
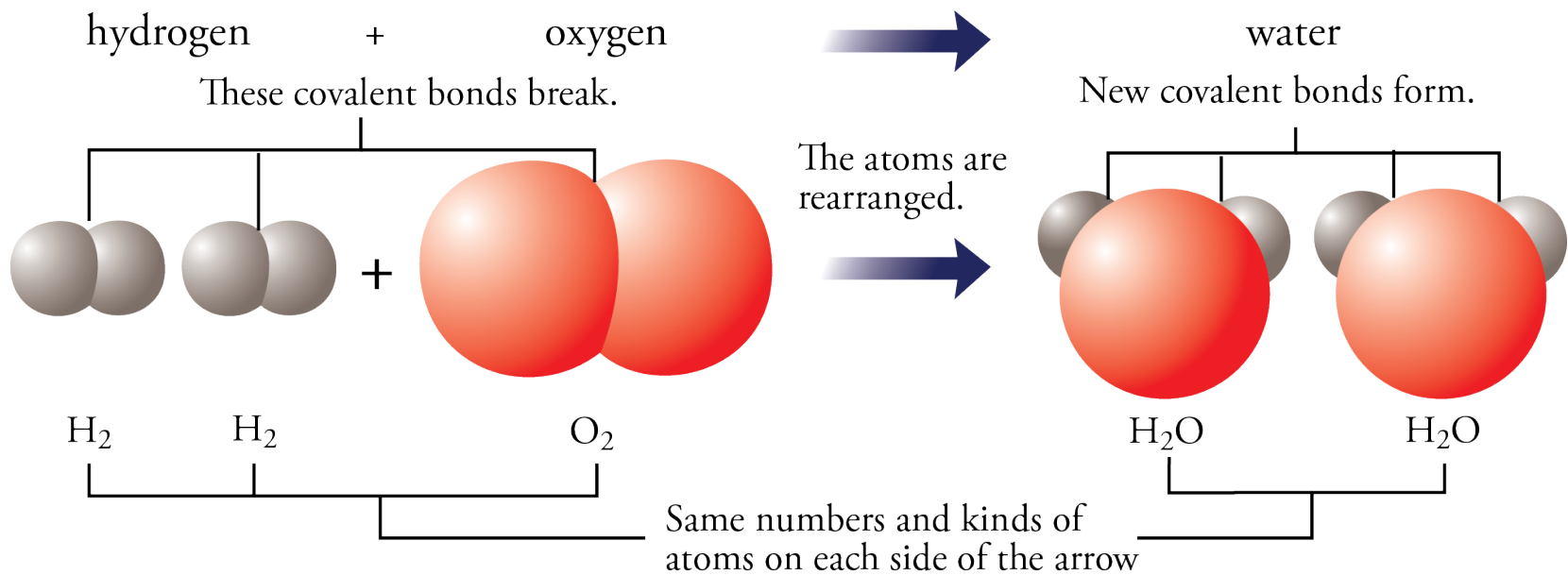


Chemical Reaction

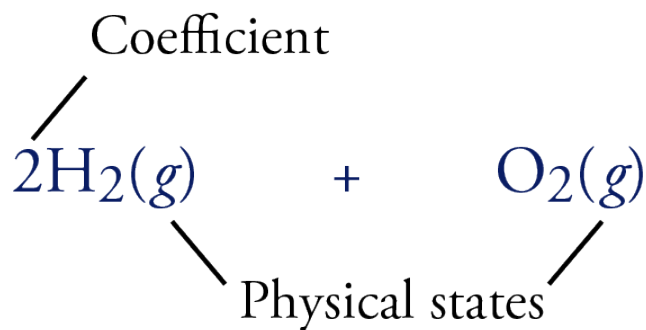


- A ***chemical change*** or ***chemical reaction*** is a process in which one or more pure substances are converted into one or more different pure substances.

