

The Shrinking Candle: Was Any Matter Destroyed?

Learning target: I can use mass data, product tests and the atom model to argue, in a Claim-Evidence-Reasoning paragraph, that a burning candle loses mass without any matter being destroyed.

Claim, evidence, reasoning

About 40 min

Individual

MS-PS1-5 · assesses

writing

data analysis

Standards connections

MS-PS1-5 (assesses, using a model of conserved atoms to explain a mass change): Students must use the idea that atoms regroup but are never created or destroyed to explain why an open candle loses mass while a sealed one does not. Their written argument is evidence toward the PE. The sheet gives no equation to balance and uses no atomic masses; the only numbers are balance readings.

Purpose: assess · **Time:** about 40 minutes · **Format:** individual

Answers with reasoning

The scenario

Ms. Okafor set a short candle in a small metal dish on a balance that reads to 0.01 g, lit it, and read the balance every two minutes for ten minutes while it burned in the open air. Then she took a second, identical candle, lit it, and lowered a 1-liter glass jar over it onto a plate with a rubber gasket so that no air could get in or out. The jar, plate, candle and dish all sat on the balance together. The flame went out after about 15 seconds. She kept reading the balance for five minutes. A student asked, 'The first candle lost mass. Where did it go? Was it destroyed?' Your job is to answer with evidence.

Run 1: candle burning in open air (teaching dataset)

Simulated teaching dataset: the numbers are invented to be realistic, not measured.

Time (min)	Balance reading (g)
0	48.20
2	47.88
4	47.56
6	47.24
8	46.92
10	46.60

Simulated data for teaching, realistic for a small candle. The dish and candle were weighed together.

Run 2: candle sealed under a jar (teaching dataset)

Simulated teaching dataset: the numbers are invented to be realistic, not measured.

Time (min)	Balance reading (g)	Flame
0	612.40	lit
1	612.40	out (went out at about 15 s)
3	612.40	out
5	612.40	out

Simulated data for teaching. The jar is rigid glass, so its size did not change. The whole sealed setup was on the balance.

Observation notes from the demonstration — 1. A cold, dry drinking glass held upside down above the open flame fogged up within seconds; the fog was tiny droplets of water. 2. Gas collected from just above the flame and bubbled through limewater turned the limewater cloudy, which is the standard test for carbon dioxide. 3. Candle wax is a mixture of molecules made of carbon and hydrogen atoms. 4. Inside the sealed jar, the glass fogged, and when the jar was lifted after the run the air inside smelled smoky. 5. After Run 2 the wick was blackened and a little wax at the top had melted and hardened again; so little wax had burned that the candle did not look any shorter.

Warm-up: organize the evidence

1. Calculate the total mass lost in Run 1 and the average loss per minute. Then describe the pattern in the readings: did the candle lose mass in equal steps or not?

Answer: Total loss: $48.20\text{ g} - 46.60\text{ g} = 1.60\text{ g}$. Average loss per minute: $1.60\text{ g} \div 10\text{ min} = 0.16\text{ g/min}$. The readings drop by exactly 0.32 g every two minutes (48.20, 47.88, 47.56, 47.24, 46.92, 46.60), so the candle lost mass in equal steps: a steady flame burns wax at a steady rate.

Why: Both the total and the rate come straight from the table; the equal steps distinguish a steadily burning candle from the fizzing reaction, which slowed as it ran out of reactant.

Also acceptable: Accept 0.16 g per minute or $0.32\text{ g per two minutes}$ with the pattern described as steady or constant.

2. Notes 1 and 2 are tests on the gases above the flame. What two substances do they show were being produced? Which atoms in each of those substances came from the wax, and which came from somewhere else?

Answer: Note 1 shows water (the fog is tiny droplets of water); note 2 shows carbon dioxide (cloudy limewater). In water, the hydrogen atoms came from the wax and the oxygen atom came from the air. In carbon dioxide, the carbon atom came from the wax and the two oxygen atoms came from the air.

Why: Note 3 says wax is made of carbon and hydrogen, so those are the only atoms the wax can supply; the oxygen in both products must come from the air, which is why the flame needs air.

Also acceptable: Accept 'water vapor' for water and ' CO_2 ' for carbon dioxide.

