

Atoms in Chemical Reactions: same atoms, new partners, same mass

25 slides · about 125 minutes of class time · Chemical Reactions

Each entry gives what to say or ask, the expected responses, misconceptions to listen for, the worksheet or lab it connects to, and pacing. Slide text is intentionally short; the explanation lives here.

Slide 1 · Atoms in Chemical Reactions · title · 2 min

In Lesson 12 students learned to tell that a reaction happened by looking at properties. This week we zoom in to the atoms and answer one question from two directions: where do the atoms go, and what does that mean for the mass on a balance? Tell students they will run three investigations: a mystery with three balances where mass is lost, kept and gained; a bead model where they regroup atoms and catch fake reactions; and a design challenge to trap every gram of gas a reaction makes. Students will never use a flame; the one burning demonstration is yours alone, or a described phenomenon.

Connects to: Overview of Lab 1, Lab 2 and Lab 3; W1 opens on the next slide.

Slide 2 · Two balances, two surprises · Phenomenon · 8 min

On the slide: Notice: which reading went down, which went up, and by how much? · Wonder: what could leave a cup, and what could join a steel pad? · Predict: run both inside sealed bags on the balance. What happens to each reading?

If you have a 0.1 g balance, run the fizzing cup live; it is safe and reliable. The steel wool burn is a teacher-only demonstration behind a shield on a heat-proof tray with goggles, or simply describe it with the numbers on the slide; the readings are illustrative values that are realistic for these amounts, not published measurements. Give two silent minutes for a notice and a wonder, then collect without judging. Push on the contradiction: one balance says matter vanished, the other says matter appeared. Ask whether a balance can lie. Park the two leading student claims, usually 'the gas is nothing' and 'the heat added weight', because the week will test both.

Expected responses: Notice: cup lost 1.1 g, steel wool gained 0.14 g. Wonder: did the bubbles weigh something; did the fire add something; would a bigger pad gain more. Predict: in a sealed bag the cup reading would stay the same; many will say the steel wool would still gain, which is the productive error.

Listen for: 'Gas has no mass' and 'heat is what was added.' Record them on a parking lot; return on slides 10, 16 and 23.

Connects to: W1 phenomenon worksheet records predictions for both balances. Lab 1 recreates all three cases (mass lost, kept and gained).

Slide 3 • What you will be able to do · Learning targets · 2 min

On the slide: Explain that a reaction breaks and forms bonds so the same atoms regroup into new substances. · Read a chemical equation: tell a coefficient from a subscript and count atoms on each side. · Sort a reaction by how its atoms regroup: break apart, join, swap, or a mix. · Use an atom model to explain why a closed system keeps its mass and an open one can seem not to. · Compare data from several process designs and combine their best features.

Read the targets aloud and have students star the one that sounds hardest. Point out that targets 1 to 3 are about what atoms do, target 4 is about what the balance does, and target 5 is the engineering strand at the end of the week. The exit ticket on the last day asks about all five.

Connects to: Targets map to Lab 2 (1-3), Lab 1 and W6 (4), Lab 3 and W9 (5), W10 (all).

Slide 4 • Zooming in: what a reaction actually does · content · 5 min

On the slide: Reactants are the substances you start with; products are the new substances that form. · A reaction breaks some bonds between atoms and forms new bonds. The atoms themselves stay whole. · The same atoms end up grouped differently, so the products have different properties. · No atom is created, destroyed or turned into a different element.

Use the bubbles from the phenomenon. Before: vinegar and baking soda, two substances with their own properties. After: carbon dioxide gas, water and a dissolved salt. Nothing was added except the mixing, so every atom in the products must have come from the reactants. Stress the sentence 'bonds break, atoms do not.' Students will meet the book's phrase 'atoms break apart' on its concept spread; tell them the careful version now. If someone asks whether atoms can ever change into other atoms, say yes in nuclear reactions, which are a different kind of change we are not studying, and that in every chemical reaction an atom keeps its identity.

Listen for: 'The atoms split' or 'carbon turned into oxygen.' Insist on the bond/atom distinction every time it comes up.

Connects to: Lab 2 bead models make the bonds (pipe cleaners) breakable and the atoms (beads) permanent.

