



Identifying Chemical Reactions

Chapter 12 of 29 • Chemical Reactions

Lesson 12: Clue or proof? Telling when something new was made

Angela's Wand • Bring Science Alive! 7th Grade Integrated

PHENOMENON

Three bags, three changes

Bag A: baking soda + vinegar. It fizzes, puffs up tight and feels cool. Bag B: calcium chloride pellets + water. It gets hot and the pellets vanish. Bag C: Epsom salt + water. It feels slightly cool and the crystals disappear. Every bag changed. In which bags did a new substance form, and how could you know for sure?

- Notice: which clues did more than one bag share?
- Wonder: is getting hot enough to prove something new was made?
- Predict: if the water in Bags B and C dried up, what would be left?





LEARNING TARGETS

What you will be able to do

- Name the reactants and products in a reaction and explain why products have their own properties.
- Tell a chemical reaction from a physical change by asking whether a new substance formed.
- Explain how heating, cooling or mixing can start a reaction, and why it stops when a reactant runs out.
- Use before-and-after property data to decide whether a reaction happened and how strong the evidence is.
- Judge competing designs, such as two medicines, against their criteria using test results.

What a chemical reaction actually is

- A chemical reaction turns one or more substances into one or more different substances.
- The starting substances are reactants; the new ones are products.
- In Bag A, acetic acid (from vinegar) and sodium bicarbonate (baking soda) are the reactants.
- The products are carbon dioxide gas, water and a dissolved salt called sodium acetate.
- Each product is a different substance, so each has its own set of properties.



Three words every reaction needs



chemical reaction: A change in which substances turn into different substances with their own properties. *Steel wool turning into orange, crumbly rust.*



reactant: A substance present before the reaction that gets changed by it. *Hydrogen peroxide is the reactant that gets used up when it foams on yeast.*



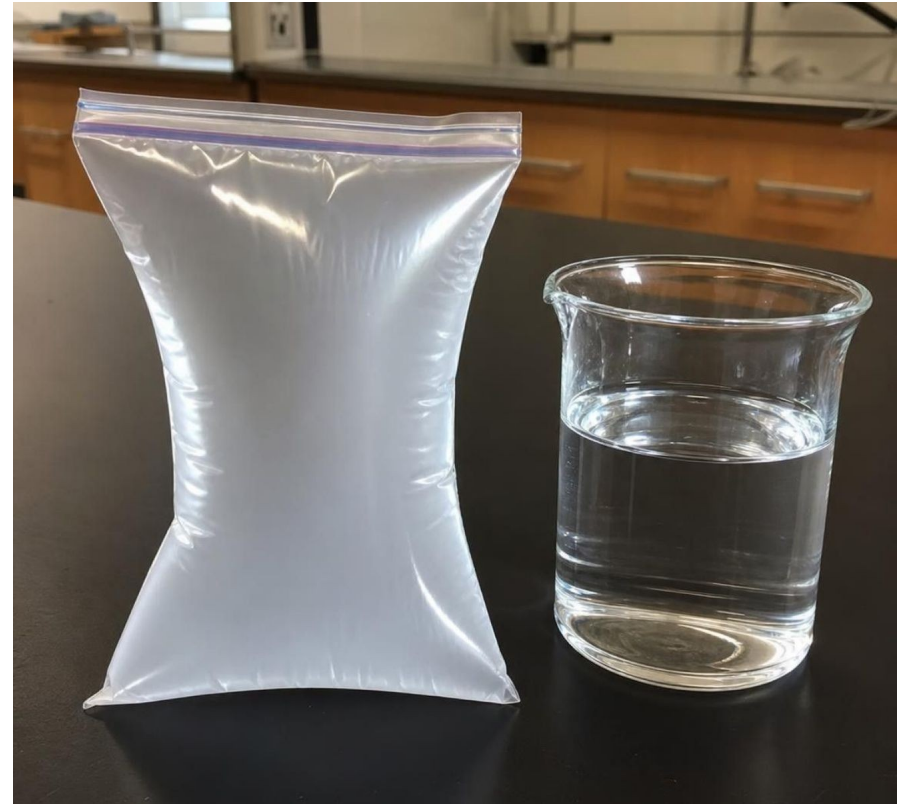
product: A substance made by the reaction that was not there before. *Oxygen gas is a product of hydrogen peroxide breaking down.*

Following one reaction from start to finish

MODEL

Model: Baking soda and vinegar as a chemical reaction

- 1 Reactants: sodium bicarbonate (baking soda) and acetic acid (from vinegar)
- 2 (mixing) They mix; the reaction starts at once
- 3 (reacting) Products: carbon dioxide gas, water and dissolved sodium acetate
- 4 (testing) Products have their own properties: the gas inflates a bag; the leftover liquid no longer fizzes with vinegar



The last box is the key: products are known by their properties, not by the show they put on.



