

From Willow Bark to a White Powder: Proving Something New Was Made

Learning target: I can explain, with evidence from a passage, how chemists use measured properties such as melting point and solubility to prove that a reaction made a new substance, and how doctors judged competing medicines against criteria.

Reading with evidence

About 35 min

Individual

MS-PS1-2 · practice

MS-ETS1-2 · supports

MS-PS1-3 · supports

reading

writing

Name _____

Date _____

Period _____

Directions

Read the passage once straight through. Read it a second time with a pencil, numbering the paragraphs 1 to 7 and circling every number with a unit (a temperature or a year). Answer the questions in complete sentences. When a question asks for evidence, quote or closely paraphrase the passage and give the paragraph number.

You will need: This worksheet, Pencil, Scrap paper for the number list

From Willow Bark to a White Powder

[1] For thousands of years, people chewed willow bark or brewed it into a tea when they had a fever or aching joints. But nobody knew which substance in the bark was doing the work, or how to make more of it. In the early 1800s, chemists in Europe set out to find it. They could boil, filter, evaporate and crystallize, and they could measure a few properties of whatever they ended up with. What they could not do was see a single atom or molecule.

[2] By the late 1820s, chemists had separated a bitter white substance from willow bark and named it salicin. In 1838 an Italian chemist, Raffaele Piria, treated salicin with other chemicals and obtained a different white powder, which he called salicylic acid. Was it truly a new substance, or just salicin cleaned up? A powder's appearance cannot answer that question, because thousands of different substances are white powders. The answer comes from what chemists still do today: measure properties that every pure substance has in its own characteristic amount. Salicylic acid dissolved in water in a different amount than salicin did, and it melted at a different temperature. Different characteristic properties mean a different substance.

[3] Salicylic acid turned out to lower fever and ease pain. Doctors tried it on patients and judged it against two criteria: did it reduce fever and pain, and did it cause harm? It passed the first test but stumbled on the second. It was hard on the stomach, and some patients could not keep taking it. By 1859 a German chemist, Hermann Kolbe, had worked out how to make salicylic acid from cheaper starting chemicals, without any willow bark, and within fifteen years factories were producing it. The supply problem was solved. The side-effect problem was not.

[4] A French chemist, Charles Gerhardt, had already made a related substance in 1853 by reacting salicylic acid with another chemical, but his product was impure and he did not pursue it. In 1897 a chemist at the Bayer company in Germany, Felix Hoffmann, produced a pure form of that substance, acetylsalicylic acid. How could he know his white powder was not just salicylic acid again? The two look identical. Reference values show the difference: salicylic acid melts at about 159 °C, while acetylsalicylic acid melts at about 135 °C, and the two dissolve in water in different amounts. A melting point roughly 24 degrees lower is far more than any error in reading a thermometer.

[5] One changed property is a clue; several that agree make a case. Chemists also know that a lower melting point can come from an impure sample, because impurities make a solid begin melting early and over a wider range of temperatures. A pure substance melts within a degree or two of one temperature. So a careful chemist checks that the new powder melts sharply, at a temperature that stays the same after the powder is purified again, and that a second property, such as solubility, has also changed. Only then is the conclusion earned: a chemical reaction has turned one substance into another.

[6] Bayer began selling acetylsalicylic acid in 1899 under the name Aspirin. Doctors tested it on patients and compared the results with salicylic acid. It lowered fever and pain about as well, and patients tolerated it better. Judged against the same two criteria, the new design was the better solution, and within about twenty years it was one of the most widely used medicines in the world.

[7] The story does not end with a perfect medicine. Aspirin can still irritate the stomach, and today it is not usually given to children and teenagers for fevers because of a rare but serious illness it can trigger. Modern clinical trials are also far more careful than the patient tests of the 1890s: they compare a new medicine with an existing one and are reviewed for safety before they begin. What has not changed is the chemist's basic question. When a flask of one substance becomes a jar of white powder, the only way to know that something new was made is to measure its properties and compare them with what you started with.

Questions: cite the passage

1. According to paragraph 1, what could chemists in the early 1800s **do** to a sample, and what could they **not** do? Why does that matter for the rest of the passage?

2. Paragraph 2 says a powder's appearance cannot tell you whether it is a new substance. Quote the reason, then name the two properties that settled the question.

3. Using the melting points in paragraph 4, calculate how much lower acetylsalicylic acid melts than salicylic acid. Then, using paragraph 5, explain whether that difference could be a thermometer-reading error.

4. Paragraph 3 names two criteria doctors used. State both, and say which one salicylic acid failed, citing the words that tell you.

5. Paragraph 5 says a lower melting point is only a clue. Explain why, and describe the **two** extra checks a careful chemist makes before concluding that a reaction produced a new substance.

6. Kolbe's work in paragraph 3 solved one problem and left another. Name both problems, and explain why a cheaper way to make the same substance could not fix the second one.

7. Using paragraphs 6 and 7, explain why aspirin was judged the **better** solution and why the passage says it was still not a **perfect** one.

8. Do you agree with this claim: "A chemist can prove that a new substance formed without ever seeing an atom"? Support your answer with evidence from at least two different paragraphs.

Mark the numbers first

Before answering, list every number in the passage on scrap paper with its paragraph: late 1820s (2), 1838 (2), 1853 (4), 1859 (3), 1897 (4), 1899 (6), 159 °C (4), 135 °C (4), 24 degrees (4), 'a degree or two' (5), 'about twenty years' (6). Questions 3, 5 and 8 can be answered by finding the right number and rereading the sentences around it.

A third check

Reference values: salicylic acid dissolves about 0.22 g per 100 mL of water at 25 °C; acetylsalicylic acid dissolves about 0.33 g per 100 mL at the same temperature. Calculate how many grams of each would dissolve in 2 liters of water at 25 °C, then write a paragraph explaining why a solubility test must be done at the same temperature for both powders and what could go wrong if one beaker were warmer than the other.