

What Is in the Unlabeled Bottle? A Claim-Evidence-Reasoning Case

Learning target: I can use measured properties (density, solubility in water, boiling point, flammability) and a reference table to argue which substance an unknown liquid is.

Claim, evidence, reasoning About 40 min Individual MS-PS1-2 · practice writing data analysis

Name

Date

Period

Directions

Read the scenario and the teacher's test record. Study the reference table of the five possible liquids. Answer the warm-up questions first; they will organize your evidence. Then write your Claim, Evidence and Reasoning in the boxes. A strong response uses specific numbers, says which candidates each piece of evidence rules out, and explains why more than one test was needed.

You will need: This worksheet, Pencil, Scrap paper for the ruling-out grid, Calculator (optional)

The scenario

While cleaning the school makerspace, Ms. Dao finds a half-full plastic bottle with a faded label. The only readable words are 'clear liquid' and 'store away from heat.' Before she can decide how to dispose of it, she needs to know what it is. The makerspace supply list shows that only five clear liquids were ever ordered: water, isopropyl alcohol, acetone, glycerin and mineral oil. Ms. Dao runs four tests herself, behind a safety shield, and records the results. Students were not present for the flame test.

Ms. Dao's test record for the unknown liquid (teaching dataset)

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

Test	What was done	Result
1. Density	Measured the mass of 25.0 mL of the liquid in a pre-weighed cup	19.7 g for 25.0 mL
2. Mixing with water	Added 5 mL of the liquid to 20 mL of water and swirled	Mixed completely; one clear layer, no separation after 10 minutes
3. Boiling point	Heated 10 mL gently in a test tube with a thermometer in the vapor	Trial 1: 82.0 °C; Trial 2: 83.0 °C; Trial 3: 82.5 °C
4. Flammability	Teacher touched a lit splint to a few drops on a watch glass	Caught fire at once; pale blue flame, hard to see

Simulated results for teaching. Boiling point measured three times with a thermometer that reads to 0.5 °C.

The five candidate liquids (real rounded values at normal air pressure)

Liquid	Density (g/cm ³)	Mixes with water?	Boiling point (°C)	Flammable?
Water	1.00	yes (it is water)	100	no
Isopropyl alcohol	0.79	yes, completely	82	yes
Acetone	0.78	yes, completely	56	yes, very
Glycerin	1.26	yes, completely	290	not easily
Mineral oil	0.84	no, forms a layer	above 300	burns only when very hot

Warm-up: organize the evidence

1. Calculate the density of the unknown from Test 1 (1 mL = 1 cm³). Which candidates are within 0.05 g/cm³ of your result, and which are ruled out?

2. Explain why Test 1 by itself leaves more than one candidate, no matter how carefully the density was measured.

3. Find the average of the three boiling-point trials. Which single candidate does it match, and by how many degrees does it miss the next-closest candidate?

Your argument

CLAIM

Claim: State which of the five liquids is in the bottle.

EVIDENCE

Evidence: Give at least three specific results from the test record, with numbers where they exist, and compare each with the reference table. For each piece of evidence, say which candidates it rules out.

REASONING

Reasoning: Explain how identifying properties connect your evidence to your claim. Your reasoning must say why density alone was not enough, which property settled the identity, and why the result would have been the same if Ms. Dao had tested a larger or smaller sample.

4. Suppose Test 3 had given 56 °C in all three trials, with every other result the same. What would your claim be, and which single piece of evidence would have changed it?

5. Ms. Dao also noticed the liquid had a sharp smell. She chose not to list odor as evidence. Give one reason odor is a weaker identifying property than the four tests she recorded.

A ruling-out grid

On scrap paper, write the five candidates across the top and the four tests down the side. In each box write 'fits' or 'out' with a two-word reason (for example, 'out: too dense', 'out: wrong boiling point'). The one column with 'fits' in every row is your claim, and each 'out' is a piece of evidence you can copy into your CER with its number.

A sixth candidate

Ethanol (the alcohol in hand sanitizer) has a density of 0.79 g/cm^3 , mixes completely with water, boils at 78°C and is flammable. Suppose it had also been on the supply list. Rewrite your Evidence section so that it rules ethanol out, and explain why a thermometer that reads only to the nearest 5°C would have left the case unsolved. Then propose a fifth test that could separate isopropyl alcohol from ethanol, and say what you would need to look up before trusting it.