Change without a new substance: physical changes

- Melting, freezing, boiling: the substance changes state but stays the same substance.
- Dissolving: the solid spreads out among the water particles; evaporate the water and it comes back.
- Crushing, cutting, stretching: new shape, same substance.
- A physical change can bubble (boiling), get cold (melting ice) or get hot (calcium chloride dissolving).
- Test for a physical change: can you get the original substance back with its original properties?

CHECK FOR UNDERSTANDING

Quick check: which change made a new substance?

Four changes. Only one made a new substance. Which?

- A. An ice cube melts into a puddle of water.
- B. A spoon of sugar disappears into hot tea.
- C. A pad of steel wool turns into orange, crumbly rust.
- D. A pot of water boils and bubbles rise through it.



Two kinds of properties, one job: identifying substances

- Physical properties are measured without changing the substance: color, density, melting point, solubility.
- Chemical properties describe whether a substance can change into new ones: does it burn? react with an acid?
- You find a chemical property only by trying the reaction.
- Every pure substance has its own combination of properties, like a fingerprint.
- So a different fingerprint after a change means a different substance is present.



Property words you will use all week



physical property: A trait you can observe or measure without turning the substance into a different one.
Epsom salt is clear and colorless and dissolves readily in water.



chemical property: Whether and how a substance can change into new substances; found by trying the reaction. *Baking soda fizzes with vinegar; steel wool rusts in moist air.*



precipitate: A solid that forms inside a liquid when dissolved substances react to make something that barely dissolves. *Two clear solutions are mixed and a cloudy white solid appears and sinks.*

MODEL

Looks like a reaction versus is a reaction

Model: Physical change or chemical reaction?

Physical change: same substance	Chemical reaction: new substance
Ice melting (gets cold)	Baking soda + vinegar (gas forms)
Water boiling (bubbles)	Steel wool rusting (color, texture change)
Epsom salt dissolving (slightly cool)	Two clear solutions making a solid
Calcium chloride dissolving (hot!)	Hydrogen peroxide foaming on yeast

The middle is the problem: the clues overlap. The decision comes from comparing properties before and after.





CHECK FOR UNDERSTANDING

Quick check: clue or proof?

Bag B (calcium chloride + water) got hot and the pellets vanished. Which statement is the best science?

- A. Getting hot proves a chemical reaction happened.
- B. The pellets vanished, so they must have changed into something new.
- C. Heat and vanishing are clues; evaporate the water and test what is left before deciding.
- D. No bubbles appeared, so nothing happened at all.

What makes a reaction start, and what makes it stop?

- A reaction needs the right substances and the right conditions; having the substances together is not enough.
- Heating: a match head holds its reactants already mixed; friction heats it and the reaction begins.
- Cooling: brown nitrogen dioxide gas in a sealed tube fades toward a colorless gas as it cools.
- Mixing: some reactants react the moment they meet, like baking soda and vinegar.
- A reaction keeps going while both reactants are present and stops when one runs out.



Conditions: three ways in, one way out

Model: Conditions that start a reaction, and the condition that ends it



Heating: Friction warms a match head; the already-mixed reactants begin to react and the head flares.



Cooling: Brown nitrogen dioxide in a sealed tube fades toward colorless dinitrogen tetroxide as it is chilled; warming brings the brown back.



Mixing: Two clear solutions meet and a solid forms at once; baking soda meets vinegar and fizzes immediately.



Running out: The fizz stops when either the baking soda or the vinegar's acetic acid is used up; adding more of the missing one restarts it.

Described examples only: matches, lead compounds and nitrogen dioxide are never handled in this chapter.





THINK, PAIR, SHARE

Discuss: why does the fizzing stop?