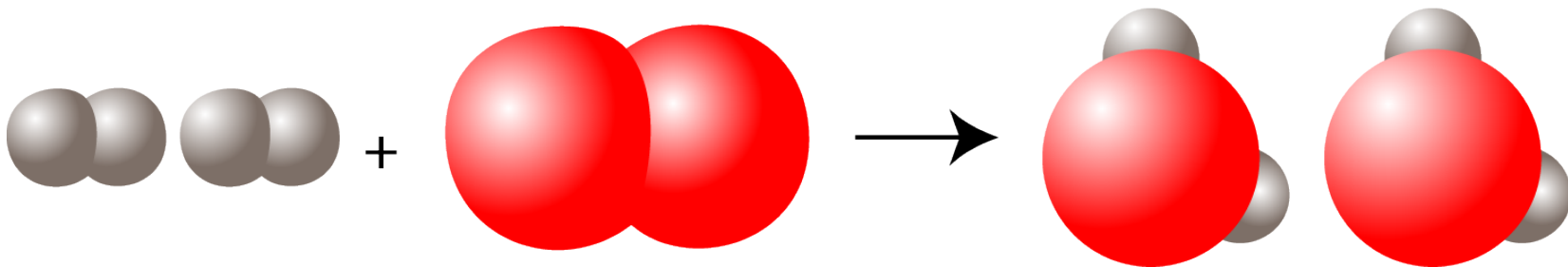
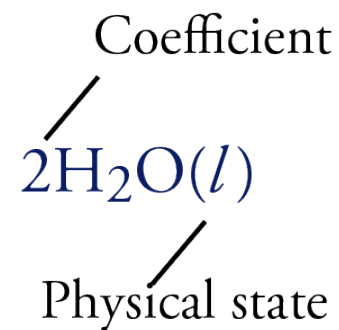
Chemical Reactions - Example



Chemical Equation Example

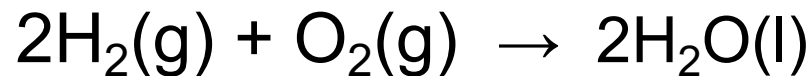


"goes to"
→



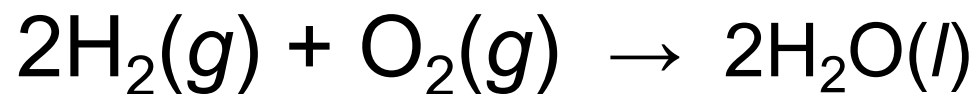
Chemical Equations (1)

- Chemical equations show the formulas for the substances that take part in the reaction.
- The formulas on the left side of the arrow represent the **reactants**, the substances that change in the reaction. The formulas on the right side of the arrow represent the **products**, the substances that are formed in the reaction. If there are more than one reactant or more than one product, they are separated by plus signs. The arrow separating the reactants from the products can be read as “goes to” or “yields” or “produces.”



Chemical Equations (2)

- The physical states of the reactants and products are provided in the equation.
 - A *(g)* following a formula tells us the substance is a gas. Solids are described with *(s)*. Liquids are described with *(l)*. When a substance is dissolved in water, it is described with *(aq)* for “aqueous,” which means “mixed with water.”



Chemical Equations (3)