Slide 5 • What changes in a reaction, and what never does · Model · 5 min

Walk both columns. Students are often surprised that the number of molecules can change: two hydrogen peroxide molecules become three molecules (two water, one oxygen), yet the atom count is identical. That is the difference between counting molecules and counting atoms, and it is why atoms, not molecules, are what we track. Introduce the party image on the caption: guests (atoms) change tables (molecules); nobody arrives or leaves. The last item on the right has a condition, 'if nothing leaves or enters,' and that condition is the whole of Lab 1.

Listen for: Students who hear 'the number of molecules changes' may conclude matter was made. Ask them to count atoms, not molecules.

Connects to: W2 vocabulary sort uses these two columns. Lab 1 tests the condition in the last right-hand item.

Slide 6 • Three words for talking about a reaction • Vocabulary in context • 4 min

Say the layout aloud: left of the arrow is what you had, right of the arrow is what you got, and the arrow means 'turns into.' Have students read the example equation as a sentence: two hydrogen peroxide molecules become two water molecules and a single oxygen molecule. Then ask which side the atoms that make the oxygen gas came from. From the left, there is nowhere else. That is the point of the next slide.

Listen for: Reading the arrow as an equals sign. The substances are different; only the atoms are the same.

Connects to: W2 vocabulary worksheet; Lab 2 reaction cards use this layout.

Slide 7 • Reading an equation as an atom inventory • content • 6 min

On the slide: A subscript (small, after a symbol) counts atoms inside one molecule: H_2O has 2 H and 1 O. • A coefficient (big, in front) counts whole molecules or formula units: $2\text{H}_2\text{O}$ means two water molecules. • Atoms of one element = coefficient $\times$ subscript. In 3O_2 there are $3 \times 2 = 6$ oxygen atoms. • Check: $2\text{H}_2\text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{O}_2$. Left: 4 H, 4 O. Right: 4 H, $2 + 2 = 4$ O. Same inventory. • Changing a subscript changes the substance. H_2O_2 is not 'water with extra oxygen'; it is hydrogen peroxide.

Do the count on the board slowly, element by element, and have students copy the two-column tally. Then give the key rule: a subscript belongs to the substance and cannot be touched; a coefficient is just how many of that substance you have. Use an analogy: 'bicycle' always has two wheels (subscript); '3 bicycles' is a coefficient and gives 6 wheels. Mention that for extended structures such as iron oxide there are no separate molecules, so the coefficient counts formula units, the smallest repeating group; the book says 'molecules' for both, and we will be more careful. Keep the activity at counting; students are not being assessed on balancing equations, so when a count does not match, the lab fix is to add or remove whole units with beads.

Listen for: Multiplying only the first element by the coefficient (reading $2\text{H}_2\text{O}$ as 4 H and 1 O). Make them say 'the coefficient multiplies everything in the formula.'

Connects to: Lab 2 recording sheet is an atom inventory for each reaction. W4 and W10 reuse the count.

Slide 8 • Quick check: count the oxygen • Check for understanding • 4 min

On the slide: Water can be split by electricity: $2\text{H}_2\text{O} \rightarrow 2\text{H}_2 + \text{O}_2$. How many oxygen atoms are on each side, and how many hydrogen atoms?

Whiteboards, ninety seconds. Walk the count: $2\text{H}_2\text{O}$ is two molecules, each with 2 H and 1 O, so 4 H and 2 O. On the right, 2H_2 is 4 H and O_2 is 2 O. The hydrogen tube in the book's picture holds twice the volume of the oxygen tube because there are twice as many hydrogen molecules; it does not hold twice the mass, and we will not use masses of atoms in this lesson.

Expected responses: B. Students who choose A or C have forgotten to multiply by the coefficient; D comes from ignoring the coefficient on H_2 .

Listen for: Reading the coefficient as applying only to the first atom in the formula.

Connects to: Lab 2 reaction card 1 is this reaction built in beads.

Slide 9 • Three ways atoms regroup · Model · 6 min

Give students a sorting rule they can apply without chemistry knowledge: count the substances on each side. One reactant, several products: break apart. Several reactants, one product: join. Two and two with the pieces traded: swap. Anything else is a mix. Have them practice on the methane equation: two reactants and two products, but it is not a clean swap because both reactants come apart completely. Two accuracy notes for you: the swap picture is bookkeeping for where atoms end up; in water the potassium nitrate is dissolved as separate ions, not bonded pairs. And Fe_2O_3 is a formula unit of a network solid, not a molecule, so ' $2\text{Fe}_2\text{O}_3$ ' means two repeating units.