A cup of vinegar with a spoon of baking soda fizzes hard, then slows, then stops. The cup is still full of liquid. Why did it stop, and how could you find out which ingredient ran out?



Clues that a reaction may have happened

- A gas forms where there was none (bubbles, foam, a bag inflating).
- A new color appears, or a solid (precipitate) forms inside a liquid.
- The mixture gets warmer or colder than its surroundings, or gives off light.
- A new smell appears, like the caramel smell when sugar is heated until it browns.
- Every one of these is also seen in some physical change. Clues start an investigation; they do not end it.

From clue to claim: how a chemist decides

MODEL

Model: The before-and-after method

1. Notice a clue: gas, color, solid, temperature, light, smell
2. Ask: which substance might be new, and what do I have after the change?
3. Measure properties of the substances before and after: solubility, melting point, density, odor, flammability
4. Compare: do the characteristic properties differ, or can the original be recovered?
5. Decide: new substance or not, and rate how strong the evidence is

Two agreeing tests make a stronger claim than one. A test that gives the same value before and after is not evidence against a reaction; it just did not help.



The six properties that count as evidence

- Density: mass per unit volume; hard to measure well for a powder, easy for a liquid or solid block.
- Melting point and boiling point: a pure substance melts or boils at its own temperature.
- Solubility: how much dissolves in a set amount of water at the same temperature.
- Flammability: whether it burns (a chemical property; a teacher-only test, and never in this chapter).
- Odor: a new smell can mean a new substance, but many substances have no smell.
- Why not color alone? Thousands of substances are white powders.



