

Five White Jars: An Evidence Jigsaw

Learning target: I can combine evidence cards from different tests with a team to identify five white solids, explain which cards decide each identity, and recognize evidence that does not help.

Collaborative investigation

About 50 min

Jigsaw

MS-PS1-2 · practice

collaboration

discussion

data analysis

Name _____

Date _____

Period _____

Directions

Work in home groups of four. Step 1 (expert round, 12 minutes): each member takes one expert set (Set 1: cards 1 to 3; Set 2: cards 4, 5 and 9; Set 3: cards 6 to 8; Set 4: cards 10 and 11 plus the reference table). Read your cards, then meet with the other students holding the same set and agree on what your cards can and cannot tell apart. Step 2 (home round, 20 minutes): return to your home group, teach your cards, and complete the group record. Step 3 (check, 8 minutes): compare your record with a neighboring group and resolve any disagreement using cards, not opinions. Step 4 (individual, 10 minutes): answer Part C alone.

You will need: Eleven cards per group, cut from the card sheet, Reference table (one per student), Group record table, Calculators, Pencils

A retired teacher left five unlabeled jars of white solids in the stockroom, marked only A, B, C, D and E. The new teacher ran a series of tests on tiny samples (students did not do the heating or flame tests) and wrote each result on a card. Your job is to decide what is in each jar. Every value on the cards is a teaching result, invented to be realistic.

Eleven evidence cards (teaching results)

1 Card 1: Appearance under a hand lens

A: clear-white irregular crystals that sparkle. B: tiny white cubes. C: very fine, soft powder that squeaks when pressed between fingers. D: fine, dull white powder, slightly gritty. E: translucent waxy flakes, slippery to the touch.

2 Card 2: Density of A and B

Because A and B dissolve in water, their volumes were measured by displacement in cooking oil instead. A: 8.0 g of crystals displaced 5.0 cm³. B: 11.0 g of crystals displaced 5.0 cm³.

3 Card 3: Density of C, D and E

Measured by displacement in water. C: 7.5 g displaced 5.0 cm³. D: 13.5 g displaced 5.0 cm³. E: 4.5 g displaced 5.0 cm³, and the flakes floated on the water.

4 Card 4: One gram in 20 mL of room-temperature water, stirred one minute

A: disappeared completely; the water stayed clear. B: disappeared completely; the water stayed clear. C: water turned cloudy; a soft layer settled on the bottom after ten minutes. D: water turned cloudy; a gritty layer settled within a minute. E: flakes floated and looked unchanged.

5 Card 5: How much will dissolve

More solid was stirred into 20 mL of room-temperature water, one gram at a time. B stopped dissolving after about 7 g; extra crystals sat on the bottom. A kept dissolving past 30 g, and the liquid became thick and syrupy.

6 Card 6: Gentle heating (teacher; test tubes in a 90 °C water bath)

A, B, C and D: no change. E: melted into a clear liquid at about 60 °C and hardened again into a white solid when cooled.

7 Card 7: Strong heating (teacher; burner, tube contents reached about 500 °C)

A: melted into a clear syrup, turned brown, then black, with a caramel smell. B: no change; still white crystals. C: turned brown, then black, and smelled like burnt toast; never became a clear liquid. D: no change. E: became liquid, then its vapor caught fire at the mouth of the tube.

8 Card 8: Flammability (teacher; lit splint touched to a small heap)

E: caught fire and burned with a yellow, smoky flame. A and C: blackened and glowed at the edges but went out when the splint was removed. B and D: no change at all.

9 Card 9: One gram in 20 mL of warm cooking oil, stirred

E: dissolved and disappeared into the oil. A, B, C and D: did not dissolve; each settled to the bottom of the oil.

10 Card 10: Mass of each jar's contents

A: 180 g. B: 250 g. C: 120 g. D: 300 g. E: 95 g.

11 Card 11: The old supply list

The stockroom records show that only six white solids were ever ordered: table salt, sugar, cornstarch, chalk powder (calcium carbonate), paraffin wax and baking soda. One of the six is not in any jar.

Reference table: the six possible solids (real rounded values)

Solid	Density (g/cm ³)	Dissolves in water at room temperature?	Behavior when heated	Burns?
Table salt (sodium chloride)	2.17	yes, up to about 36 g per 100 g of water; clear	no change until it melts at 801 °C	no
Sugar (sucrose)	1.59	yes, about 200 g per 100 g of water; clear	melts and starts to break down near 186 °C, turning brown (caramel)	chars; burns with difficulty
Cornstarch	about 1.5	no; cloudy, settles slowly	browns and chars; no clear melt	chars; burns slowly
Chalk powder (calcium carbonate)	2.71	no; practically none, settles fast	no change below about 800 °C	no
Paraffin wax	0.90	no; floats	melts between about 50 and 70 °C	yes, yellow smoky flame
Baking soda (sodium bicarbonate)	2.20	yes, up to about 10 g per 100 g of water; clear	breaks down above about 80 °C, giving off gas and losing mass; no melt	no

Part A: Expert round (one set per person)

1. Your expert set: _____. Using only your cards and the reference table, write (a) one jar your set can identify on its own, with the card that does it, and (b) two jars your set cannot tell apart on its own and why.

Part B: Home group task

1. Each expert teaches their cards to the group in two minutes. Listeners write down which jars each card helps with.
2. Work out the density for every jar from cards 2 and 3 (mass ÷ volume) and write the five values in the group record.
3. For each jar, agree on the identity and list every card number that supports it. A card counts as support only if the group can say what the card rules out.
4. Decide which candidate from the supply list is missing from all five jars, and name the cards that rule it out of each jar it might have matched.
5. Find the card that gave no useful evidence. Write one sentence saying why.

6. Prepare to defend the record to a neighboring group with cards, not opinions.

Group record (fill in)

Jar	Density (g/cm ³)	Identity	Cards that decide it	Candidate it could be confused with, and the card that rules it out
A				
B				
C				
D				
E				

2. Group answer: Which jar could be identified from a **single** card? Name the card and explain why one value was enough for that jar but not for the others.

3. Group answer: Which candidate on the supply list is in none of the jars? Name the jar it most nearly matched and the two cards that rule it out.

Part C: Individual accountability (complete alone)

4. Calculate the density of jar D from card 3 and name the solid it matches. Then explain why card 4 alone could not have separated jar D from jar C.

5. Jars A and C both turned brown and black under strong heating (card 7). Name two cards that separate A from C and say what each shows.

6. Card 10 gives the mass of each jar's contents. Explain why this card cannot help identify any jar, using the words *object* and *substance*.

7. Jar E did not dissolve in water (card 4) but did dissolve in warm oil (card 9). What does this pair of results show about the property called solubility?

8. A sixth jar, F, turns up: density 2.2 g/cm^3 , dissolves clear in water but only about 2 g in 20 mL, and gives off gas and loses mass when heated strongly. Identify it and name the two results that separate it from jar B.

Start with the easy jar

If the group is stuck, begin with the only solid that floats on water. Its density is below 1 g/cm^3 , and only one candidate in the reference table is that light. Identify that jar first, cross that candidate off the list, and then look for the next jar that has a value no other remaining candidate shares. Each time you identify a jar, cross a candidate off; the list gets shorter and the choices get easier.

Design the minimum test set

Your group used eleven cards. Suppose the teacher could run only three tests on every jar. Choose the three tests (from the eleven) that would still identify all five jars and rule out the missing candidate. Write out the reasoning jar by jar, and then explain which single test you would add back first if a seventh unknown white solid appeared, and why.