the dry solid with a hand lens or phone zoom. Record whether the grains are clear cubes, clear chunks or rods, or a fine soft powder with no visible grains.
 6. Repeat Tests 1 to 4 for every solid you can get; rinse cups between solids. Bring the completed field sheet to session 2.
 7. Session 2 (class, about 45 minutes): the pooler adds your group's results to the class table as counts (for example, baking soda in water: 18 'dissolves clear', 6 'cloudy'). For any test where the class disagrees, the protocol keeper checks whether the amounts, water temperature or stirring time differed, and the class agrees on one result with a reason.
 8. Build the key: choose a first test that splits the eight solids into two groups as evenly as possible, then a second test for each branch, and so on, until every solid sits alone at the end of a path. Draw it as a flow chart of yes/no questions.
 9. The mystery tester runs the water test and the vinegar test on powder X at the station, follows the key, and the group writes down the identity and the path of tests that led there. Answer the analysis questions individually.

Expected observations

- Water: salt, sugar and Epsom salt dissolve clear within the minute; baking soda dissolves clear but slowly; powdered sugar dissolves but leaves a faint haze; flour and cornstarch go cloudy and settle; baking powder fizzes briefly and leaves a cloudy liquid.
- Vinegar: baking soda and baking powder fizz; the other six do not.
- Dried drops: salt leaves tiny cubes; Epsom salt leaves needle or rod crystals; baking soda leaves a white crust; sugar leaves a glassy, sticky film; powdered sugar a similar film; flour, cornstarch and baking powder leave a dull powdery smear.
- Lens: salt shows clear cubes; sugar shows clear irregular chunks; Epsom salt shows clear rods; baking soda, baking powder, flour, cornstarch and powdered sugar look like fine powders with no clear grains.

Likely difficulties

- Students stop stirring at 20 seconds and report baking soda or Epsom salt as cloudy; the protocol keeper should ask about the stirring time whenever a result disagrees with the class.
- Hard tap water can leave its own faint ring on the dried drop; have students dry a drop of plain water as a control.
- The dried-drop test is skipped because it takes a night; remind students the evening before, or run it at the station on day one so results are ready for session 2.
- Keys that ask about color or texture first, which split nothing because all eight are white; steer groups toward tests with yes/no answers.
- Families may not have Epsom salt or cornstarch; the station fills gaps, and a missing row on one sheet does not break the pooled table.

Structured debrief

1. Start with the disagreements in the pooled table. Baking soda is the usual one: at 1 teaspoon in 120 mL it is below its solubility limit (about 9.6 g per 100 mL at room temperature) and will dissolve, but slowly and more slowly in cold or hard water, so students who stopped stirring early saw cloudiness. Use it to make the point that solubility has an amount and a condition attached.
2. Ask which test every group put first in its key. The vinegar test splits the set into fizzers (baking soda, baking powder) and non-fizzers (the other six); the water test splits it into clear-dissolvers (salt, sugar, Epsom salt, baking soda, mostly powdered sugar) and cloudy or settling (flour, cornstarch, baking powder). Groups that chose the water test first have a more balanced tree. Either order works; the question is how many tests the mystery powder needs.
3. Point out that the vinegar fizz is a different kind of evidence from the others: the gas was not there before, so a new substance formed. That is the chemical-property idea from the flammability slide and the opening of Lesson 12.
4. Reveal the mystery powder and have groups compare paths. If any group reached the wrong name, trace where its key branched on a result the class had disagreed about; that is exactly why the pooled decision matters.

Recording sheet: what students fill in

Lab 3 field sheet: Kitchen solids survey

Home rules — Only the eight listed food solids and white vinegar. Tell an adult what you are doing. Label every cup. No tasting, no sniffing. Keep cups away from small children and pets. Wash hands and rinse everything down the sink with running water when you finish.

Use exactly the amounts in the protocol so your results can be compared with everyone else's: 1 level teaspoon of solid in 1/2 cup (120 mL) of room-temperature water, stirred 60 seconds; 10 drops of vinegar on a pinch of dry solid; drops dried overnight. Write what you actually see, not what you expect.

My field data

Solid	Test 1, water (dissolves clear / cloudy / settles / fizzes)	Test 2, vinegar (fizz: yes / no)	Test 3, dried drop (cubes / needles / crust / glassy film / nothing)	Test 4, grains under the lens
Table salt				
Granulated sugar				
Baking soda				
Baking powder				
Flour				
Cornstarch				
Epsom salt				
Powdered sugar				

Class pooled results (session 2)

Solid	Water test: class decision	Vinegar test: class decision	Dried drop: class decision	Any disagreement? How was it settled?
Table salt				
Granulated sugar				
Baking soda				
Baking powder				
Flour				
Cornstarch				
Epsom salt				
Powdered sugar				

-  Draw your group's identification key as a flow chart. Start with one yes/no test at the top, branch on the answer, and keep going until each of the eight solids sits alone at the end of a path. Write the test question in each box.