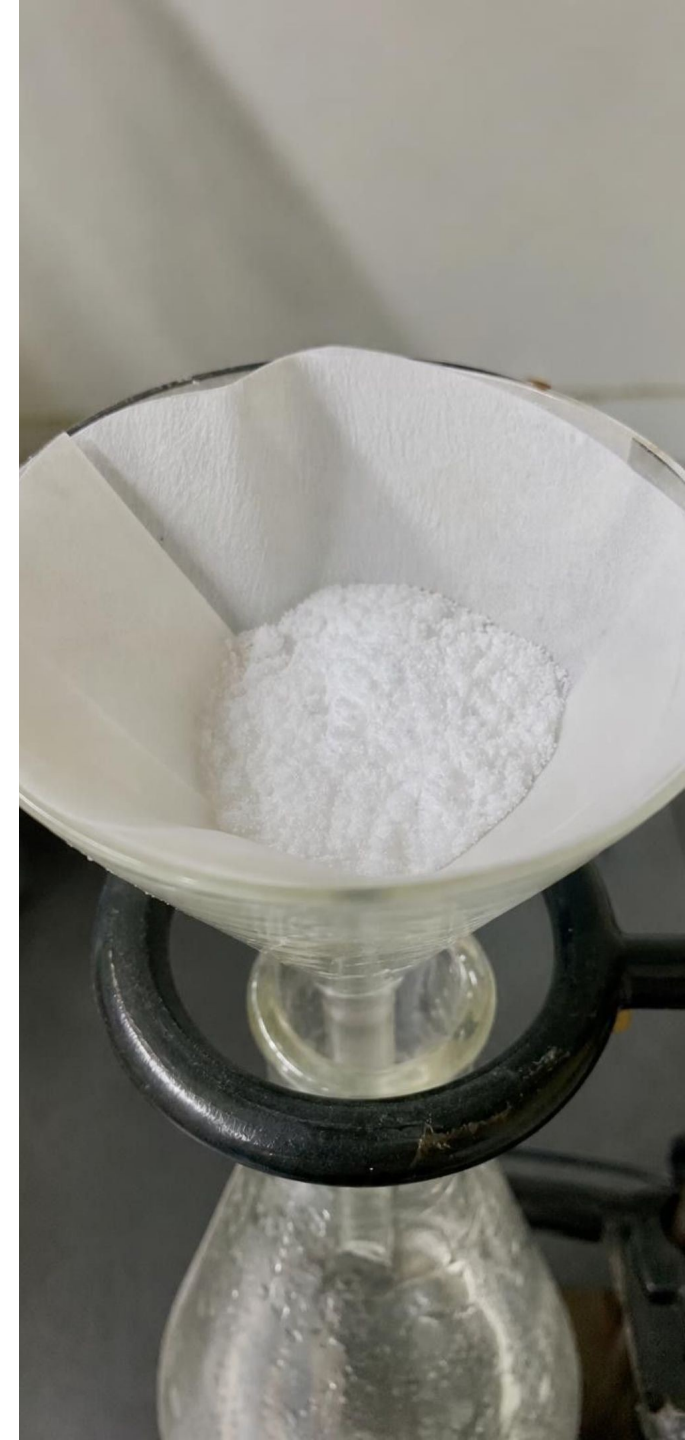
APPLY IT

Task: did the chemist make a new substance?

Simulated data for practice.

A chemist reacts salicylic acid with a second substance, heats and cools the mixture, and collects a white powder. Use the five test results to decide if it is a new substance and which results carry the argument.

Test	Starting powder (salicylic acid)	Powder after the procedure
Appearance	white powder	white powder
Density of a packed cube	about 1.4 g/cm ³	about 1.4 g/cm ³
Solubility in water at 25 °C	about 2.2 g per liter	about 3.3 g per liter
Melting range	158-159 °C (narrow)	134-136 °C (narrow)
Odor	none noticed	none noticed

