

Substances and Their Properties: Mastery Check

Learning target: I can tell substances from mixtures, separate identifying properties from object properties, calculate and use density, and plan a set of tests to identify an unknown.

Retrieval and mastery check

About 35 min

Individual

MS-PS1-2 · practice

independent practice

writing

Standards connections

MS-PS1-2 (practice): This check assesses the property-analysis skills the PE depends on (density, melting point, boiling point, solubility, flammability as identifying properties). It does not include substances interacting, so it is evidence of readiness for the PE rather than of the PE itself.

Purpose: assess · **Time:** about 35 minutes · **Format:** individual

Answers with reasoning

Reference table for this check (real rounded values at normal air pressure)

Substance	Density (g/cm ³)	Melting point (°C)
Aluminum	2.7	660
Zinc	7.14	420
Iron	7.87	1538
Copper	8.96	1085
Silver	10.5	962
Palladium	12.0	1555
Gold	19.3	1064

Part A: Retrieval (12 items)

1. Which of these is a single substance rather than a mixture?

1 pt

Answer: C. Copper.

Why: Air (nitrogen, oxygen, argon and more), wood (cellulose, lignin and more) and brass (copper and zinc) are mixtures; copper is one substance with one fixed makeup.

Also acceptable: None.

2. A gray metal bar needs to be identified. Which property of the bar could identify the substance it is made of? 1 pt

Answer: C. Its melting point.

Why: Mass, volume and shape describe this particular bar and change if the bar is cut or reshaped. Melting point is the same for every sample of the substance.

Also acceptable: None.

3. True or false: If a block of gold is cut exactly in half, each half has half the density of the original block. 1 pt

Answer: False.

Why: Each half has half the mass and half the volume, so mass $\div$ volume is unchanged: both halves are still 19.3 g/cm³. Density is a property of the substance, not of the amount.

Also acceptable: Accept 'false' with the halving-both argument or 'false, density stays 19.3.'

4. A shiny gray chip has a mass of 54.0 g and a volume of 20.0 cm³. Calculate its density and name the substance from the reference table. 2 pts

Answer: Density = 54.0 g $\div$ 20.0 cm³ = 2.70 g/cm³. The substance is aluminum (reference 2.70 g/cm³).

Why: Mass divided by volume, then matched to the table; aluminum is the only entry near 2.70.

Also acceptable: Accept 2.7 g/cm³.

5. Silver and palladium are both shiny, silvery-gray metals. Name one measurement from the reference table that would tell them apart more reliably than density, and explain why it is more reliable. 1 pt

Answer: Melting point: silver melts at about 962 °C and palladium at about 1555 °C, a gap of nearly 600 degrees, while their densities (10.5 and 12.0) are only 1.5 g/cm³ apart. A measurement error large enough to confuse the densities is easy to make; one large enough to confuse the melting points is not.

Why: The reliability comes from the size of the gap compared with the likely error.

Also acceptable: Accept 'the melting points are far apart but the densities are close.'

- Names melting point
- Explains the larger gap or smaller chance of confusion

6. At sea level water boils at 100 °C. In a mountain town 2,500 m above sea level, where air pressure is lower, water boils at a temperature that is: 1 pt

Answer: B. Lower than 100 °C.

Why: Lower air pressure lowers the boiling point; water boils around 92 °C at 2,500 m. Option C is the textbook's simplification; reference boiling points are stated for sea-level pressure.

Also acceptable: None.

7. Flammability is called a _____ property because it can only be observed while the substance changes into new substances. 1 pt

Answer: chemical

Why: A chemical property is observed only while the substance becomes different substances; burning does exactly that.

Also acceptable: None.

8. What is the mass of a copper piece with a volume of 5.0 cm^3 ? Show the calculation using the reference table.

2 pts

Answer: Mass = density $\times$ volume = $8.96 \text{ g/cm}^3 \times 5.0 \text{ cm}^3 = 44.8 \text{ g}$.

Why: Rearranging density = mass $\div$ volume.

Also acceptable: Accept 45 g if the student rounds and shows the multiplication.

9. A spoon of sugar stirred into water leaves a clear liquid that stays clear. A spoon of flour stirred into water leaves a cloudy liquid that settles into a layer. Which solid dissolved in water, and what two observations tell you?

1 pt

Answer: The sugar dissolved. Two observations: the sugar-water stayed clear (dissolved particles are spread out too finely to make the liquid cloudy), and nothing settled out over time (a dissolved substance stays mixed). The flour made a cloudy mixture that settled, so it did not dissolve.

Why: Clear-and-stays-mixed versus cloudy-and-settles is the observable test for dissolving.

Also acceptable: Accept 'you could see through it and it stayed that way.'

- Names sugar
- Gives both observations: clear and no settling

10. A scientist measures an unknown's density as 7.3 g/cm^3 , and two metals in her table are within 0.3 g/cm^3 of that value. What should she do next?

