

Case Closed? Where the Water on a Cold Can Comes From

Learning target: I can write a claim-evidence-reasoning argument, using test data and a particle model, that explains where the water on a cold container comes from and why it forms.

Claim, evidence, reasoning

About 45 min

Individual

MS-PS1-4 · assesses

writing

data analysis

Standards connections

MS-PS1-4 (assesses, the describing half: changes in particle motion and state when thermal energy is removed from water vapor): The reasoning section requires students to describe how water vapor particles lose thermal energy to a colder surface, slow down and are held together by their attractions as a liquid, which is the PE's model applied to energy removal. The argument is qualitative; no part asks for an amount of energy.

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

Answers with reasoning

The scenario

Ms. Ortiz's class wanted to settle the question from W1. They set up six tests in a classroom kept at 25 °C. Each container sat on a dry dish on an electronic balance, so any drops that formed, even ones that dripped onto the dish, stayed on the balance. After 15 minutes, students read the change in mass first, recorded whether drops formed, and only then pressed a white paper towel against the drops to check their color. A humidity meter showed how much water vapor the air held.

Reading the humidity meter — The meter gives a percent: how much water vapor is in the air compared with the most the air could hold at that temperature. A higher percent means more water vapor in the air. The dry box was a sealed clear plastic box with packets of drying crystals inside, which pull water vapor out of the air.

Six tests of cold and room-temperature containers, 15 minutes each (teaching dataset)

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

Test	Container	Starting surface temperature (°C)	Air around it (humidity reading)	Drops after 15 min?	Color on white towel	Mass change (g)
A	Sealed can of purple grape juice from the refrigerator	4	Classroom air, humid day (60%)	Many drops, some dripped	Clear	+0.8
B	Sealed can of purple grape juice at room temperature	25	Classroom air, humid day (60%)	None	Nothing to blot	0.0
C	Sealed glass jar of plain tap water from the refrigerator	4	Classroom air, humid day (60%)	Many drops	Clear	+0.7
D	Sealed can of purple grape juice from the refrigerator	4	Inside the dry box (under 5%)	None	Nothing to blot	0.0
E	Sealed can of purple grape juice from the refrigerator	4	Classroom air, dry day (30%)	A faint mist in the first minutes that soon disappeared; no drops	Nothing to blot	0.0
F	Sealed empty can (air only) from the refrigerator	4	Classroom air, humid day (60%)	Mist and small beads for about 4 minutes, then they dried	Clear (blotted at minute 2)	0.0

Simulated data for teaching. The pattern matches what real tests show; the exact numbers were invented. Mass was read to the nearest 0.1 g.

Warm-up: organize the evidence

1. In test A the container and dish had a mass of 391.4 g at the start. What was the mass after 15 minutes? Then think it through: if juice had leaked out through the metal onto the outside of the can and the dish, what would the mass change have been, and why?

Answer: $391.4\text{ g} + 0.8\text{ g} = 392.2\text{ g}$. If juice had leaked out through the metal, the mass change would have been 0.0 g, because the juice would still be on the can or the dish, which were both on the balance. Matter moving from the inside to the outside of the can does not change the total mass on the balance; only matter arriving from outside the balance, such as water from the air, can make it go up.

Why: This is the strongest single piece of evidence against leaking: the total mass increased, so matter was added from outside the system on the balance.

Also acceptable: Accept 'it would stay at 391.4 g' as the leaking prediction.

- 392.2 g with the addition shown
- States that leaking would give no mass change
- Explains that the dish and can were both on the balance, so leaked liquid would still be counted

2. Sort the tests. Write the test letters in the cells and be ready to explain each choice.

Answer: From inside: supports = none; contradicts = A (clear drops from purple juice and a mass gain), B (same juice, no drops), C (plain water in glass, mass gain), D (same cold can, no drops in dry air), F (empty can still formed drops). From the air: supports = A, B, C, D, E, F (all of them); contradicts = none.

Why: Every test fits the air explanation. Several tests directly contradict the inside explanation. Students may list fewer tests in each cell if each choice is justified.

Also acceptable: Accept B under 'supports from the air' or 'contradicts from inside' as long as the student explains that the same juice in the same can stayed dry when it was not cold.

- No test listed as supporting the inside explanation
- At least three tests listed as contradicting it, including A or F
- Air explanation supported by A and D or A and E at minimum

3. Which two tests are the best fair comparison to show that the container's temperature matters? Which two show that the amount of water vapor in the air matters? For each pair, name what was kept the same.

Answer: Temperature: A and B. Both are sealed cans of the same grape juice in the same humid air; only the starting temperature differs (4 °C versus 25 °C), and only the cold one formed drops. Water vapor in the air: A and D (or A and E). The can, the juice and the temperature (4 °C) are the same; only the amount of water vapor differs (60% versus 5%, or 60% versus 30%), and drops formed only in the humid air.

Why: A fair comparison changes one factor and keeps the others the same.

Also acceptable: Accept C and A as showing the container material does not matter, as an addition.

- A and B for temperature
- A and D or A and E for water vapor
- Names what was kept the same in each pair

Your argument

Answer: Claim: The water on a cold container comes from water vapor in the surrounding air, which condenses (turns from gas into liquid) on the cold surface. Evidence: In test A the mass rose by 0.8 g, so water was added from outside; leaking would not change the mass. The drops in test A were clear although the juice was purple. Test B, the same juice at 25 °C, formed no drops, while test A at 4 °C did. Test D, the same cold can in very dry air, formed no drops, and test E in drier air formed only a faint mist. Test F, an empty can, still formed drops. Reasoning: The room air is warmer than the 4 °C can, so heat flows from the air, including its water vapor, into the can. The water vapor particles touching the can lose thermal energy and slow down. When they are moving slowly enough, the attractions between water molecules keep them together after they bump into one another, rather than letting them bounce apart, so they gather as liquid drops. That needs both a cold surface (A versus B) and water vapor in the air (A versus D), and it adds mass that came from the air (A, C).