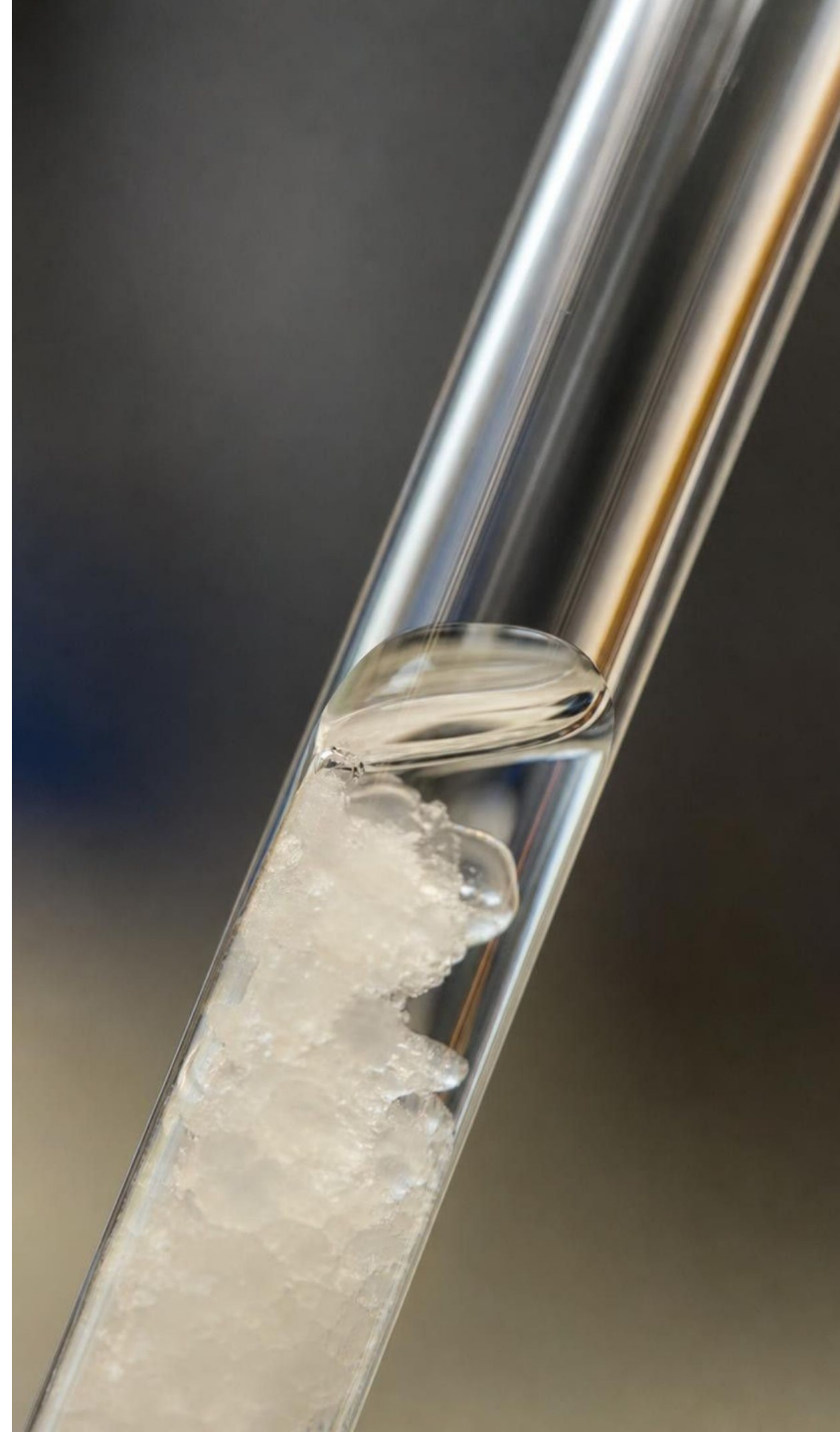


CHECK FOR UNDERSTANDING

Quick check: which pair of results makes the case?

From the task table, which two results together give the strongest evidence that the chemist made a new substance?

- A. Appearance and density
- B. Density and solubility
- C. Solubility and melting range
- D. Appearance and melting range





THINK, PAIR, SHARE

Discuss: design the test that settles Bag B

- Use only our materials: cups, water, vinegar, baking soda solution, droppers, a thermometer, a hand lens.
- Your test must compare something before with the same thing after.

Bag B got hot and the pellets vanished. Design one test, say what result would convince you it was a physical change, and what result would convince you it was a reaction.

REAL-WORLD CONNECTION

California connection: the bridge that never stops rusting

The Golden Gate Bridge is steel, and the fog that rolls through the Golden Gate carries salt water. Iron in the steel reacts with oxygen and water to form rust, a different substance that is crumbly and flakes away. Painters work year-round removing rust and repainting the orange steel, because the reaction never stops while iron, oxygen and moisture meet. Paint works by keeping two of the three reactants apart.





Medicines made by reactions, tested against criteria

- For centuries people chewed willow bark for pain and fever; chemists wanted the substance that worked.
- Salicin was taken from the bark; reactions turned it into salicylic acid, the form that acts in the body.
- Salicylic acid worked but irritated the stomach; some patients could not keep taking it.
- Chemists reacted salicylic acid into a new substance, acetylsalicylic acid, now called aspirin.
- Criteria for the design: reduce pain and fever, and cause few side effects. Patient tests judged both.

From bark to tablet: a timeline of reactions

MODEL

Model: How willow bark became aspirin

For centuries: Willow bark chewed or brewed for pain and fever; nobody knows which substance helps.

1829: Salicin is isolated from willow bark by the French pharmacist Henri Leroux.

1838: Raffaele Piria makes salicylic acid from salicin by chemical reactions; it treats fever but irritates the stomach.

Each arrow in the chain is a chemical reaction that produced a substance with different properties from the one before it.

1853: Charles Gerhardt first makes acetylsalicylic acid from salicylic acid; it is not yet used as a medicine.

1897: Felix Hoffmann at Bayer makes it in pure form; patient tests follow and Bayer sells it as Aspirin from 1899.

Early 1900s: Aspirin becomes one of the most widely used medicines in the world.



CHECK FOR UNDERSTANDING

Quick check: which conclusion do the tests support?

- Salicylic acid: fevers and pain reduced; stomach irritation common, some patients stopped taking it.
- Aspirin: fevers and pain reduced; fewer complaints of stomach trouble in the patients tested.

Criteria: reduce fever and pain; cause few side effects. Which conclusion do the test results below support?

- A. Aspirin has no side effects, so it is safe for everyone.
- B. Aspirin met both criteria better than salicylic acid in these tests.
- C. Salicylic acid failed both criteria, so it was never a useful medicine.
- D. The tests prove that aspirin works for every illness.



MISCONCEPTION CHECK

True or false? If it bubbles, it reacted

"If something bubbles when you mix or heat it, a chemical reaction definitely happened."

