

Atoms and Elements: Mastery Check

Learning target: I can show what I know about atoms, elements, matter, the atomic scale, criteria and constraints, and the periodic table, and connect the ideas in a short paragraph.

Retrieval and mastery check

About 35 min

Individual

MS-PS1-1 · supports

MS-ETS1-1 · practice

independent practice

writing

Standards connections

MS-PS1-1 (supports): This quiz checks the prerequisite ideas (atoms as particles of elements, symbols and masses from the table) that the PE's molecular models are built from; it does not ask students to model a molecule.

MS-ETS1-1 (practice): Two items ask students to distinguish and write criteria and constraints, a retrieval check on the defining skill of the PE rather than a full design task.

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

Answers with reasoning

Part A: Retrieval (12 items)

1. Which statement uses the words atom and element correctly?

Answer: B. A gold ring is made of the element gold, which consists of many gold atoms.

Why: An element is a substance made of one kind of atom; the ring contains an enormous number of gold atoms.

Also acceptable: None.

2. Which of these is matter?

Answer: C. The air inside a pumped basketball.

Why: Air has mass and takes up space. Light, sound and warmth are energy or vibration, not matter.

Also acceptable: None.

3. True or false: With a strong enough magnifying glass, a person could see a single atom.

Answer: False.

Why: Atoms are far below what any light-based tool can show; scientists map individual atoms with instruments such as the scanning tunneling microscope, which uses a probe and a tiny electric current.

Also acceptable: None.

4. Which unit do scientists usually use to describe the width of an atom?

Answer: C. picometers

Why: One picometer is a trillionth of a meter; atoms are roughly 100-300 pm across.

Also acceptable: None.

5. A rigid ball reads 598.4 g on a balance when flat and 603.1 g after being pumped, with no change in size. In one sentence, what does this show about air?

Answer: Air is matter: it has mass (4.7 g was added) even though it cannot be seen and the ball's size did not change.

Why: The sentence should connect the mass gain to the conclusion that air has mass.

Also acceptable: Accept 'the pumped-in air added 4.7 g of mass.'

- States that air has mass or is matter
- Refers to the mass gain

6. Calcium has an atomic mass of 40 Da and barium 137 Da. They sit at the top and bottom of a three-element column. Use the halfway rule to predict the atomic mass of the element between them. Show your work.

Answer: $(40 \text{ Da} + 137 \text{ Da}) \div 2 = 177 \div 2 = 88.5 \text{ Da}$, about 88 or 89 Da. (The real element, strontium, is about 88 Da.)

Why: The halfway rule averages the outer two masses.

Also acceptable: Accept 88.5 Da, or 88 or 89 Da, with the work shown.

7. Why did Mendeleev leave empty spaces in his 1869 table?

Answer: C. Because he predicted that undiscovered elements would fill them.

Why: The gaps were deliberate predictions later confirmed by gallium, scandium and germanium.

Also acceptable: None.

8. Helium, neon and argon share a column of the periodic table. Name one property they share.

Answer: All three are gases at room temperature; or none of them reacts with other elements under normal conditions.

Why: Either shared property is correct and comes from the lesson.

Also acceptable: Accept 'used in lights' as a shared use, though it is not a chemical property; prompt for the gas or unreactive answer.

9. Write the chemical symbol for each element: sodium ____ potassium ____ carbon ____ iron ____

Answer: Sodium Na; potassium K; carbon C; iron Fe.

Why: Na (natrium), K (kalium) and Fe (ferrum) come from Latin names; C is from the English name.

Also acceptable: Capitalization matters: 'NA' or 'na' is not a correct symbol; mark it and explain the first-letter-capital rule.

10. A team designing a microscope writes: 'It must show details as small as 100 pm' and 'We can only use parts already in the lab.' Label each as a criterion or a constraint and explain the difference in one sentence.

Answer: 'Must show details as small as 100 pm' is a criterion: it describes what the microscope must do to be a success. 'Only parts already in the lab' is a constraint: it is a limit on the possible solutions. Criteria define success; constraints define the limits the design must stay inside.

Why: Both labels and the one-sentence distinction are required for full credit.

Also acceptable: Accept 'requirement for success' versus 'restriction.'

