

Where Did the Oxygen Go? A Sealed-Jar Claim-Evidence-Reasoning Case

Learning target: I can use data from a sealed model biosphere to argue what caused its oxygen to fall, explain the reasoning with energy and matter, and say how the model should be changed for the next test.

Claim, evidence, reasoning

About 45 min

Individual

MS-ETS1-4 · practice

MS-LS2-3 · supports

writing

data analysis

Standards connections

MS-ETS1-4 (practice): Students analyze data generated by a physical model, decide what the data reveal about the design, and propose a modification for the next test. This is the iterative test-and-modify practice the PE names, done on a model someone else built.

MS-LS2-3 (supports): Explaining the oxygen drop requires tracing matter (oxygen, carbon dioxide) and energy (sunlight in, heat from decomposition) among living and nonliving parts of a closed model, which is background for the ecosystem model this PE asks for.

Purpose: practice · **Time:** about 45 minutes · **Format:** individual

Answers with reasoning

The scenario

A seventh-grade class built three sealed 4-liter glass jars as small models of a biosphere. Each jar held the same three small, healthy plants, the same 200 mL of water, and the same air to start. The only planned difference was the soil: **Jar A** had washed, baked sand; **Jar B** had ordinary garden soil; **Jar C** had garden soil mixed with a cup of fresh compost (partly rotted leaves and vegetable scraps). Each jar was sealed with a lid and wax so that no air, water or soil could get in or out, placed on the same sunny windowsill, and fitted with small sensors that read the percentage of oxygen and of carbon dioxide in the jar's air every five days for thirty days.

Oxygen and carbon dioxide in the three sealed jars (teaching dataset)

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

Day	Jar A oxygen (%)	Jar B oxygen (%)	Jar C oxygen (%)	Jar A carbon dioxide (%)	Jar B carbon dioxide (%)	Jar C carbon dioxide (%)
0	20.9	20.9	20.9	0.04	0.04	0.04
5	21.0	20.5	19.6	0.03	0.1	0.25
10	21.1	20.1	18.4	0.03	0.15	0.45
15	21.1	19.8	17.3	0.03	0.2	0.65
20	21.2	19.5	16.4	0.03	0.24	0.85
25	21.2	19.3	15.7	0.03	0.27	1.0
30	21.3	19.1	15.1	0.03	0.3	1.1

Simulated data written for teaching. The pattern is realistic for sealed jars with and without decomposing material, but these numbers were not measured in a real classroom.

Observation notes from the class log — Day 5: Jar C's glass is fogged every morning and the soil surface has turned darker; a thermometer taped to Jar C's glass reads 1 °C warmer than the other two jars overnight. Day 15: all plants in all three jars are green and upright; Jar C's soil has a few white threads of fungus. Day 30: all plants still alive; Jar A's plants have grown the least, Jar B's the most. No jar leaked (the wax seals were checked with a soap-film test each week).

Warm-up: organize the evidence

1. Calculate the change in oxygen from day 0 to day 30 for each jar (final minus starting). Which jar changed the most, and in which direction?

Answer: Jar A: $21.3 - 20.9 = +0.4$ percentage points (a small rise). Jar B: $19.1 - 20.9 = -1.8$ points. Jar C: $15.1 - 20.9 = -5.8$ points. Jar C changed the most, downward.

Why: Final minus starting for each jar; the sign matters. Jar A's slight rise shows the plants alone add a little oxygen.

Also acceptable: Accept answers written as 'dropped 5.8%' as long as the direction is clear.

2. Describe what the carbon dioxide readings did in each jar over the thirty days, and how the carbon dioxide pattern compares with the oxygen pattern.

Answer: Jar A's carbon dioxide stayed almost flat (0.04 to 0.03). Jar B rose steadily from 0.04 to 0.30. Jar C rose the most, from 0.04 to 1.10. The carbon dioxide pattern is the mirror image of the oxygen pattern: the jar that lost the most oxygen gained the most carbon dioxide.

Why: The mirror pattern is the clue that oxygen was being used by something that releases carbon dioxide, which is what respiration by living things does.

