

Fixing Priya's Notebook: Six Mistakes About Atoms and Elements

Learning target: I can find the errors in another student's statements about atoms, elements, matter and the periodic table, explain why each is wrong, and rewrite it correctly.

Error analysis

About 35 min

Individual

MS-PS1-1 · supports

writing

independent practice

Standards connections

MS-PS1-1 (supports): Students who confuse atom with element, or think invisible gases are not matter, build molecular models that are wrong in their basic parts. Clearing these errors prepares students for the PE's modeling work.

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

Answers with reasoning

Priya's notebook (copied exactly) — **1.** Atoms are really small, but if you use a strong enough magnifying glass you can see them. **2.** An element is one atom. A gold ring is one element made of many atoms, so each atom in the ring is also an element. **3.** Air is not matter because it has no mass and you cannot see it; that is why a balloon full of air feels like it weighs nothing. **4.** Lithium, beryllium and boron are in the same row, so they have the same properties. **5.** Mendeleev left empty spaces in his table because he made mistakes and had to fix them later. **6.** Atomic mass is different for every atom, so an atom of oxygen could easily have the same mass as an atom of sulfur. **7.** Scientists use picometers to describe atoms because a meter is far too big a unit for something on the atomic scale. **8.** The symbol for sodium is Na because it comes from the Latin name natrium, not from the English name.

Part A: Diagnose

1. Complete the table. For each incorrect statement, name in a few words the word or idea Priya got wrong.

Answer: 1 incorrect (magnifying glass; atoms are far below what light tools can show). 2 incorrect (element = one atom; confuses substance with particle). 3 incorrect (no mass; invisibility does not mean no mass). 4 incorrect (row; properties are shared down a column, not along a row). 5 incorrect (mistakes; the gaps were predictions). 6 incorrect (every atom different; each element has its own typical mass). 7 correct. 8 correct.

Why: Six errors and two correct statements, matching the directions. The 'few words' column is a quick check that the student located the broken idea before writing the full explanation.

Also acceptable: Accept any short phrase that points at the right idea (for example, 'row vs column' for statement 4).

Part B: Explain and rewrite

For each incorrect statement, write two things: (a) **What went wrong:** the mistaken idea behind the statement, and (b) **Rewrite:** the statement corrected so that it is scientifically true.

2. Statement 1 (magnifying glass). (a) What went wrong? (b) Rewrite it. In your rewrite, say what kind of tool did finally let scientists map individual atoms.

Answer: (a) Priya assumed that seeing small things is only a matter of magnifying more. But atoms are about a ten-billionth of a meter across, millions of times smaller than anything a magnifying glass or even a light microscope can show, so more magnification with light does not help. (b) Rewrite: 'Atoms are far too small to see with a magnifying glass or a light microscope. Scientists first mapped individual atoms on a surface in the 1980s with the scanning tunneling microscope, which uses a sharp probe and a tiny electric current instead of lenses and light.'

Why: The explanation must recognize that atoms are below the limit of light-based tools, and the rewrite must name the STM (or 'a probe that senses current').

Also acceptable: Accept 'STM' or 'a microscope with a probe that detects electric current' for the tool.

- Explains that atoms are far below what light tools can show
- Rewrite says atoms cannot be seen with a magnifying glass
- Names the scanning tunneling microscope or describes its probe

3. Statement 2 (an element is one atom). (a) What went wrong? (b) Rewrite it so that the words atom and element are each used correctly.

Answer: (a) Priya used element to mean a single particle. An element is a substance made of only one kind of atom; an atom is one particle of that substance. (b) Rewrite: 'A gold ring is made of the element gold, and gold is a substance made entirely of gold atoms. Each gold atom is one particle of the element gold, not an element by itself.'

Why: This is the lesson's most important distinction and the textbook's own vocabulary box blurs it; insist on substance versus particle.

Also acceptable: A rewrite such as 'Gold is an element; the ring contains a huge number of gold atoms' is sufficient.

- Identifies that element and atom were swapped or merged
- Rewrite uses element as a substance
- Rewrite uses atom as a single particle

4. Statement 3 (air is not matter). (a) What went wrong? (b) Rewrite it, and include one piece of evidence from this lesson that air has mass.

Answer: (a) Priya reasoned that invisible means weightless. Matter is anything with mass that takes up space, and air has both; it is simply made of particles too small to see. A balloon feels light because the air inside is only a few grams and the air outside pushes up on it, not because it has no mass. (b) Rewrite: 'Air is matter. It has mass and takes up space even though we cannot see it. A rigid basketball gained about 4.7 g on a balance after forty pump strokes of air, with no change in size.'

Why: The evidence should come from this lesson's phenomenon (the pumped ball) or the equivalent textbook observation that a filled balloon has more mass.

Also acceptable: Accept the textbook's filled-balloon observation as evidence, or the mass gain from W1 or W5.

- Breaks the link between invisible and massless
- Rewrite states air is matter with mass and volume
- Includes a specific mass-gain observation

5. Statement 4 (same row, same properties). (a) What went wrong? (b) Rewrite it using the words group and period correctly.