1 pt

Answer: B. Measure a different identifying property, such as melting point.

Why: Repeating the density test cannot separate two substances whose densities are nearly equal; a second property can. Option D is wrong because a close match to two table entries is not evidence of a mixture.

Also acceptable: None.

11. Oxygen gas is invisible. Is it still a substance? Answer yes or no and give one reason using the word *macroscopic*.

1 pt

Answer: Yes. A balloon or a room full of oxygen is a macroscopic amount of oxygen molecules, large enough to measure its mass, density and other properties, even though the gas is colorless. Being invisible is not the same as not being matter.

Why: The lesson's point that gases such as oxygen, carbon dioxide and methane are substances.

Also acceptable: Accept 'yes, because it has mass and properties you can measure' if macroscopic is used anywhere in the answer.

- Yes
- Uses macroscopic correctly to mean a measurable amount

12. Three liquids that do not mix are poured into one jar: liquid X (density 0.80 g/cm^3), liquid Y (1.00 g/cm^3) and liquid Z (1.30 g/cm^3). A bead with a density of 1.10 g/cm^3 is dropped in. Draw the jar with the three liquids in the correct order, label each with its density, and draw the bead where it comes to rest. 2 pts

Answer: From top to bottom: X (0.80 g/cm^3), Y (1.00 g/cm^3), Z (1.30 g/cm^3). The bead (1.10 g/cm^3) sinks through X and Y because it is denser than both, and floats on Z because it is less dense than Z, so it rests at the boundary between Y and Z, on top of Z.

Why: Liquids order by density with the least dense on top; an object stops at the first liquid denser than itself.

Also acceptable: A bead drawn slightly into the top of Z is acceptable.

- Correct order X, Y, Z from top
- Each liquid labeled with its density
- Bead drawn at the Y/Z boundary

Part B: Synthesis

13. You are handed a jar of unlabeled white powder and told it is either table salt, sugar or chalk. Plan three tests, using only properties from this lesson, that would identify it. For each test say what result each candidate would give. Then explain why a scientist usually runs more than one test even when the first result seems clear. 4 pts

Answer: Sample plan. Test 1, solubility in water: stir one gram into 20 mL of water. Salt and sugar dissolve and leave a clear liquid; chalk makes a cloudy mixture that settles. If it dissolves, Test 2, how much dissolves: keep adding; salt stops at about 7 g in 20 mL , while sugar keeps dissolving far past that. Test 3, density by displacement in oil (since two candidates dissolve in water): salt about 2.2 g/cm^3 , sugar about 1.6 g/cm^3 , chalk about 2.7 g/cm^3 . (A heating test done by the teacher would also work: sugar browns, salt and chalk do not change at a burner's temperature.) Scientists run more than one test because different substances can share one property, because a single measurement can be off, and because an identification is only trusted when every tested property matches the same candidate; a second test that agrees confirms, and one that disagrees catches an error before it causes harm.

Why: Full credit requires three tests using lesson properties (density, melting or heating behavior, solubility, flammability), the expected result for each candidate, and a reasoned explanation of why multiple tests are standard.

Also acceptable: Odor or appearance may be mentioned as a first look but should not count as one of the three tests. Values need not be exact; the direction of each result (dissolves or not, more or less, higher or lower) is what matters.

- Three tests using properties from the lesson
- Expected result stated for each candidate in each test
- Explains that substances can share a property and that measurements can err
- Explains that agreement across tests confirms the identity

Teacher notes

Suggested scoring: Part A items are 1 point each except q4, q8 and q12 (2 points each), for 15 points; Part B is 4 points, for 19 total. Reference values are real: aluminum 2.70 g/cm^3 and 660°C ; zinc 7.14 and 420 ; iron 7.87 and 1538 ; copper 8.96 and 1085 ; silver 10.5 and 962 ; palladium 12.0 and 1555 ; gold 19.3 and 1064 . For q13 the real values are table salt 2.17 g/cm^3 and about 36 g per 100 g of water, sugar 1.59 g/cm^3 and about 200 g per 100 g , chalk (calcium carbonate) 2.71 g/cm^3 and practically insoluble. Items q3, q6 and q10 target

the three misconceptions that persist longest (density halves with the sample, boiling point never changes, remeasuring one property can resolve a tie). If many students miss q6, revisit W7 entry 6. Allow the reference table during the check; the skill being assessed is using it, not memorizing it.

Scaffold offered to students: Two formulas, one rule

Density = mass $\div$ volume. If you know the density and the volume, mass = density $\times$ volume. The one rule for deciding whether a property can identify a substance: ask whether every sample of that substance, big or small, would give the same value. If yes, it can identify; if the value changes with the amount, it cannot.

Extension: Write the hardest item

Write one new multiple-choice item for this check that a student who has only memorized the formula for density would get wrong, but a student who understands that density is an identifying property would get right. Include four options, mark the correct one, and write two sentences explaining why each wrong option is tempting.