Answer: A flow chart with yes/no boxes, for example: 'Fizzes with vinegar?' yes → 'Fizzes in plain water?' yes = baking powder, no = baking soda; no → 'Dissolves clear in water?' no → 'Lens shows fine powder with no grains?' both flour and cornstarch, separated by the dried-drop or by feel (cornstarch squeaks); yes → 'Dried drop: cubes?' yes = salt; 'needles?' yes = Epsom salt; 'glassy film?' → 'slightly cloudy in water?' yes = powdered sugar, no = granulated sugar.

Why: Many valid trees exist. Flour versus cornstarch is the hardest split; accept any observable difference the group actually recorded (cornstarch feels squeaky and makes a thicker, smoother suspension; flour clumps).

- Yes/no test questions in boxes
- Every solid ends alone at a leaf
- Uses at least two different tests
- The path for the mystery powder leads to the correct name

1. Mystery powder X: record its water test and vinegar test results, list the path of tests you followed through the key, and name the solid.

Answer: Depends on the teacher's choice. Epsom salt: water test dissolves clear; vinegar test no fizz; path for example 'fizz with vinegar? no → dissolves clear? yes → dried drop needles? yes'; identity Epsom salt. Baking soda: water test dissolves clear (slowly); vinegar test fizz; path 'fizz with vinegar? yes → fizzes in plain water? no'; identity baking soda.

Why: The path must follow the group's own key and reach the identity using the recorded results; a correct name reached by a path that contradicts the key earns partial credit.

- Both test results recorded as observations
- A path that follows the group's key step by step
- Correct identity for the powder used

2. Which single test in your key splits the eight solids most evenly into two groups? Which test was the least useful, and why?

Answer: The water test splits the eight into about five that dissolve clear (salt, sugar, Epsom salt, baking soda, powdered sugar) and three that do not (flour, cornstarch, baking powder), the most even split. The vinegar test splits only two from six, so it is useful for naming baking soda and baking powder but poor as a first question. The least useful is the lens test on the five powders, which all look like fine white powder; it helps only for the three with visible crystals.

Why: Students should judge tests by how evenly they split the remaining set, which is how a good key is built.

Also acceptable: Accept the vinegar test as 'most useful' if the student argues it gives the cleanest yes/no with no disagreement, provided the evenness point is addressed.

Analysis questions: answer key

3. Why does the protocol fix the amount of solid, the amount of water, the temperature and the stirring time? What could go wrong with a solubility comparison if one student used a heaping tablespoon in a quarter cup of cold water?

Answer: Solubility has a limit: water can hold only so much of a solid at a given temperature, and cold water usually holds less and dissolves more slowly. A heaping tablespoon in a quarter cup of cold water puts far more solid in far less water, so a solid that dissolves easily at the protocol amounts could look 'insoluble' because the water was overloaded and cold. Fixing the amounts, temperature and time makes every student's result comparable.

Why: Controlled variables and the idea that solubility is an amount under conditions, not a yes/no fact.

- States that solubility has a limit that depends on amount and temperature
- Explains that the heaping-tablespoon test could wrongly read as insoluble
- Connects fixed conditions to comparable results

4. Baking powder fizzed in plain water, but baking soda fizzed only when vinegar was added. What does that tell you about what baking powder contains? Explain why the fizz is a chemical property and not a kind of dissolving.

Answer: Baking powder must contain both baking soda and a dry acid, so adding water lets them react with each other and fizz; baking soda alone needs an acid from outside (the vinegar) to react. The fizz is a chemical property because a gas that was not there before appears: the baking soda and the acid turn into new substances, including carbon dioxide gas. Dissolving is different: the dissolved solid is still the same substance, spread out in the water, and comes back when the water evaporates.

Why: Baking powder is a mixture of sodium bicarbonate, a dry acid (such as cream of tartar or sodium aluminum sulfate) and starch. The before-and-after reasoning here previews MS-PS1-2.

- Infers that baking powder contains an acid as well as baking soda (or 'two things that react')
- States that a new substance (gas) forms, so it is a chemical change
- Contrasts with dissolving, where the substance is unchanged

5. Powdered sugar left a slightly cloudy liquid, while granulated sugar dissolved completely clear. Suggest an explanation and describe one test from this lab that could check it.

Answer: Powdered sugar is a mixture: it contains a small amount of cornstarch to stop it clumping, and cornstarch does not dissolve in water, so it makes the haze. Test: filter or let the cloudy liquid settle, then dry a drop of the clear part; it should leave the same glassy film as granulated sugar, while the settled solid would behave like cornstarch (cloudy again in water, no crystals).

Why: Connects an unexpected observation to the mixture idea and to the lab's own tests.

Also acceptable: Accept 'powdered sugar is ground so fine that some of it stays suspended' as a hypothesis if a test is proposed; the cornstarch explanation is the correct one and should be shared in the debrief.

6. The dried drop of salt water left tiny cube-shaped crystals. What does this show about what happened to the salt when it dissolved? Use the word substance in your answer.