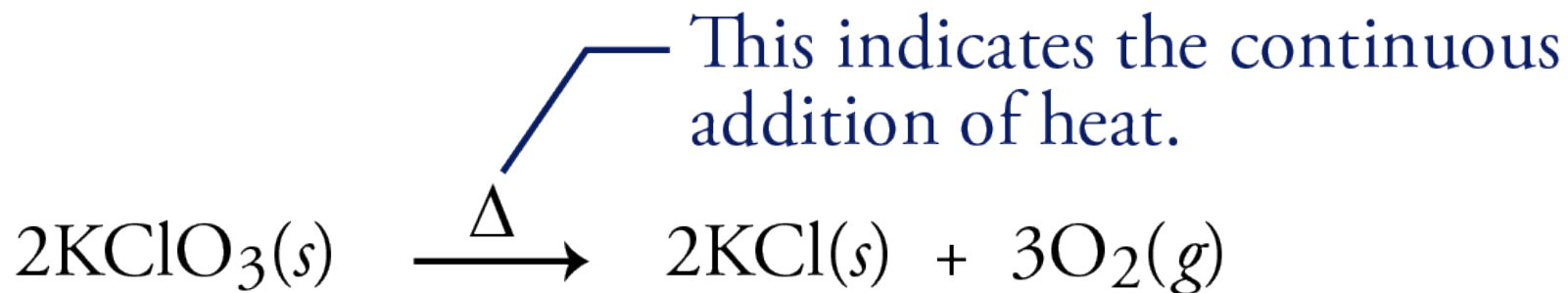
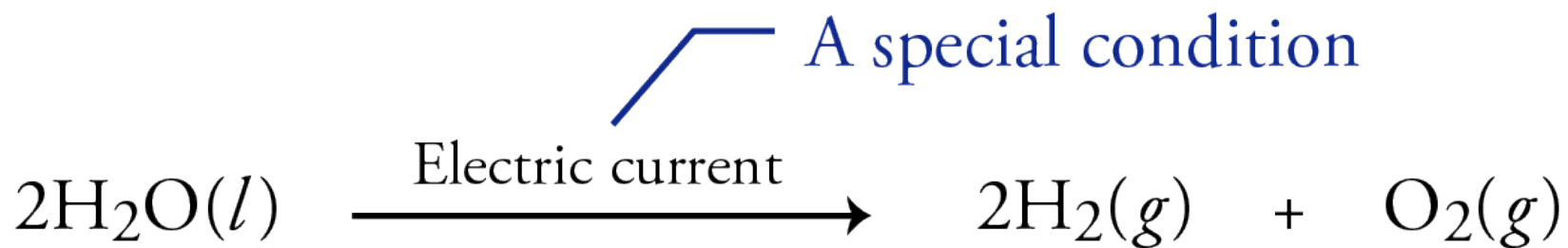
- The relative numbers of particles of each reactant and product are indicated by numbers placed in front of the formulas.
 - These numbers are called **coefficients**. An equation containing correct coefficients is called a balanced equation.
 - If a formula in a balanced equation has no stated coefficient, its coefficient is understood to be 1.

Chemical Equations (4)



- If special conditions are necessary for a reaction to take place, they are often specified above the arrow.
 - Some examples of special conditions are electric current, high temperature, high pressure, or light.

