Balancing Chemical Equations: Introductory Stoichiometry

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A chemical equation describes what happens in a chemical reaction. The equation identifies the reactants (starting materials) and products (resulting substance), the formulas of the participants, the phases of the participants (solid, liquid, gas), and the amount of each substance. Balancing a chemical equation refers to establishing the mathematical relationship between the quantity of reactants and products. The quantities are expressed as grams or moles.

It takes practice to be able to write balanced equations. There are essentially three steps to the process:

1. **Write the unbalanced equation.**
    - Chemical formulas of reactants are listed on the left side of the equation.
    - Products are listed on the right side of the equation.
    - Reactants and products are separated by putting an arrow between them to show the direction of the reaction. Reactions at equilibrium will have arrows facing both directions.

Balance the equation.

Apply the Law of Conservation of Mass [a relation stating that in a chemical reaction, the mass of the products equals the mass of the reactants].

- to get the same number of atoms of every element on each side of the equation. Tip: Start by balancing an element that appears in only *one* reactant and product.
- Once one element is balanced, proceed to balance another, and another, until all elements are balanced.
- Balance chemical formulas by placing coefficients in front of them. Do not add subscripts, because this will change the formulas.

Indicate the states of matter of the reactants and products.

- Use (g) for gaseous substances.
- Use (s) for solids.
- Use (l) for liquids.
- Use (aq) for species in solution in water.
- Write the state of matter immediately following the formula of the substance it describes.

Worked Example Problem

Tin oxide is heated with hydrogen gas to form tin metal and water vapor. Write the balanced equation that describes this reaction.

1. **Write the unbalanced equation.**

    $SnO_2 + H_2 \rightarrow Sn + H_2O$

    Refer to Table of Common Polyatomic Ions and Formulas of Ionic Compounds if you have trouble writing the chemical formulas of the products and reactants.

2. **Balance the equation.**

   Look at the equation and see which elements are not balanced. In this case, there are two oxygen atoms on the left side of the equation and only one on the right side. Correct this by putting a coefficient of 2 in front of water:

   $SnO_2 + H_2 \rightarrow Sn + 2\ H_2O$

   This puts the hydrogen atoms out of balance. Now there are two hydrogen atoms on the left and four hydrogen atoms on the right. To get four hydrogen atoms on the right, add a coefficient of 2 for the hydrogen gas. Remember, coefficients are multipliers, so if we write 2 H_2O it denotes 2x2=4 hydrogen atoms and 2x1=2 oxygen atoms.

   $SnO_2 + 2\ H_2 \rightarrow Sn + 2\ H_2O$

   The equation is now balanced. Be sure to double-check your math! Each side of the equation has 1 atom of Sn, 2 atoms of O, and 4 atoms of H.

3. **Indicate the physical states of the reactants and products.**

   To do this, you need to be familiar with the properties of various compounds or you need to be told what the phases are for the chemicals in the reaction. Oxides are solids, hydrogen forms a diatomic gas, tin is a solid, and the term 'water vapor' indicates that water is in the gas phase:

   $SnO_2(s) + 2\ H_2(g) \rightarrow Sn(s) + 2\ H_2O(g)$

   This is the balanced equation for the reaction.

Balancing Chemical Equations Worksheet

Balance the equations below:

1) ______ N_2 + ______ H_2 → ______ NH_3

2) ______ $KClO_3$ → ______ KCl + ______ O_2

3) ______ $NaCl$ + ______ F_2 → ______ NaF + ______ Cl_2

4) ______ H_2 + ______ O_2 → ______ H_2O

5) ______ $Pb(OH)_2$ + ______ HCl → ______ H_2O + ______ $PbCl_2$

6) ______ $AlBr_3$ + ______ K_2SO_4 → ______ KBr + ______ $Al_2(SO_4)_3$

7) ______ CH_4 + ______ O_2 → ______ CO_2 + ______ H_2O

8) ______ C_3H_8 + ______ O_2 → ______ CO_2 + ______ H_2O

9) ______ C_8H_{18} + ______ O_2 → ______ CO_2 + ______ H_2O

10) ______ $FeCl_3$ + ______ $NaOH$ → ______ $Fe(OH)_3$ + ______ $NaCl$

11) ______ P + ______ O_2 → ______ P_2O_5

12) ______ Na + ______ H_2O → ______ $NaOH$ + ______ H_2

13) ______ Ag_2O + ______ Ag → ______ O_2

14) ______ S_8 + ______ O_2 → ______ SO_3

15) ______ CO_2 + ______ H_2O → ______ $C_6H_{12}O_6$ + ______ O_2

16) ______ K + ______ $MgBr_2$ → ______ KBr + ______ Mg

17) ______ HCl + ______ $CaCO_3$ → ______ $CaCl_2$ + ______ H_2O + ______ CO_2

18) ______ HNO_3 + ______ $NaHCO_3$ → ______ $NaNO_3$ + ______ H_2O + ______ CO_2

19) ______ H_2O + ______ O_2 → ______ H_2O_2

20) ______ $NaBr$ + ______ CaF_2 → ______ NaF + ______ $CaBr_2$

21) ______ H_2SO_4 + ______ $NaNO_2$ → ______ HNO_2 + ______ Na_2SO_4

Balancing Chemical Equations Worksheet - Answer Key

Balance the equations below:

1) **1** N_2 + **3** H_2 → **2** NH_3

2) **2** $KClO_3$ → **2** KCl + **3** O_2

3) **2** $NaCl$ + **1** F_2 → **2** NaF + **1** Cl_2

4) **2** H_2 + **1** O_2 → **2** H_2O

5) **1** $Pb(OH)_2$ + **2** HCl → **2** H_2O + **1** $PbCl_2$

6) **2** $AlBr_3$ + **3** K_2SO_4 → **6** KBr + **1** $Al_2(SO_4)_3$

7) **1** CH_4 + **2** O_2 → **1** CO_2 + **2** H_2O

8) **1** C_3H_8 + **5** O_2 → **3** CO_2 + **4** H_2O

9) **2** C_8H_{18} + **25** O_2 → **16** CO_2 + **18** H_2O

10) **1** $FeCl_3$ + **3** $NaOH$ → **1** $Fe(OH)_3$ + **3** $NaCl$

11) **4** P + **5** O_2 → **2** P_2O_5

12) **2** Na + **2** H_2O → **2** $NaOH$ + **1** H_2

13) **2** Ag_2O + **4** Ag → **1** O_2

14) **1** S_8 + **12** O_2 → **8** SO_3

15) **6** CO_2 + **6** H_2O → **1** $C_6H_{12}O_6$ + **6** O_2

16) **2** K + **1** $MgBr_2$ → **2** KBr + **1** Mg

17) **2** HCl + **1** $CaCO_3$ → **1** $CaCl_2$ + **1** H_2O + **1** CO_2

18) **1** HNO_3 + **1** $NaHCO_3$ → **1** $NaNO_3$ + **1** H_2O + **1** CO_2

19) **2** H_2O + **1** O_2 → **2** H_2O_2

20) **2** $NaBr$ + **1** CaF_2 → **2** NaF + **1** $CaBr_2$

21) **1** H_2SO_4 + **2** $NaNO_2$ → **2** HNO_2 + **1** Na_2SO_4