- Names water and carbon dioxide
- Assigns carbon and hydrogen to the wax
- Assigns oxygen to the air

3. In Run 2 the flame went out after about 15 seconds and the reading never changed. Explain both facts: why the flame died, and why the reading stayed at 612.40 g even though some wax burned.

Answer: The flame died because burning needs oxygen from the air and the sealed jar held only a limited amount; once the oxygen near the flame was used up, the reaction could not continue. The reading stayed at 612.40 g because the jar was sealed: the wax that burned became carbon dioxide and water vapor, but those gases stayed inside the jar, where the balance was still weighing them. The candle lost mass, the air in the jar gained the same amount, and the total did not change.

Why: Two separate ideas: oxygen as a reactant that runs out, and the sealed boundary that keeps the products on the balance. Both are needed for full credit.

Also acceptable: Accept 'the jar ran out of oxygen' and 'the gases could not escape' as the two explanations.

- Flame went out because the oxygen inside was used up
- Reading held because the gaseous products stayed inside the sealed jar
- States that the candle's loss equals the air's gain

Your argument

Answer: Claim: No matter was destroyed; the 1.60 g the open candle lost is now in the air of the room as carbon dioxide and water vapor. Evidence: (1) In Run 1 the reading fell from 48.20 g to 46.60 g, a loss of 1.60 g in equal steps of 0.32 g every two minutes, so matter was steadily leaving the dish. (2) The fogged glass (note 1) and the cloudy limewater (note 2) show that water and carbon dioxide were being produced above the flame; both are gases at flame temperature, and gases drift away. (3) In Run 2, with the same kind of candle sealed under a jar, the reading stayed at 612.40 g for the whole five minutes even though wax burned (the blackened wick in note 5) and the glass fogged (note 4). (4) The flame in the jar went out after about 15 seconds, showing that the burning used up something from the air. Reasoning: Candle wax is made of carbon and hydrogen atoms (note 3). When wax burns, bonds break and the carbon and hydrogen atoms bond to oxygen atoms from the air, making carbon dioxide and water. Atoms are never created or destroyed in a reaction, and each atom keeps its mass, so the mass of the wax plus the mass of the oxygen it used equals the mass of the gases made. In the open air those gases crossed the boundary of the dish and left, so the balance stopped weighing them and the reading fell by 1.60 g. Under the sealed jar the same gases were made but could not leave, so the balance kept weighing every atom and the reading never changed. If burning destroyed matter, the sealed jar's reading would have fallen as its wax burned; it did not. The difference between the two runs is only whether the atoms could leave, which proves the mass was moved, not destroyed.

Why: This is the solved model response. Full credit requires a claim that says no matter was destroyed and names where the mass is, at least three evidence items with numbers or note references and what each shows, and reasoning that tracks the atoms from wax and air into the gaseous products and uses the sealed run as the decisive comparison.

Also acceptable: A student who claims the mass is 'in the smoke and gases' without naming the products can earn full credit on the claim if the evidence names them. A student who argues matter was destroyed has ignored Run 2; that response earns partial credit for evidence organization only.

- Claim says no matter was destroyed and locates the mass in the gases in the room
- At least three evidence items with specific numbers or note references
- Each evidence item says what it shows
- Reasoning tracks carbon and hydrogen from the wax and oxygen from the air into carbon dioxide and water
- Reasoning uses the sealed run to rule out destruction

4. After Run 2, Ms. Okafor lifted the jar and weighed the candle and dish by themselves. Predict whether that reading was higher than, lower than, or the same as at the start, and say exactly where the difference is at that moment. Then explain what the air inside the jar gained or lost.

Answer: Lower, by only a few hundredths of a gram. The candle and dish alone would read less than at the start, because some wax burned and its carbon and hydrogen atoms left the candle as gases. At that moment the difference is in the jar's air as carbon dioxide and water (some of the water is the fog on the glass). The air inside the jar lost oxygen atoms, which bonded to the wax atoms, and gained the carbon dioxide and water molecules; the air's total mass rose by exactly what the candle lost, which is why the sealed reading never moved.

Why: The candle and the air are two parts of one closed system; mass moved from one part to the other while the sum stayed the same. Students should name both directions: oxygen out of the air into the products, products into the air.