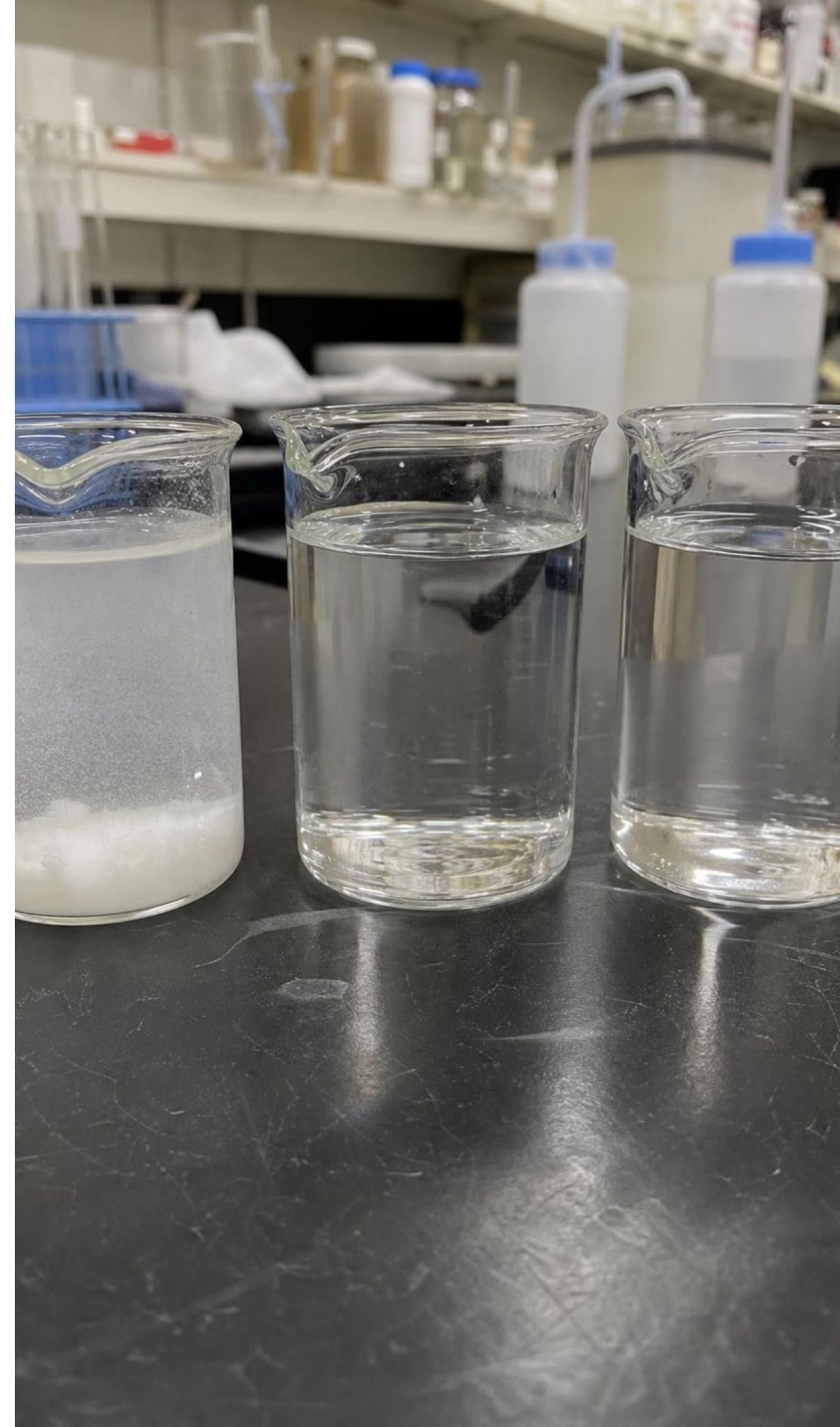
True or false? Explain your reasoning.

