

Conservation of Atoms and Balancing Chemical Equations – Teacher copy

Answers and suggested responses

The Law of Conservation of Mass states that matter cannot be created or destroyed in a chemical reaction. Therefore, the number of atoms of each element must be equal on both the reactant side (left) and the product side (right) of a chemical equation. To balance an equation, we place coefficients in front of chemical formulas. We never change subscripts, as doing so changes the identity of the substance.

To count atoms, multiply the coefficient (the big number in front) by the subscript (the small number after an element). If there are parentheses, multiply the subscript outside the parentheses by the subscripts inside.

Example: Count the atoms in $3\text{Ca}_3(\text{PO}_4)_2$

* **Calcium (Ca):** 3 (coefficient) $\times$ 3 (subscript) = 9 atoms

* **Phosphorus (P):** 3 (coefficient) $\times$ 1 (inside) $\times$ 2 (outside) = 6 atoms

* **Oxygen (O):** 3 (coefficient) $\times$ 4 (inside) $\times$ 2 (outside) = 24 atoms

Balance the following six chemical equations using the smallest whole-number coefficients, including 1 (do not leave blanks empty). Show your atom counts for both the Reactants (R) and Products (P) to prove the equation is balanced.

1. Balance the synthesis of water:



Show your atom counts for Reactants (R) and Products (P): (2 pts)

Answer: $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$. Reactants: H = 4, O = 2.
Products: H = 4, O = 2.

2. Balance the synthesis of ammonia:



Show your atom counts for Reactants (R) and Products (P): (2 pts)

Answer: $\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$. Reactants: N = 2, H = 6.
Products: N = 2, H = 6.

3. Balance the combustion of methane:



Show your atom counts for Reactants (R) and Products (P): (2 pts)

Answer: $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$. Reactants: C = 1, H = 4, O = 4.
Products: C = 1, H = 4, O = 4.

4. Balance the formation of iron(III) oxide:



Show your atom counts for Reactants (R) and Products (P): (2 pts)

Answer: $4\text{Fe} + 3\text{O}_2 \rightarrow 2\text{Fe}_2\text{O}_3$. Reactants: Fe = 4, O = 6.
Products: Fe = 4, O = 6.

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5. Balance the single replacement reaction:



Show your atom counts for Reactants (R) and Products (P): (2 pts)

Answer: $2\text{Al} + 6\text{HCl} \rightarrow 2\text{AlCl}_3 + 3\text{H}_2$. Reactants: Al = 2, H = 6, Cl = 6. Products: Al = 2, Cl = 6, H = 6.

6. Balance the combustion of propane:



Show your atom counts for Reactants (R) and Products (P): (2 pts)

Answer: $\text{C}_3\text{H}_8 + 5\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O}$. Reactants: C = 3, H = 8, O = 10. Products: C = 3, H = 8, O = 10.

Analyze the chemical scenario below and explain the scientific reasoning.

7. A student is asked to balance the equation for the synthesis of water:

$\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O}$. To balance the oxygen atoms, the student changes the product's subscript to create hydrogen peroxide: $\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O}_2$. While the second equation is balanced and conserves atoms, it describes the formation of hydrogen peroxide (H_2O_2) rather than water (H_2O). Explain why changing subscripts fails to balance the specified water-forming reaction, and write the correct balanced equation for the synthesis of water. (4 pts)

Answer: Changing H_2O to H_2O_2 changes water into hydrogen peroxide. The second equation conserves atoms but represents a different reaction. Balance water formation by changing coefficients only: $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$. Both sides have 4 hydrogen atoms and 2 oxygen atoms.