- Correct labels
- Difference stated as success versus limit

11. Reading across row 3 of the periodic table, sodium is 23 Da and argon is 40 Da. There are seven steps between them. What is the average mass increase per step? Show your work.

Answer: $(40 \text{ Da} - 23 \text{ Da}) \div 7 \text{ steps} = 17 \text{ Da} \div 7 \approx 2.4 \text{ Da per step}$.

Why: Subtract the first mass from the last, then divide by the number of steps.

Also acceptable: Accept 2.43 or 'about 2.4 Da per step'.

12. Draw a small piece of the periodic table showing lithium, sodium and potassium in their column and lithium's row neighbors beryllium and boron. Write each symbol and atomic mass (Li 7, Be 9, B 11, Na 23, K 39). Label which direction is a **group** and which is a **period**, and draw an arrow showing where atomic mass increases.

Answer: A vertical column with Li 7 at top, Na 23 below, K 39 at the bottom; Be 9 and B 11 to the right of Li in the same row; the column labeled 'group' and the row labeled 'period'; an arrow pointing down the column (and/or right along the row) labeled 'atomic mass increases'.

Why: The drawing checks that the student can place elements correctly and knows that group is vertical and period is horizontal, with mass rising both down and to the right.

Also acceptable: A drawing with a second arrow along the row is better than one; either direction alone earns the criterion.

- Five symbols with correct masses in the correct positions
- Group labeled as vertical, period as horizontal
- Mass arrow pointing down the column or to the right along the row

Part B: Synthesis

13. Write a paragraph (5-7 sentences) that answers: **How did scientists learn to organize the elements before they could observe a single atom, and why does that organization still work?** Your paragraph must use the words atomic mass, group (or column), and predict, and must mention at least one scientist by name.

Answer: Model paragraph: In the 1800s chemists could measure an element's atomic mass and test how it behaved, but no instrument could show them an atom. Johann Döbereiner noticed sets of three similar elements in which the middle element's atomic mass was about the average of the other two, which hinted that mass and behavior were connected. Dmitri Mendeleev then arranged all the known elements by increasing atomic mass and stacked the ones that behaved alike into the same group, or column. Where an element did not fit its column he left a space and predicted the mass and properties of the missing element; gallium, scandium and germanium were later discovered and matched his predictions. The arrangement still works because elements in a group really do behave alike, so an element's position lets scientists predict how it will act, and later discoveries, such as ordering by atomic number, confirmed the pattern instead of breaking it. A model that keeps predicting correctly earns our trust.

Why: Score for the required words (atomic mass, group or column, predict), a named scientist, a correct account of how the organization was built, and an explanation of why it still works (shared behavior in groups and confirmed predictions).

Also acceptable: A paragraph that centers on Newlands's octaves or on Moseley's atomic number is acceptable if it still explains the mass-and-behavior pattern and the predictive power.

- Uses atomic mass, group/column and predict correctly
- Names Döbereiner, Newlands, Mendeleev or Moseley accurately
- Explains that organization came from patterns in mass and behavior, not from seeing atoms
- Explains why the table still works (position predicts behavior; predictions confirmed)
- 5-7 sentences, coherent

Teacher notes

Suggested scoring: q1-q11 one point each (q6, q10 and q11 two points each if you want to weight calculation and reasoning), q12 three points, q13 four points, for 20 points. Items q1, q2 and q3 are the misconception sentinels; a wrong answer on any of them means the student still holds the atom-element confusion, the air-is-not-matter idea or the magnification idea, and should revisit W7. For q6, students who answer 88 because they remember strontium should still show the averaging calculation to earn full credit.

Scaffold offered to students: Paragraph frame for Part B

Sentence 1: what scientists could measure in the 1800s (mass and behavior) and what they could not do (see atoms). Sentence 2: what Döbereiner noticed. Sentence 3: what Mendeleev did with mass and columns. Sentence 4: what he predicted and what happened. Sentence 5: why position in a group lets scientists predict behavior today. Sentence 6: your own concluding sentence about trust in a model.

Extension: Two-way check

After the quiz, trade with a partner and grade each other's drawing (q12) using three checks: are the masses in the right places, is the group direction vertical, and does the mass arrow point down the column and to the right along the row? Then write one question of your own about the periodic table that is harder than any item on this quiz, and solve it. Hand both in.