Also acceptable: Accept 'opposite' for mirror image.

- Describes all three jars
- States the mirror-image relationship with oxygen

3. Each jar was sealed so that no matter could enter or leave. Name one form of energy that **could** still cross the glass, and explain why the plants needed it.

Answer: Sunlight (radiation) crossed the glass; heat could also pass out through the glass. The plants needed sunlight to make their food (and release oxygen); without energy entering, nothing in the jar could keep going, because matter cannot be brought in to replace what is used.

Why: This is the accurate meaning of a system closed to matter but open to energy; it also explains why Jar A's oxygen crept up.

Also acceptable: Accept 'energy from the sun' without the word radiation.

- Names light or heat as energy crossing the glass
- Connects sunlight to the plants' food-making

Your argument

Answer: Claim: The oxygen in Jar C fell because living things in the compost (bacteria and fungi, the decomposers) used it up as they broke down the rotting material, faster than the plants could replace it. Evidence: (1) Jar C lost 5.8 percentage points of oxygen while Jar B lost 1.8 and Jar A gained 0.4; the only planned difference was the soil, and Jar C's soil had the most rotting material. (2) Jar C's carbon dioxide rose from 0.04% to 1.10%, the mirror image of its oxygen loss; living things that use oxygen release carbon dioxide. (3) The plants cannot be the cause: all three jars had the same plants, and Jar A, with sand, gained oxygen, so the plants add oxygen rather than removing it. (4) A leak is ruled out: the soap-film test found no leaks, and a leak would have pulled oxygen toward 20.9%, not down to 15.1%. (5) The log notes Jar C's soil darkened, grew fungus threads, and ran 1 °C warmer, which are signs of active decomposers releasing energy as heat. Reasoning: Decomposers get their energy by breaking down dead matter, and that process uses oxygen from the air and releases carbon dioxide. In a sealed jar no fresh air can come in, so every bit of oxygen the decomposers use is subtracted from the same 4 liters, and the carbon dioxide they release piles up. Sunlight still entered through the glass, so the plants kept making some oxygen (which is why Jar A rose), but in Jar C the compost held far more food for decomposers than the three small plants could balance. The warm soil is the energy the decomposers released as heat. Matter inside the jar only changed form (oxygen became carbon dioxide and water); it was the sealed lid that turned a normal soil process into a falling oxygen reading.

Why: This is the solved model response. Full credit requires a claim naming decomposers in the compost, at least three evidence items with numbers that each support or rule out a suspect, and reasoning that explains where the oxygen went (used by decomposers, becoming carbon dioxide), what they gained (energy, seen as heat), and why the seal matters (no replacement from outside).

Also acceptable: A student who claims 'the compost used the oxygen' without naming living things has the right direction; award the claim level 3 and prompt for who in the compost. A student who blames the plants has ignored Jar A and the identical plants; partial credit for evidence organization only.

- Claim names living things in the compost (decomposers, bacteria, fungi)
- At least three evidence items with numbers
- Evidence rules out a leak and the plants
- Reasoning explains oxygen used by decomposers and carbon dioxide released
- Reasoning explains that the sealed lid prevents replacement
- Energy is mentioned (sunlight in, heat from decomposition)

Design the next test

4. The class wants Jar C's design to keep oxygen above 19% for thirty days while still having rich soil. Propose one specific change for the next version of the jar, and name the data you would collect to find out whether the change worked.

Answer: Examples of specific changes: use less compost (half a cup) or fully finished compost instead of fresh scraps; add more plants or larger plants so oxygen production rises; use a larger jar so the same decomposition changes the percentage less; add a water plant or algae in the water. Data to collect: the same oxygen and carbon dioxide readings every five days, plus a note on plant health, to compare with Jar C's curve and check whether oxygen stays above 19%.

Why: Any change that reduces decomposer oxygen use or raises plant oxygen production is sound; the data plan must allow a direct comparison with the first test.

Also acceptable: Accept 'keep the jar in brighter light' with the reasoning that plants would make more oxygen.