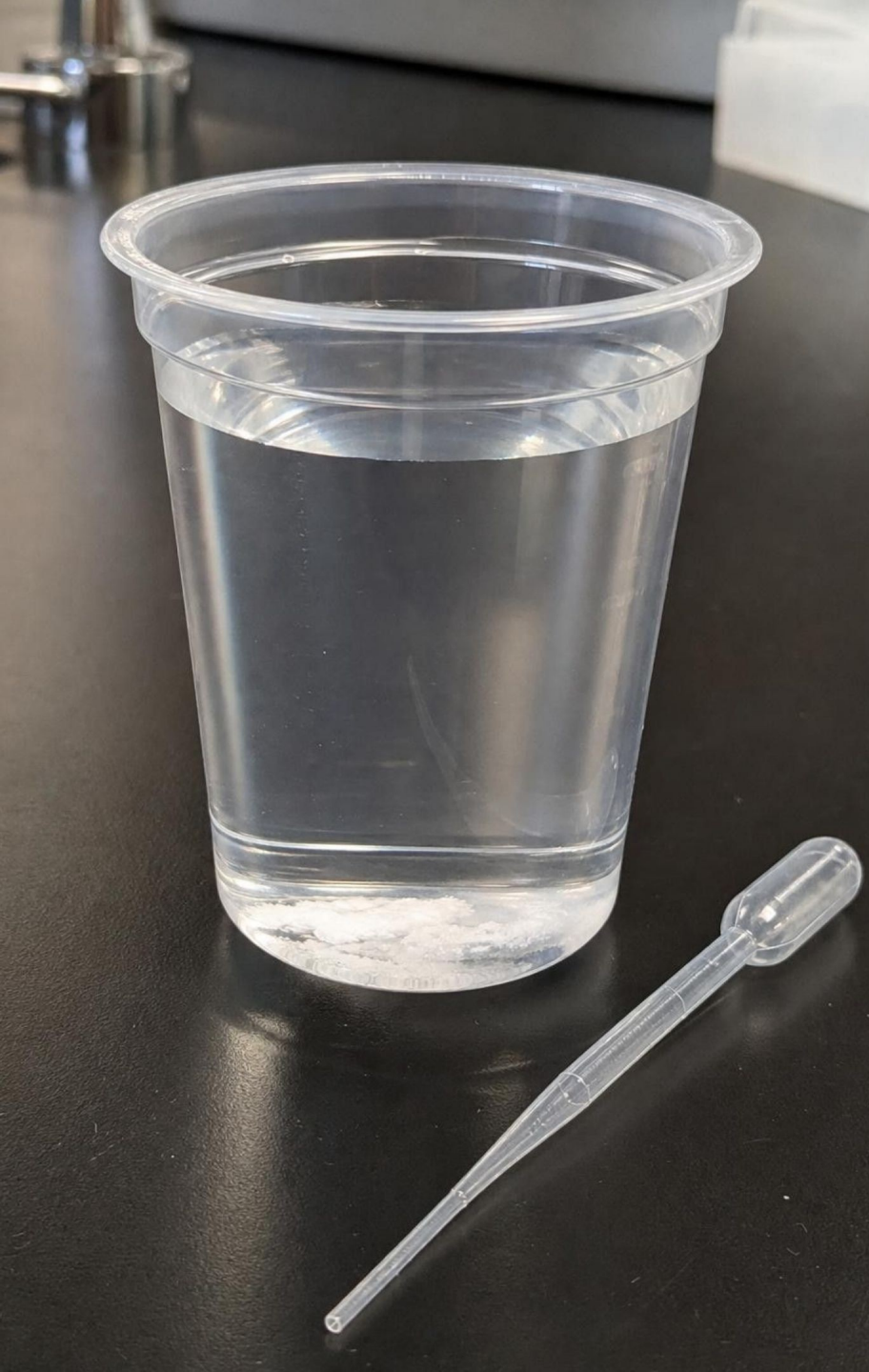


PUTTING IT TOGETHER

Putting it together

- A chemical reaction makes different substances; reactants in, products out, each with its own properties.
- Melting, boiling and dissolving change how a substance looks but leave it the same substance.
- Gas, color, solid, heat, light and smell are clues. They also show up in physical changes.
- Proof comes from before-and-after tests: solubility, melting point, density, odor, flammability.
- Conditions (heating, cooling, mixing) decide whether a reaction starts; it stops when a reactant runs out.
- The same tests confirmed each step from willow bark to aspirin, and criteria judged which medicine was better.





EXIT TICKET

Exit ticket

- Name one clue that a reaction may have happened and one physical change that shows the same clue.
- A powder dissolves at 20 g/L before a change and 20 g/L after. Does this prove no reaction happened? Explain.
- Which reactant ran out in your Lab 3 cup, and what test told you?
- In one sentence: why did aspirin count as a better design than salicylic acid?