Listen for: Students may think the pattern tells you how fast or how violent the reaction is. It only describes the regrouping.

Connects to: Lab 2 asks students to build and sort all four. W2 applies the sort to new equations.

Slide 10 • Why burning steel wool gets heavier · content · 5 min

Connect back to balance 2. Count with the class: 4 Fe and 6 O on the left, $2 \times 2 = 4$ Fe and $2 \times 3 = 6$ O on the right. The product is heavier than the iron alone because it contains six oxygen atoms that used to be in the air. Ask: if we had weighed the air too, would the total change? No. Two accuracy notes: the book's printed equation has a typo, ' $2\text{F}_2\text{O}_3$ ', and F is fluorine, so write Fe. And real burned steel wool can form more than one iron oxide; Fe_2O_3 is our model. Rust on a car is the slow cousin of this reaction and needs water as well as oxygen, which is why the steel-wool pads in Lab 1 are kept damp.

Listen for: 'The fire added the weight.' Heat is energy, not matter; it cannot register on a balance. The extra mass is oxygen atoms.

Connects to: Lab 1 station C (rusting pads) measures this gain without any flame. W7 repairs the 'heat added mass' error.

Slide 11 • Discuss: did the steel wool make new matter? · Think · pair · share · 6 min

On the slide: A classmate says, 'The steel wool gained 0.14 g, so burning created matter.' Argue against this using atoms, then design one test that would settle it.

On the slide: Where could 0.14 g of atoms come from if not from nowhere? · What would you have to include on the balance to catch those atoms before and after? · What reading would prove the classmate wrong? What reading would prove you wrong?

Pairs, four minutes, then collect. Steer toward the sealed-container test: put the steel wool and the air it needs in a closed jar on the balance, burn it inside (as a thought experiment or a video), and read the balance again. If the total stays the same, the gain on the pad was a transfer from the air. Push the last bullet: a good test says in advance what would count against you. If the sealed jar read heavier, the classmate would be right. It does not.

Expected responses: The oxygen atoms came from the air; weigh the pad and its air together in a sealed container; equal readings before and after support conservation, a higher reading would support creation.

Connects to: Lab 1 station C and the analysis questions; Lab 3 is the student version of 'include everything on the balance.'

Slide 12 • Numbers in a formula and what they count • Vocabulary in context • 4 min

Have students write each term next to a number in $2\text{Fe}_2\text{O}_3$ on their whiteboards: the 2 in front is the coefficient, the ₂ and ₃ are subscripts, Fe_2O_3 is one formula unit. Then ask the trick question: how many oxygen atoms in $2\text{Fe}_2\text{O}_3$? Six, from 2×3 . The reason we bother with 'formula unit' is honesty: iron oxide, table salt and most minerals are networks, not collections of little molecules, and the book calls everything a molecule.

Listen for: Changing a subscript to make a count come out even. Say it plainly: a changed subscript is a different substance.

Connects to: Lab 2 claimed-reaction cards include a 'fixed' equation that changed a subscript; W7 misconception repair.

Slide 13 • Quick check: coefficient or subscript? • Check for understanding • 3 min

On the slide: In the equation $4\text{Fe} + 3\text{O}_2 \rightarrow 2\text{Fe}_2\text{O}_3$, how many oxygen atoms are on the right side, and which number told you that?

Quick vote, then one sentence of reasoning from a student who chose C. Follow up: how many iron atoms on the right ($2 \times 2 = 4$) and does that match the left (4Fe)? Yes. Finish by asking what would happen to the substance if a student changed Fe_2O_3 to Fe_2O_2 to 'make the oxygen easier.' It would describe a different substance, which is not what forms.

Expected responses: C: $2 \times 3 = 6$ oxygen atoms. Students who answer B have added instead of multiplying.

Listen for: Adding the coefficient and subscript. Repeat the bicycle example: 3 bicycles have $3 \times 2 = 6$ wheels, not $3 + 2 = 5$.

Connects to: Lab 2 inventory table; W10 mastery.

Slide 14 • The law of conservation of matter • content • 5 min

On the slide: In every ordinary chemical or physical change, matter is neither created nor destroyed. • Reason at the atom level: atoms are only regrouped, and each atom keeps its own mass. • So the mass of the products equals the mass of the reactants, every time, for every reaction. • A scientific law describes a pattern that has held in every careful test. The atom model explains why. • The rule applies to chemical and physical changes. Nuclear changes are a separate topic.