Answer: The salt did not vanish or change into something else when it dissolved; its particles spread out through the water, too small to see. When the water evaporated it left the salt behind as the same substance, which is why the crystals have salt's cube shape. Dissolving changed where the salt was, not what it was.

Why: Evidence for 'dissolved is not gone'; the cube shape is the signature of the same substance returning.

- States that the salt was still present in the solution
- States that the recovered crystals are the same substance as before
- Uses the word substance

7. Table salt and granulated sugar both dissolved clear and neither fizzed. Which test in your survey separated them? Then name one property from the lesson that would separate them but that you could not safely measure at home, and give the reason.

Answer: The dried-drop test separated them: salt leaves cube crystals while sugar leaves a glassy, sticky film; the lens test also helps, since salt grains are cubes and sugar grains are irregular chunks. A lesson property that would separate them but cannot be measured safely at home is melting point: sugar melts and browns at about 186 °C while salt melts at about 801 °C, far beyond a kitchen stove's safe range, and heating sugar to melting is a burn risk. Density would also separate them (salt about 2.17 g/cm³, sugar about 1.59) but a home balance and cylinder are usually not precise enough for grains.

Why: Students should pick a test they actually ran, then reach into the lesson for a second property with a safety reason.

- Names the dried-drop or lens test as the separator
- Names melting point (or density, flammability) as a lesson property
- Gives a safety or equipment reason why it was not done at home

8. Different kitchens reported different water-test results for baking soda ('dissolves clear' versus 'cloudy'). List two reasons the results might differ, and explain how the class should decide which result goes in the key.

Answer: Reasons: stirring time (baking soda dissolves slowly, so 20 seconds looks cloudy while 60 seconds looks clear); water temperature (cold tap water dissolves it more slowly); a heaping rather than level teaspoon; hard tap water, which can leave a faint haze of its own. The class should check which results followed the protocol exactly and set aside the ones that did not, retest the solid at the station under the fixed conditions, and record the result that the protocol gives, with a note that it dissolves slowly. A key built from a majority vote of mixed-protocol results would be unreliable.

Why: This is the fair-test reasoning the field design is meant to provoke; full credit requires both specific causes and an evidence-based resolution.

- Two specific protocol or water differences
- A decision rule based on following the protocol or retesting, not on majority alone

Individual evidence of learning

Each student submits their own completed field data table, a copy of the group's pooled decisions, the identification key drawing, the mystery-powder table (q1), and written answers to q2 through q8. The key drawing and q1 are the evidence for the identify-an-unknown target; q4 and q6 are the evidence for the solubility and chemical-property targets.

Assessment criteria

Criterion	Proficient looks like
Protocol and data	All four tests recorded for at least six solids with the stated amounts and times; results written as observations, not names.
Identification key	A flow chart of yes/no test questions in which every solid ends alone, using at least two different tests, and that names the mystery powder correctly when followed.
Reasoning about solubility and reactions	Explains that dissolved solids are still present (evaporation evidence), that solubility depends on amount and conditions, and that the vinegar fizz shows a new substance forming.
Handling disagreement	Names a specific protocol difference that could explain conflicting results and proposes retesting under the fixed conditions.

Accessibility adaptations

- Provide the field sheet with picture icons for each result (clear glass, cloudy glass, bubbles, settled layer) that students can circle instead of writing.
- Allow the whole survey to be done at the class station over two lunch periods for students who cannot test at home, with a partner reading the protocol aloud.
- Offer a half-built key with the first test already placed for groups that need a starting point, and accept a key built physically on the floor with string and cards.
- Accept spoken answers for q4 and q8, and let a student with low vision use the phone-zoom version of Test 4 with the image enlarged on a screen.

Low-cost alternative

Run the entire survey at a class station with four solids (salt, sugar, baking soda, flour) instead of eight; the key then has four leaves and takes one session. Vinegar can be replaced by lemon juice for the fizz test. If overnight drying is impossible, dry drops on a sunny windowsill for an hour or skip Test 3 and rely on the lens test to separate salt from sugar.

Model limitations

The tests are qualitative: 'dissolves clear' at one teaspoon in 120 mL does not measure solubility, and two solids with very different solubility limits (sugar at roughly 200 g per 100 mL and baking soda at roughly 10 g per 100 mL) both read 'dissolves' under this protocol. Powdered sugar and baking powder are themselves mixtures (powdered sugar contains a little cornstarch; baking powder contains baking soda, a dry acid and starch), so the key identifies products, not pure substances. Hard water, cold water and short stirring all shift results. This activity has not been physically tested by the authors in the form written here; the expected results come from the known solubilities and reactions of the listed solids.

Teacher notes

Grade the key by whether it works, not by whether it matches the example; have groups trade keys and run the mystery powder through each other's. If your tap water is hard, add a plain-water control drop to the

evaporation test so the mineral ring is not mistaken for a solid's residue. Keep the vinegar test small; a teaspoon of baking soda with a splash of vinegar foams over a plate.