- One specific, testable change
- Names the data (oxygen readings over time) that would judge it

5. A classmate suggests a fourth jar to test your claim directly: garden soil plus compost that has first been baked in an oven to kill everything living in it. Predict the oxygen reading on day 30 for that jar if your claim is right, and explain what result would make you change your claim.

Answer: If the claim is right, the baked-compost jar should behave much more like Jar A or B, with oxygen staying near or above 20% on day 30, because the decomposers were killed. If that jar's oxygen still fell to about 15%, something other than living decomposers would be using the oxygen, and the claim would have to change (for example, to a chemical reaction in the soil).

Why: Students should state a prediction that follows from the claim and a result that would overturn it.

Also acceptable: Accept a prediction of 'a small drop, like Jar B' since baking may not remove every organism and new microbes can arrive on the plants.

- Predicts little or no oxygen drop
- States the disconfirming result

Scoring rubric

Criterion	4 • Exemplary	3 • Proficient	2 • Developing	1 • Beginning
Claim	States clearly that living decomposers in the compost used the oxygen, in one sentence that answers the question.	Names the compost or soil as the cause without naming living things, or names decomposers vaguely.	Names a cause that the evidence contradicts (the plants, a leak) or gives two competing claims.	No claim, or a claim unrelated to the jars.
Evidence	Three or more pieces of evidence with numbers from the table or log, each tied to a suspect it supports or rules out; both the leak and the plants are ruled out.	Three pieces with numbers, but only one suspect is ruled out, or one piece lacks a number.	One or two pieces of evidence, or evidence copied without connecting it to any explanation.	Evidence missing, invented, or contradicting the data.

Reasoning	Explains that decomposers use oxygen and release carbon dioxide to get energy, that the sealed lid prevents replacement, and that sunlight still entered; uses the warm soil as energy evidence.	Explains decomposers using oxygen and the sealed lid, but energy (sunlight in, heat out) is missing or vague.	Restates evidence without a mechanism, or gives a mechanism not linked to the claim.	No reasoning, or reasoning that contradicts how living things use oxygen.
Design thinking (q4 and q5)	Proposes a specific, testable change with a data plan, and states both the confirming and the disconfirming result for the baked-compost jar.	Change and data plan given; prediction for the baked jar given without a disconfirming result.	A vague change ('fix the soil') or a prediction with no reason.	Design questions blank or unrelated.

Teacher notes

The jars are a classroom-scale version of the Biosphere 2 oxygen story: there, soil microbes in rich soil consumed oxygen faster than expected, oxygen fell from about 21% to about 14% in roughly sixteen months, and the carbon dioxide rose far less than the lost oxygen predicted because much of it reacted with the building's exposed concrete. The dataset is simulated; the pattern (sand jar steady or slightly rising, garden soil slowly falling, compost jar falling fast with rising carbon dioxide and slight warmth) is realistic. Jar C's mismatch between oxygen lost (5.8 points) and carbon dioxide gained (1.1 points) is deliberate and feeds the extension: carbon dioxide dissolves in water and is taken up by plants during the day, so the air readings understate it. Do not let students conclude that compost is 'bad'; in an open garden the same decomposers are essential. No lab in this chapter builds a sealed jar; if students want to build one, use a plant-only version with no animals, keep it out of direct midday sun, and treat W9 as the design brief.

Scaffold offered to students: Three suspects, one table

On scrap paper make three columns headed 'A leak,' 'The plants,' and 'Living things in the soil.' Under each heading list every number or note from the sheet that fits or does not fit that suspect. For example: the soap-film test goes under 'A leak' as evidence against; the fact that all three jars had the same plants goes under 'The plants' as evidence against. The suspect with evidence for it and nothing against it is your claim, and the columns are your evidence section.

Extension: The missing carbon dioxide

When living things use oxygen to break down food, they release carbon dioxide in roughly equal amounts. Jar C lost about 5.8 percentage points of oxygen but gained only about 1.1 percentage points of carbon dioxide. Propose two places the missing carbon dioxide could have gone inside a sealed jar (think about the water, the plants and the glass), and design a measurement for each. Then find out what happened to carbon dioxide in the real Biosphere 2 project and compare it with your ideas.