

Fix the Lab Notebook: Six Conclusions That Went Wrong

Learning target: I can find the mistake in a conclusion about whether a chemical reaction happened, explain why the reasoning fails, and rewrite the conclusion so that it rests on the right kind of evidence.

Error analysis

About 35 min

Individual

MS-PS1-2 · practice

writing

independent practice

discussion

Standards connections

MS-PS1-2 (practice, judging whether observations justify the conclusion that a reaction occurred): Each notebook entry pairs an observation (a temperature drop, bubbles, a vanished solid, a shared melting point, a stopped fizz, light) with a conclusion about reaction or no reaction. Students must decide whether the evidence supports the conclusion and what property comparison would, which is the judgment the PE assesses, practiced on short cases rather than on a full dataset.

Purpose: practice · **Time:** about 35 minutes · **Format:** individual

Answers with reasoning

Theo's notebook

Entry 1: Ice in lemonade — I dropped four ice cubes into my lemonade. The thermometer went from 20 °C down to 4 °C and the cubes got smaller. A temperature change means a chemical reaction happened, so the ice must have reacted with the lemonade.

Entry 2: Sugar in warm water — I stirred a spoonful of sugar into warm water until I could not see it anymore. The sugar is gone, so it must have turned into a new substance. Dissolving is a chemical change.

Entry 3: Sparkling water — When I twisted the cap off a bottle of sparkling water it hissed and fizzed for a whole minute. Gas coming out is a sign of a chemical reaction, so a reaction happened when I opened the bottle.

Entry 4: Two white powders — In class we measured the melting points of two white powders from different jars. Both melted at 801 °C. Two substances with the same melting point are definitely the same substance, so the jars hold the same thing.

Entry 5: The fizz that stopped — I poured vinegar on a spoonful of baking soda in a cup. It fizzed hard for about a minute and then stopped, even though there was still plenty of liquid. The reaction ran out of energy, like a battery going flat.

Entry 6: The glow stick — I snapped a glow stick and it lit up bright green for hours. Light proves a chemical reaction, so a new substance definitely formed inside the stick.

Theo's rule — My rule for next time: if anything changes (temperature, bubbles, color, light, or a solid disappearing), it is a chemical reaction. If nothing you can see changes, it is a physical change.

Part A: Diagnose each entry

1. For each entry, say whether Theo's conclusion is right or wrong, then name the mistake in his reasoning. One entry has a right conclusion reached by weak reasoning; say so.

Answer: Entry 1: wrong; a temperature change is a clue, not proof, and melting absorbs energy without making a new substance. Entry 2: wrong; a solid that can no longer be seen has spread through the water, not stopped existing; dissolving is a physical change. Entry 3: wrong; the gas was already dissolved in the drink, so bubbles leaving a liquid are not evidence of a new substance. Entry 4: wrong; two different substances can share a melting point, so one matching test is not proof of sameness. Entry 5: wrong; reactions stop when a reactant is used up, not when energy runs out. Entry 6: right conclusion, weak reasoning; light is a clue, and the conclusion needs a property comparison to be proof.

Why: Five conclusions are wrong and one (the glow stick) is right for a weak reason. Each mistake maps to a chapter misconception: temperature as proof, dissolving as disappearance, bubbles as proof, one shared property as identity, reactions 'running out of energy', and a clue treated as proof.

Also acceptable: Accept Entry 6 marked 'partly right' if the student explains that the conclusion is right and the reason is not.

- All six judged correctly
- Entry 6 marked as right conclusion with weak reasoning
- Each mistake named in terms of clue versus proof or substance identity

Part B: Rewrite the faulty conclusions

2. Rewrite Entry 1. Explain why the lemonade got colder, say what the ice became, and name one measured property of the melted ice that shows it is still the same substance.

Answer: Model rewrite: The lemonade got colder because melting ice takes in energy from the liquid around it; the cubes shrank as they melted. The ice became liquid water, which is the same substance in a different state. The melted water freezes at 0 °C and boils at 100 °C, the same as any water, so no new substance formed. This is a physical change, and the temperature drop is a clue about energy, not about a reaction.