Write the one-line version on the board: mass before = mass after. Ask the class which is the law and which is the explanation: the mass statement is the law (a pattern you can test with a balance); the atom story is the model that explains the pattern. This matches how the book separates laws from theories. Add the scope carefully: the book says the rule holds for 'any other change in matter,' but nuclear reactions can turn one element into another, so we say 'ordinary chemical and physical changes.' Then raise the obvious objection: balance 1 lost 1.1 g. Either the law is wrong or the measurement left something out. The next slide decides.

Listen for: Students may treat the law as a rule that is sometimes broken (burning, fizzing). It is never broken; the measurement is what fails to include everything.

Connects to: W3 reading passage on how the law was established; W6 CER.

Slide 15 • Open system or closed system: what does the balance see? • Model • 6 min

This is the slide that resolves the phenomenon. The cup was an open system, so the carbon dioxide left and took its mass with it. The steel wool was an open system in the other direction: oxygen came in. In both cases the atoms are still somewhere; the balance simply did not have them all. Have students define the boundary of each of the three Lab 1 stations before they weigh anything and predict which way the reading can move. Point out that energy can still cross a closed boundary; a sealed bag can warm or cool, and a sealed jar can be lit by a lamp. Closed means closed to matter. One measurement caution for Lab 1: a sealed bag that puffs up is lifted by the air it pushes aside, about 1.2 g for every liter of puff, so it reads lower on the balance even though its mass has not changed; a rigid container that cannot swell reads exactly the same.

Listen for: 'Closed means nothing can get in or out at all.' Energy can; matter cannot. This matters in Lesson 14.

Connects to: Lab 1 recording sheet asks for the boundary and a prediction at each station. Lab 3 designs a closed boundary.

Slide 16 • Quick check: the cup that lost 1.1 g • Check for understanding • 4 min

On the slide: The open cup of vinegar and baking soda read 142.6 g before and 141.5 g after. Which statement is correct?

Vote, then ask a B voter to explain where the carbon and oxygen atoms in the gas came from (the baking soda and the vinegar). Then ask: if we sealed the cup inside a rigid container before mixing, what would the reading do? Stay at 142.6 g. (Inside a zip bag the mass would also stay 142.6 g, but the puffed-up bag would read about 0.7 g low because the air around it lifts it; see the Lab 1 teacher notes.) A student may ask why a bit less than the whole gas escapes; some carbon dioxide stays dissolved in the liquid, so a real open-cup loss is a little smaller than the total gas made. That is a good observation, not an error.

Expected responses: B. The gas has mass; it left the system. Sealing the system would keep the mass at 142.6 g; a rigid container would also read 142.6 g, while a puffed-up bag reads lower because of the air's lift.

Listen for: Choosing C: temperature changes do not change mass. The balance measures mass, not temperature.

Connects to: Lab 1 stations A and B test the open and sealed versions. W5 data worksheet; W6 applies the same open-versus-sealed reasoning to a burning candle.

Slide 17 • Words for the law and for the boundary • Vocabulary in context • 4 min

Ask students to sort three systems they know: a sealed can of soda (closed until opened), a boiling pot without a lid (open: steam leaves), a sealed terrarium under a lamp (closed to matter, open to light energy). Then have them write one sentence using 'open system' to explain balance 2 from the phenomenon slide. Remind them that the law never stops being true in an open system; it is just harder to see because you have to count the atoms that crossed.

Listen for: 'Open system means the law does not apply.' It always applies; the system boundary decides what the balance can see.

Connects to: W2 vocabulary; Lab 1 boundary table.

Slide 18 • California connection: a bridge that is always being painted • Real-world

connection • 4 min

This is a true example and students may have seen the bridge. Ask: what is the paint actually doing at the atom level? It is a boundary that keeps oxygen and water molecules from reaching iron atoms. Ask why salt fog makes it worse: salty water speeds the reaction, which is also why cars rust faster near the coast or on salted roads. Connect to Lab 1: the damp steel-wool pads rust faster than dry ones for the same reason, water is a necessary partner. Keep the engineering idea simple: you cannot stop the law of conservation of matter, but you can control the boundary so the reaction cannot happen.