Also acceptable: Accept 'the candle is lighter by the same amount the jar's air got heavier.'

- Predicts a lower reading for the candle alone
- Locates the difference in the gases inside the jar (and the fog)
- Says the air lost oxygen and gained the product gases, so its mass rose by the same amount

Scoring rubric

Criterion	4 • Exemplary	3 • Proficient	2 • Developing	1 • Beginning
Claim	One clear sentence stating that no matter was destroyed and that the lost mass is now in the room's air as carbon dioxide and water.	States that no matter was destroyed; the location of the mass is vague ('in the air') or missing.	Claim is hedged or mixed (for example, 'some was destroyed and some became gas').	No claim, or a claim that matter was destroyed.
Evidence	Three or more specific pieces of evidence with numbers or note references, including the sealed-jar reading, each stating what it shows.	Three pieces of evidence, but one lacks a number or does not say what it shows, or the sealed run is not used.	One or two pieces of evidence, or evidence listed without connecting it to the question.	Evidence is missing, invented, or contradicts the data.
Reasoning	Tracks carbon and hydrogen atoms from the wax and oxygen atoms from the air into the gaseous products, states that atoms keep their mass, and uses the open-versus-sealed comparison to rule out destruction.	Uses the atom model and the open-versus-sealed comparison, but does not trace which atoms came from where.	Restates the evidence or says 'the gas escaped' without the atom model, or gives the atom model without connecting it to the two runs.	No reasoning, or reasoning that treats heat or light as the lost mass.
Scientific language and accuracy	Uses reactant, product, atom, bond, closed system or open system correctly; says bonds break, not atoms; no scientific errors.	Terms mostly correct; one slip (for example, 'weight' for mass, or 'the wax turned into energy' alongside a correct atom account).	Several terms used loosely (atoms 'burn up', gas 'weighs nothing', molecules and atoms confused).	Scientific language absent or consistently wrong.

Teacher notes

The data are simulated and labeled as such. They are realistic: a small candle burns roughly 0.1 to 0.2 g of wax per minute, and a rigid sealed jar on a balance shows no change because the volume of the setup does not change (a sealed bag that inflates would read noticeably lighter because of the air it displaces, about 1.2 g per liter of puff, which is why a glass jar is specified). Run 2 is realistic only because it is small: a 1-liter jar holds about 0.28 g of oxygen, and a candle goes out after using roughly a quarter of it, so only a few hundredths of a gram of wax burns, the flame lasts roughly 10 to 20 seconds and the candle does not look shorter. The sealed run shows that the burning that did happen lost nothing; the product tests and the open run carry the rest of the argument. The fogging-glass and limewater tests are standard product tests; paraffin wax is a mixture of hydrocarbons, so students need no formula and the sheet gives none, which keeps the task inside the MS-PS1-5 boundary (no balancing, no atomic masses). If you run the demonstration, the teacher handles all flame; use a heat-proof plate, keep the jar size modest, and note that the glass gets hot. The sheet matches the teacher note in W1, which flagged this as the candle CER that revisits students' first explanations: students who wrote in W1 that heat or energy accounts for the mass change should be directed to note 3 and the sealed run. Watch for arguments that say 'the candle turned into energy'; the candle releases energy, but the balance reads mass, and the atoms are all accounted for in the gases.

Scaffold offered to students: Evidence sentence frames

For each piece of evidence, write one sentence in this shape: 'The _____ (reading, test or note) shows _____ because _____.' Example: 'The sealed reading of 612.40 g at every time shows that nothing left the jar because a sealed system keeps all its atoms.' For reasoning, use this chain in order: the wax's carbon and hydrogen atoms bonded to oxygen atoms from the air; the new substances were gases; in the open the gases drifted away with their mass; under the jar they stayed and were weighed. Remember that an atom's mass does not change when it changes partners.

Extension: The argument in reverse

A steel wool pad burned in open air gains mass (2.00 g becomes 2.14 g). Write a second, shorter Claim-Evidence-Reasoning argument, five to seven sentences, that uses the same atom model to explain the gain. Then explain why the candle and the steel wool, one losing and one gaining, are actually evidence for the same law. Finish by describing one sealed experiment that would test both at once, and the reading you would expect.