Answer: (a) Priya mixed up rows and columns. Elements that behave alike are stacked in the same column (group); a row (period) runs across elements whose properties change step by step. Lithium is a soft reactive metal, beryllium a harder metal and boron a hard non-metal, so they are very different. (b) Rewrite: 'Lithium, beryllium and boron are in the same period (row), so their atomic masses increase in order, but their properties are different. Elements with similar properties, such as lithium, sodium and potassium, are in the same group (column).'

Why: Both terms must be used correctly in the rewrite.

Also acceptable: Any correct same-group example (helium, neon, argon) is acceptable.

- Identifies the row-column confusion
- Rewrite uses period for row and group for column correctly
- Gives a same-group example or a reason the three differ

6. Statement 5 (Mendeleev's empty spaces). (a) What went wrong? (b) Rewrite it, and name one element that was later found to fill a space.

Answer: (a) Priya thought a gap meant a mistake. The gaps were deliberate predictions: when the next element by mass did not fit the column's behavior, Mendeleev left the space for an undiscovered element and predicted its mass and properties. (b) Rewrite: 'Mendeleev left empty spaces in his table on purpose, to stand for elements still waiting to be discovered, and he predicted their properties. Gallium (found in 1875), scandium (1879) and germanium (1886) later filled three of those spaces.'

Why: The rewrite must present the gaps as predictions and name at least one of gallium, scandium or germanium.

Also acceptable: Dates are not required.

- Explains that gaps were predictions, not errors
- Names gallium, scandium or germanium

7. Statement 6 (oxygen could weigh as much as sulfur). (a) What went wrong? (b) Rewrite it using the atomic masses of oxygen (16 Da) and sulfur (32 Da).

Answer: (a) Priya thought atomic mass varies freely from atom to atom. Each element has its own typical atomic mass, and the masses of different elements are far apart: oxygen atoms are about 16 Da and sulfur atoms about 32 Da, twice as much. (b) Rewrite: 'Every element has its own atomic mass. An oxygen atom has a mass of about 16 Da and a sulfur atom about 32 Da, so an oxygen atom never has the same mass as a sulfur atom.' Teacher note: at this lesson's level the book treats all atoms of an element as having the same mass. In reality the table value is an average; atoms of one element can differ slightly in mass (isotopes), but the differences are small compared with the gap between elements, so Priya's statement is still wrong.

Why: Students are not expected to mention isotopes. Accept rewrites that say 'all oxygen atoms have the same mass, 16 Da' as correct at this level, but if a student has heard of isotopes and writes 'about 16 Da on average,' that is the more accurate statement and deserves full credit.

Also acceptable: Either 'the same mass' or 'about the same mass (an average)' is acceptable for atoms of one element.

- Identifies the 'every atom different' idea as the error
- Rewrite uses 16 Da and 32 Da
- Rewrite says each element has its own typical mass

Part C: Step back

8. Statements 2 and 6 are both about the difference between one atom and a whole element. Write one sentence Priya could tape inside her notebook cover that would stop her from making both mistakes again.

Answer: Example: 'An atom is one particle; an element is the substance made of that kind of particle, and each element's atoms have their own typical mass.'

Why: One sentence that keeps particle and substance separate and attaches mass to the element's atoms covers both statements.

Also acceptable: Accept a shorter version such as 'Atom = one particle; element = a substance of one kind of atom with its own atomic mass.'

- Distinguishes atom (particle) from element (substance)
- Connects atomic mass to the element's atoms

9. Statements 7 and 8 are correct. Pick one and explain why it is correct, as if Priya had asked you to check it.

Answer: Statement 7: atoms are about a ten-billionth of a meter wide, so writing their size in meters needs ten or more decimal places; the picometer (one trillionth of a meter) fits the atomic scale the way kilometers fit road distances. Statement 8: chemical symbols sometimes come from older names; sodium's Latin name natrium gives Na, just as potassium's kalium gives K and lead's plumbum gives Pb.

Why: Either explanation earns credit if it gives the actual reason, not just 'the book says so.'

Also acceptable: Extra examples (K, Pb, Fe) are welcome.

- Picks one correct statement
- Gives the scientific or historical reason it is right

Teacher notes

Statement 6 is deliberately the subtle one. The textbook states that every atom of an element has one identical atomic mass; the accurate statement is that the table value is an average and atoms of one element differ only slightly (isotopes). Both versions make Priya's claim false, because oxygen (16 Da) and sulfur (32 Da) are far apart. Do not introduce isotopes to the whole class unless asked; the extension is there for students who are ready. Use the q1 table as a quick diagnostic: students who mark statement 2 or 3 as correct hold the two misconceptions that most affect later molecular modeling.

Scaffold offered to students: The 'because' test

A statement usually goes wrong at the word 'because' or 'so.' Underline that word in each of Priya's statements and ask: does the first half really lead to the second half? For statement 3, for example, 'you cannot see it' does not lead to 'it has no mass'; lots of things you cannot see have mass. Finding the broken link is the 'what went wrong' part of your answer.

Extension: Write the tricky ninth statement

Statement 6 hides a real subtlety. This lesson treats every atom of an element as having the same atomic mass, but the number on the periodic table is actually an average: atoms of one element can differ very slightly in mass (scientists call these variations isotopes), though never enough to match a different element. Write a ninth statement for Priya's notebook that is true at this lesson's level AND true at the more advanced level, then explain in two sentences what you had to leave out to keep it accurate for both.