Special Conditions



Balancing Chemical Equations

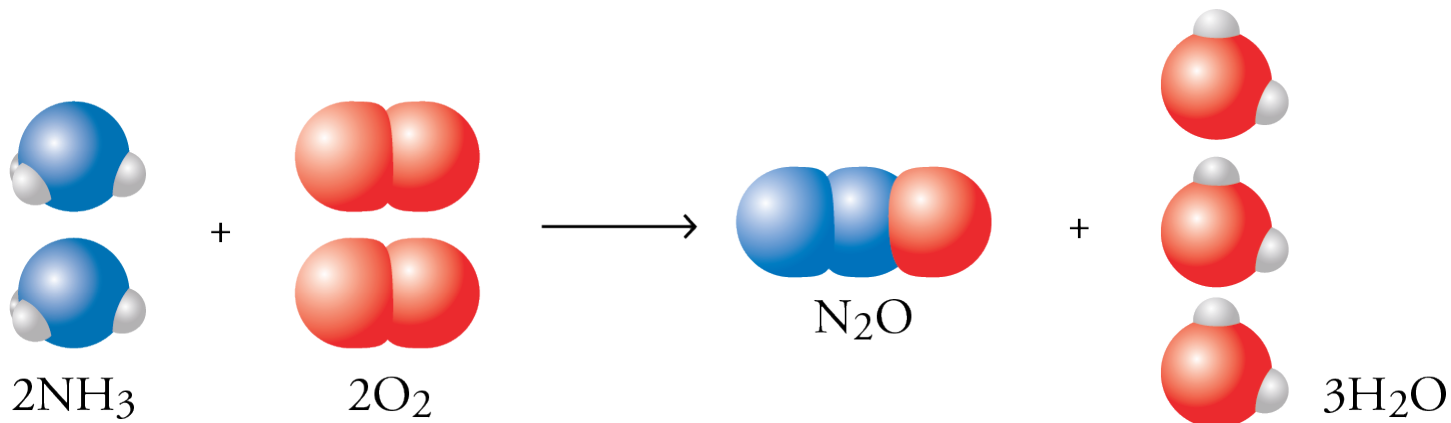


- Consider the first element listed in the first formula in the equation.
 - If this element is mentioned in two or more formulas on the same side of the arrow, skip it until after the other elements are balanced.
 - If this element is mentioned in one formula on each side of the arrow, balance it by placing coefficients in front of one or both of these formulas.
- Moving from left to right, repeat the process for each element.
- When you place a number in front of a formula that contains an element you tried to balance previously, recheck that element and put its atoms back in balance.

Example 1

Balancing Equations

- $\text{NH}_3(g) + \text{O}_2(g) \rightarrow \text{N}_2\text{O}(g) + \text{H}_2\text{O}(l)$
- $2\text{NH}_3(g) + \text{O}_2(g) \rightarrow \text{N}_2\text{O}(g) + \text{H}_2\text{O}(l)$
- $2\text{NH}_3(g) + \text{O}_2(g) \rightarrow \text{N}_2\text{O}(g) + 3\text{H}_2\text{O}(l)$
- **$2\text{NH}_3(g) + 2\text{O}_2(g) \rightarrow \text{N}_2\text{O}(g) + 3\text{H}_2\text{O}(l)$**




Example 2

Balancing Equations

- $\text{N}_2\text{H}_4(l) + \text{N}_2\text{O}_4(l) \rightarrow \text{N}_2(g) + \text{H}_2\text{O}(l)$
- $\text{N}_2\text{H}_4(l) + \text{N}_2\text{O}_4(l) \rightarrow \text{N}_2(g) + \mathbf{2}\text{H}_2\text{O}(l)$
- $\text{N}_2\text{H}_4(l) + \text{N}_2\text{O}_4(l) \rightarrow \text{N}_2(g) + \mathbf{4}\text{H}_2\text{O}(l)$
- $\mathbf{2}\text{N}_2\text{H}_4(l) + \text{N}_2\text{O}_4(l) \rightarrow \text{N}_2(g) + \mathbf{4}\text{H}_2\text{O}(l)$
- $\mathbf{2}\text{N}_2\text{H}_4(l) + \text{N}_2\text{O}_4(l) \rightarrow \mathbf{3}\text{N}_2(g) + \mathbf{4}\text{H}_2\text{O}(l)$