Connects to: Lab 1 station C; W9 transfer problem can use corrosion control as a design context.

Slide 19 • Atom accounting in a factory: where does every atom go? • content • 5 min

On the slide: Every reactant atom ends up in a product. Some products are wanted; the rest are waste. • Chemists measure a process by its atom economy: the share of reactant mass that lands in wanted products. • Making ibuprofen in the 1960s took six reaction steps and sent about 60 percent of the reactant mass to waste. • 1990s: a reusable catalyst cut it to three steps; about 77 percent of the mass became ibuprofen. • A by-product, acetic acid, was collected and used elsewhere instead of discarded: about 99 percent useful.

Conservation of matter has a consequence engineers cannot escape: waste is not something that disappears, it is atoms that went to the wrong product. So a green chemist's first question is how to send more atoms into the wanted product. Explain a catalyst as a helper that is not used up and can be recovered, so it does not become waste. Give the ibuprofen story as a design example: fewer steps meant fewer reactants and less waste, and collecting the acetic acid turned a waste product into a useful one. Accuracy notes for you: the efficiency figure is a calculated percentage from the balanced equations, not a weighing of a batch; the book prints both 75 and 77 percent for the three-step process, and 77 (or 'about 80') is the right figure; the polyvinyl alcohol detail in the book is not verified, so we only say the acetic acid was collected and used.

Listen for: 'Efficient means fast.' Atom economy is about where the atoms go, not about speed.

Connects to: W3 reading; W9 transfer problem; Lab 3 criteria include waste.

Slide 20 • Three designs for the same medicine • Model • 4 min

Read the bars with the class. Ask what the gap above each bar represents: atoms that went to waste. The jump from 40 to 77 came from a different route with fewer steps and a catalyst that is recovered; the jump from 77 to 99 came from reclassifying a by-product as useful by finding a use for it. Point out the engineering pattern that the standard MS-ETS1-3 names: the second solution did not throw away the first; it added to it. The 40 and 99 percent figures match EPA's Green Chemistry Challenge records; 77 percent is the textbook's figure ($206 \div 266$), which EPA rounds to about 80. The exact numbers depend on how the calculation is set up, so treat them all as 'about.'

Listen for: Students may think 99 percent means almost no waste in the building. It means almost no reactant atoms went to unwanted products; energy use and other issues are separate.

Connects to: The task on the next slide; W5 data worksheet graphs a similar comparison.

Slide 21 • Task: which features should the engineers combine? • Apply it • 10 min

On the slide: Three test runs of a new cleaning-product process gave the data below. Identify the best characteristic of each design, then propose a combined design and predict its results.

This is a teaching dataset, invented so the numbers are clean; say so. Groups get eight minutes. Step 1: check conservation in every row: product plus waste must equal 100 kg (45 + 55, 70 + 30, 60 + 40), which it does, because atoms do not vanish. Step 2: name the strongest feature of each design. A is weak everywhere except that it is simple to run; B has the fewest steps, a recovered catalyst and the most product; C is fastest and turns its waste into a product someone buys. Step 3: combine: B's three catalytic steps plus C's idea of selling the by-product, and look for why C is faster. Step 4: predict: product stays about 70 kg, but the 30 kg of 'waste' may become useful, so the useful share could approach 100 percent. Insist that predictions keep the 100 kg total.

Expected responses: Best features: B for fewest steps, recovered catalyst and highest product; C for speed and for selling the by-product; A offers little beyond simplicity. Combined design: B's route plus C's by-product sale, aiming for about 70 kg product and 30 kg sold by-product from 100 kg of reactants, with time somewhere between 5 and 9 hours. Any prediction that adds to more than 100 kg is wrong.

Listen for: Groups that pick one design and stop. The standard asks them to combine characteristics, not crown a winner.

Connects to: Lab 3 session 2 does this with the class's own gas-trap data. W9 transfer problem is a fuller version.

Slide 22 • Discuss: is there really such a thing as 'throwing it away'? • Think • pair • share • 6 min

On the slide: At the atom level, what happens to the carbon dioxide from the open cup, the oxygen that joined the steel wool, and the waste from a factory? Where is 'away'?