Why: A full-credit argument names the air as the source and condensation as the change, supports both with specific data, and explains the mechanism with heat direction, loss of thermal energy, slowing particles and attractions.

Also acceptable: Accept 'the gas sticks together and becomes liquid' for the attraction idea if slowing is described.

- Claim names water vapor in the air as the source and condensation as the change
- Three or more pieces of evidence with test letters and numbers, including the mass gain and a one-variable comparison
- Reasoning gives the direction of heat (air to can) and why (temperature difference)
- Reasoning describes vapor particles losing thermal energy, slowing and being held together by attractions
- Temperature, heat and thermal energy each used correctly

Answer a rival explanation

4. A classmate still says, 'The juice soaks through tiny holes in the can.' Write a respectful reply that uses two different tests to show why the data do not support this idea.

Answer: Example: 'I see why it looks that way, because the drops are right where the juice is. But in test A the drops were clear even though the juice was purple, and the mass went up by 0.8 g; if juice had soaked out, the color would show and the mass on the balance would not change. Also, test F was an empty can with no juice at all, and it still formed drops.'

Why: Any two tests that contradict the leaking idea earn credit: A (color or mass), B (same juice, no drops), D (same cold can, dry air, no drops) or F (empty can).

Also acceptable: Accept C (plain water in a glass jar, which cannot be purple) as one of the tests.

- Respectful tone
- Two different tests named
- Each test is explained, not just listed

5. Predict test G: a sealed can of grape juice taken from a freezer at -15°C and set out in the humid classroom. What would form on it, what is that change of state called, and would the mass go up, go down or stay the same? Explain.

Answer: White frost (ice crystals) would form on the can. The water vapor would turn straight from gas into solid, which is deposition, because the surface is colder than 0°C . The mass would go up, because water from the air is added to the can, just as in test A.

Why: A surface well below 0°C takes enough energy from the water vapor that the particles lock into a solid without passing through the liquid state. Some liquid drops that freeze could also form, but the main new idea is deposition.

Also acceptable: Accept 'drops that freeze into ice' as a partial answer if the mass prediction is correct.

- Predicts frost or ice crystals
- Names deposition
- Mass goes up, because water comes from the air

Scoring rubric

Criterion	4 • Exemplary	3 • Proficient	2 • Developing	1 • Beginning
Claim	Names water vapor in the air as the source and condensation (gas to liquid) as the change, in one clear statement.	Names the air as the source but not the change, or names condensation without saying the water came from the air.	States a vague source ('the air', 'humidity') with no change of state, or mixes two sources.	No claim, or claims the water came from inside the container.
Evidence	Three or more specific pieces with test letters and numbers, including the mass gain and a comparison that changes only one factor.	Three pieces with test letters, but the mass data or a one-factor comparison is missing.	One or two pieces, or evidence described without test letters or numbers.	Evidence missing, invented, or contradicting the table.
Reasoning	Explains heat flowing from the warmer air to the colder surface because of the temperature difference, vapor particles losing thermal energy and slowing, and attractions holding them together as liquid; links this to why both cold and water vapor are needed.	Gives the energy direction and the slowing of particles, but omits attractions or the link to the evidence.	Mentions that the can is cold or that vapor cools, without particle motion or energy direction.	No reasoning, or reasoning that says cold moves into the vapor or that the can makes water.
Use of terms	Temperature, heat and thermal energy each used once or more with the scientific meaning, and condensation used correctly.	Two of the three energy terms used correctly.	Terms used, but heat is used to mean temperature or stored energy.	Energy terms missing or used incorrectly throughout.

Teacher notes

The dataset is simulated but realistic: a cold 355 mL can in humid room air gains well under 1 g of condensed water in 15 minutes, and in air at 25°C with 30% humidity, water vapor starts to condense only on surfaces colder than about 6°C , so a 4°C can fogs faintly until its surface warms past that point. Test F, the empty can, warms within minutes because it holds so little matter, so its drops evaporate again; this is why its mass change reads 0.0 g at 15 minutes even though drops formed. (The few beads blotted at minute

2 weighed far less than the balance's 0.1 g resolution, so that color check does not explain the 0.0 g.) If students use F's mass as evidence against the air explanation, ask what happened to the drops after minute 4. This sheet works as the written assessment in Period 8; use the rubric's Reasoning row as the main evidence for MS-PS1-4. The extension introduces the dew point, which students meet again with weather.

Scaffold offered to students: Sentence frames for the argument

Claim: 'The water on the outside of a cold container comes from _____. It forms when _____ changes from a _____ to a _____, which is called _____.' Evidence: 'In test _____, _____, but in test _____, _____.' 'The mass in test A went up by _____, which shows _____.' Reasoning: 'Because the air is warmer than the can, heat flows from _____ to _____. The water vapor particles lose thermal energy, so they _____. When they are slow enough, _____.'

Extension: How cold is cold enough?

In test E, the can was cold but only a faint mist formed. Weather reporters use the dew point: the temperature to which air must be cooled for its water vapor to start condensing. Using tests A and E, explain why air with less water vapor has a lower dew point. Then predict whether a can at 15 °C would sweat on the humid day of test A, and describe a test you could run to find the temperature at which the can just starts to fog.