Why: The rewrite must give the energy reason for the cooling, state that ice and water are the same substance, and cite a property (freezing or boiling point, or density of about 1 g/cm³) as the evidence.

Also acceptable: Accept 'it is a state change' with a property named.

- Melting absorbs energy from the lemonade
- Ice became water, same substance
- A measured property of water (freezing point 0 °C, boiling point 100 °C) named as evidence

3. Rewrite Entry 2. Explain what 'the sugar is gone' really means, name the kind of change, and describe a test that would bring the evidence back. (Nothing in a lab is tasted.)

Answer: Model rewrite: The sugar did not stop existing; its particles spread out among the water particles until the pieces were too small to see. Dissolving is a physical change: the sugar is still sugar. Test: let the water evaporate from a small sample. White sugar crystals come back, and they dissolve in water in the same amount as the original sugar at the same temperature. If a new substance had formed, something with different properties would be left instead.

Why: The recovery test is the student-level proof that dissolving keeps the substance. Tasting is excluded on purpose.

Also acceptable: Accept weighing the solution to show the sugar's mass is still there as an additional point, but the recovery test must be present.

- Explains 'gone' as spread out, not destroyed
- Names dissolving as a physical change
- Describes an evaporation or recovery test with a property check

4. Rewrite Entry 3. Where was the gas before Theo opened the bottle, and why does that matter? Then explain how this fizz differs from the fizz of vinegar on baking soda.

Answer: Model rewrite: The gas was already in the bottle, dissolved in the water under pressure at the factory (the label says 'carbonated'). Opening the bottle lets the pressure drop, and the dissolved carbon dioxide escapes as bubbles. Nothing new formed: the gas was carbon dioxide before and after, and the flat water left behind is still water. This is a physical change. The vinegar-and-baking-soda fizz is different because no gas was present at the start; a liquid and a solid were mixed and a gas appeared that neither contained, and the solid left behind has different properties from baking soda.

Why: The key move is asking where the gas was before. Bubbles count as evidence only when the gas is a substance that was not present before.

Also acceptable: Accept 'the pressure dropped so the gas came out' as the mechanism.

- Gas was dissolved in the drink before opening
- Bubbles here are a physical change, gas leaving a liquid
- Contrast: in the baking soda reaction the gas was not present before and the leftover solid differs

5. Rewrite Entry 4. Explain what a matching melting point can and cannot tell you, and name two more tests that would settle whether the jars hold the same substance.

Answer: Model rewrite: A matching melting point is consistent with the two powders being the same substance, but it does not prove it, because different substances can happen to melt at the same temperature. (Table salt melts at 801 °C, and other substances can share that value.) To settle it, compare two more characteristic properties at the same conditions: solubility in water at 20 °C and density. If both of those also match, the powders are very likely the same substance; if either differs clearly, they are different.

Why: This reverses the usual direction: a shared property does not prove identity, just as a changed property does prove difference. Tests must be characteristic properties, not appearance.

Also acceptable: Accept 'behavior with vinegar' or 'odor' as one of the tests, but at least one should be a measured value such as solubility or density.

- Shared melting point is consistent with but not proof of sameness
- States that different substances can share a melting point
- Names two more characteristic-property tests (solubility, density, boiling point, fizz with vinegar)

6. Rewrite Entry 5. Explain why the fizzing stopped, then describe a two-step test Theo could do with more vinegar and more baking soda to prove his new explanation.

Answer: Model rewrite: The fizzing stopped because one of the reactants, the baking soda, was all used up; the reaction keeps going only while both reactants are present, and energy does not 'run out'. Test, step 1: add more vinegar to the stopped cup. Prediction: no new fizz, because there is no baking soda left for it to react with. Step 2: add a pinch of fresh baking soda to the same cup. Prediction: fizzing starts again, because the leftover vinegar still has acid in it. The two results together show that the missing reactant, not missing energy, stopped the reaction.

Why: The leftover test is the chapter's direct evidence that a reaction stops when a reactant is consumed. Both steps and both predictions are required.

Also acceptable: If the student assumes the vinegar ran out instead, accept the mirror-image test (more baking soda does nothing; more vinegar restarts it) as long as the logic is consistent.