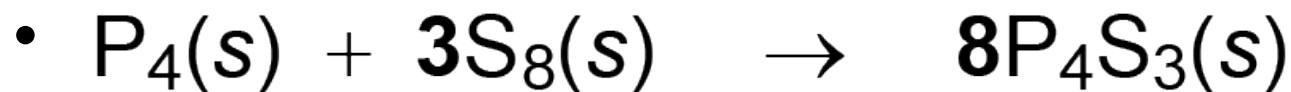
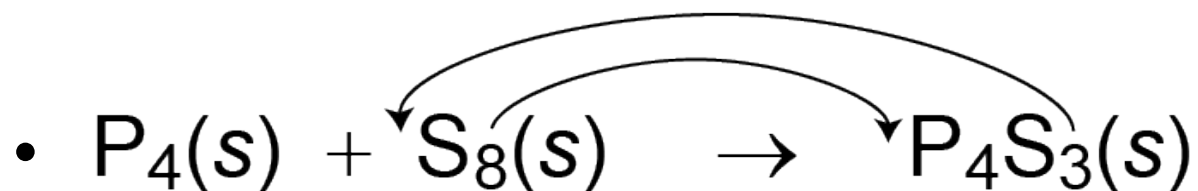
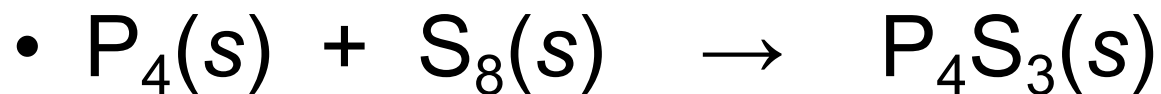
Balancing Equations – Strategies (1)



- **Strategy 1:** Often, an element can be balanced by using the subscript for this element on the left side of the arrow as the coefficient in front of the formula containing this element on the right side of the arrow and vice versa (using the subscript of this element on the right side of the arrow as the coefficient in front of the formula containing this element on the left side).

Example 3

Balancing Equations



Balancing Equations – Strategies (2)

- **Strategy 2:** The pure nonmetallic elements (H_2 , O_2 , N_2 , F_2 , Cl_2 , Br_2 , I_2 , S_8 , Se_8 , and P_4) can be temporarily balanced with a fractional coefficient ($1/2$, $3/2$, $5/2$, etc.). If you do use a fraction during the balancing process, you can eliminate it later by multiplying each coefficient in the equation by the fraction's denominator.

Example 4

Balancing Equations

- $\text{Al}(s) + \text{O}_2(g) \rightarrow \text{Al}_2\text{O}_3(s)$
- **$2\text{Al}(s) + \text{O}_2(g) \rightarrow \text{Al}_2\text{O}_3(s)$**
- **$2\text{Al}(s) + \frac{3}{2}\text{O}_2(g) \rightarrow \text{Al}_2\text{O}_3(s)$**
- **$4\text{Al}(s) + 3\text{O}_2(g) \rightarrow 2\text{Al}_2\text{O}_3(s)$**

Balancing Equations – Strategies (3)

- **Strategy 3:** If polyatomic ions do not change in the reaction, and therefore appear in the same form on both sides of the chemical equation, they can be balanced as if they were single atoms.
- **Strategy 4:** If you find an element difficult to balance, leave it for later.

Example 5

Balancing Equations

- $\text{Zn}(\text{NO}_3)_2(aq) + \text{Na}_3\text{PO}_4(aq)$
 $\rightarrow \text{Zn}_3(\text{PO}_4)_2(s) + \text{NaNO}_3(aq)$
- $3\text{Zn}(\text{NO}_3)_2(aq) + \text{Na}_3\text{PO}_4(aq)$
 $\rightarrow \text{Zn}_3(\text{PO}_4)_2(s) + \text{NaNO}_3(aq)$
- $3\text{Zn}(\text{NO}_3)_2(aq) + \text{Na}_3\text{PO}_4(aq)$
 $\rightarrow \text{Zn}_3(\text{PO}_4)_2(s) + 6\text{NaNO}_3(aq)$
- $3\text{Zn}(\text{NO}_3)_2(aq) + 2\text{Na}_3\text{PO}_4(aq)$
 $\rightarrow \text{Zn}_3(\text{PO}_4)_2(s) + 6\text{NaNO}_3(aq)$

Practice



- You can practice balancing equations by
 - working Exercise 4.1 of the chemistry-first version of my text or Exercise 7.1 of the atoms-first version,
 - working the end-of-chapter problems in the text
 - and/or working the problems on the book's website.

https://preparatorychemistry.com/Balancing_Equations_Canvas.html