Pairs, four minutes. Steer toward the realization that atoms always go somewhere: into the air, into water, into soil, into another substance. The open cup's carbon dioxide is now part of the room's air; the oxygen on the steel wool came out of the room's air; a factory's waste atoms end up in a landfill, a river or the atmosphere unless a chemist finds a product for them. Ask: if atoms cannot be destroyed, what are the only two options for waste? Store it somewhere, or turn it into something useful. That is the whole reason green chemistry exists, and it is the reason conservation of matter is an engineering idea as much as a science idea.

Expected responses: Atoms are conserved, so 'away' is just another place: air, water, ground, or another product. The two choices are to store waste or to redesign so it becomes a product.

Connects to: W8 collaborative stations; Lesson 15 (Chemical Engineering and Society) continues this thread.

Slide 23 · True or false? Burning destroys most of the wood · Misconception check · 6 min

Statement shown: “When a log burns in a campfire, almost all of it is destroyed. Only a little ash is left, so this is a case where matter is not conserved.”

Have students write a verdict with evidence before any discussion. The wood is mostly carbon, hydrogen and oxygen atoms. Burning joins the carbon and hydrogen with oxygen from the air to make carbon dioxide and water vapor, which rise with the heat; the ash is the small part that was not turned into gas. Ask them to imagine the campfire inside a giant sealed, see-through box on a balance: the box would read the same before and after, because every atom of wood and the oxygen it used is still inside. Then flip it: the gases plus ash together have more mass than the wood alone, by exactly the mass of oxygen that joined in. Same rule as the steel wool.

Expected responses: False. Most of the wood's atoms left as gases (carbon dioxide and water vapor) that have mass; in a sealed box the mass would be unchanged. The products even outweigh the wood because oxygen from the air joined them.

Listen for: Students who accept conservation for the fizzing cup but not for burning. Both are open systems with a gas leaving; burning also has a gas (oxygen) coming in.

Connects to: W7 misconception worksheet; W6 CER.

Slide 24 · Putting it together · Putting it together · 6 min

On the slide: A reaction breaks and forms bonds; the atoms stay whole and keep their identity. · A chemical equation is an atom inventory: coefficient × subscript, the same count on both sides. · Atoms regroup by breaking apart, joining, swapping, or a mix. Count substances to sort. · Atoms are conserved, so mass is conserved. A closed system shows it; an open one hides it. · Engineers use atom accounting to send more reactant atoms into products and fewer into waste.

Have students write a three-sentence explanation of both balances from the first day, using at least four vocabulary terms, then trade with a partner who checks that 'open system' and 'conserved' are used correctly. Ask for one thing from each lab: Lab 1 (which station went up and why), Lab 2 (one claimed reaction they rejected and the atom that was missing), Lab 3 (one feature they borrowed from another group's design). Preview Lesson 14: the same reactions also absorb or release energy, and energy is not an atom, so it is tracked separately.

Connects to: W10 mastery as the quiz; L14 Energy in Chemical Reactions next.

Slide 25 • Exit ticket • Exit ticket • 5 min

On the slide: In $2\text{Fe}_2\text{O}_3$, how many iron atoms and how many oxygen atoms? Show the multiplication. • The fizzing cup lost 1.1 g and the steel wool gained 0.14 g. Explain both with one rule. • Name the regrouping pattern for $2\text{H}_2\text{O} \rightarrow 2\text{H}_2 + \text{O}_2$ and for $4\text{Fe} + 3\text{O}_2 \rightarrow 2\text{Fe}_2\text{O}_3$. • A sealed, rigid bottle of reactants reads 85.0 g before the reaction. What does it read after, and why?

Collect on index cards or a shared form. Item 1 checks coefficient versus subscript; item 2 is the heart of the lesson; item 3 checks the sort; item 4 checks the closed-system idea. Sort the cards before the next class and reteach from the largest pile; items 2 and 4 together tell you whether students see the open cup and the sealed bottle as the same law.

Expected responses: 1: 4 Fe (2×2) and 6 O (2×3). 2: atoms are conserved; in an open system atoms cross the boundary, carbon dioxide left the cup and oxygen from the air joined the iron, so the readings changed while total matter did not. 3: break apart; join together. 4: 85.0 g, because no atoms can enter or leave the sealed bottle, every atom keeps its mass, and a rigid bottle cannot puff up.

Listen for: Item 2 answers that explain the cup but say the steel wool 'made' mass or gained it from heat.

Connects to: W10 mastery; chapter evidenceOfLearning.