- Stopped because a reactant (baking soda) was used up
- Step with more vinegar predicting no fizz
- Step with more baking soda predicting fizz returns

7. Entry 6 reaches the right conclusion: a glow stick does work by a chemical reaction. Explain what is weak about Theo's reasoning, and say what kind of evidence would turn 'light' from a clue into proof.

Answer: Theo's reasoning treats light as proof. Light is a clue: it shows energy is being released, but a hot wire in a lamp gives light without any reaction, so light alone cannot prove a new substance formed. His conclusion happens to be right because glow sticks work by mixing two liquids that react, but he has not shown it. Proof would be a comparison of properties: for example, a chemist could show that the spent liquid no longer glows when more of one starting liquid is added (students never cut a glow stick open: the liquids irritate skin and eyes and the inner tube is glass), or a measured property of the liquid (its color, how much of a substance dissolves in it, its density) differs before and after the glow. A right answer with a weak reason is still a weak argument.

Why: This entry checks whether students can separate the truth of a conclusion from the quality of the reasoning. Any characteristic-property comparison, or the loss of the reactants' ability to glow again, earns credit.

Also acceptable: Accept 'the stick stops glowing and cannot be restarted' as the used-up evidence.

- Identifies light as a clue, not proof, with an example of light without reaction
- Acknowledges the conclusion is right
- Names a property comparison or a 'used up' test that would be proof

8. Rewrite Theo's rule so that it is correct. Your rule must say what the clues are good for, what counts as proof, and what to do when a change is seen but no test has been done. Three to five sentences.

Answer: Model rule: A temperature change, bubbles, a new color, light, or a solid vanishing are clues that something happened; they tell me to look closer, but each can also come from a physical change such as melting, boiling, dissolving or gas escaping from a drink. A chemical reaction is proved only when a characteristic property of what is left, such as solubility, melting point, density or odor, is measured under the same conditions as before and comes out different from the starting substance; two agreeing properties make the case strong. When I see a change but have not tested the properties, I write 'possible reaction, test needed' instead of a conclusion. Seeing nothing change does not prove a physical change either, because some reactions make products that look like the reactants.

Why: A full-credit rule separates clues from proof, names at least one characteristic property, gives the 'not yet tested' category, and avoids the mirror-image error that 'no visible change means physical change'.

Also acceptable: The final sentence about invisible reactions is a bonus; do not deduct if it is missing.

- Clues are reasons to test, not proof, with one physical change that shares a clue
- Proof is a changed characteristic property compared under the same conditions
- A 'test needed' category for untested changes
- Three to five sentences

Teacher notes

The six entries map onto the chapter's misconception list: temperature as proof (Entry 1), dissolving as disappearance (Entry 2), bubbles as proof (Entry 3), one shared property as identity (Entry 4), a reaction 'running out of energy' (Entry 5), and a clue treated as proof (Entry 6). Entry 6 is deliberately a correct conclusion so students practice separating the truth of a claim from the strength of its reasoning; glow sticks do work by a chemical reaction between two liquids that releases energy as light. Entry 4's 801 °C is the melting point of sodium chloride; the point is not to identify the powders but to see that one matching test is not proof. Expect debate on Entry 3; settle it by asking where the gas was before the cap came off. Collect q8 rules and build a class anchor chart with 'clue', 'proof' and 'test needed' columns.

Scaffold offered to students: Two questions for any change

Ask these two questions about every entry. Question 1: Is the substance at the end the same substance as at the start? (Melted ice is still water. Dissolved sugar is still sugar. Rust is not iron.) Question 2: What evidence would show it? A clue is something you can see or feel during the change: bubbles, heat, cold, light, a color. Proof is a measured property of the stuff that is left, compared with the same property of the stuff you started with, at the same temperature. If Theo's conclusion rests on a clue alone, the reasoning is weak even when the conclusion happens to be right.

Extension: Write two trap entries

Write two notebook entries of your own about changes you have seen outside school. One must have a wrong conclusion built on a clue, and one must have a right conclusion built on a weak reason, like Theo's glow stick. Swap with a partner, diagnose each other's entries and rewrite them. Then agree on the single most common mistake in your four entries and write one sentence explaining why that mistake is so easy to make.