

6.4: Composition, Decomposition, and Combustion Reactions

Learning Objectives

- Recognize composition, decomposition, and combustion reactions.
- Predict the products of a combustion reaction.

Three classifications of chemical reactions will be reviewed in this section. Predicting the products in some of them may be difficult, but the reactions are still easy to recognize.

A **composition reaction** (sometimes also called a *combination reaction* or a *synthesis reaction*) produces a single substance from multiple reactants. A single substance as a product is the key characteristic of the composition reaction. There may be a coefficient other than one for the substance, but if the reaction has only a single substance as a product, it can be called a composition reaction. In the reaction

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water is produced from hydrogen and oxygen. Although there are two molecules of water being produced, there is only one substance—water—as a product. So this is a composition reaction.

A **decomposition reaction** starts from a single substance and produces more than one substance; that is, it decomposes. The key characteristics of a decomposition reaction are: one substance as a reactant and more than one substance as the products. For example, in the decomposition of sodium hydrogen carbonate (also known as sodium bicarbonate):

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sodium carbonate, carbon dioxide, and water are produced from the single substance sodium hydrogen carbonate.

Composition and decomposition reactions are difficult to predict; however, they should be easy to recognize.

✓ Example [Math Processing Error]: Identifying Reactions

Identify each equation as a composition reaction, a decomposition reaction, or neither.

- a. [Math Processing Error]
- b. [Math Processing Error]
- c. [Math Processing Error]

Solution

- a. In this equation, two substances combine to make a single substance. This is a composition reaction.
- b. Two different substances react to make two new substances. This does not fit the definition of either a composition reaction or a decomposition reaction, so it is neither. In fact, you may recognize this as a double-replacement reaction.
- c. A single substance reacts to make multiple substances. This is a decomposition reaction.

? Exercise [Math Processing Error]

Identify the equation as a composition reaction, a decomposition reaction, or neither.

[Math Processing Error]

Answer

decomposition

A **combustion reaction** occurs when a reactant combines with oxygen, many times from the atmosphere, to produce oxides of all other elements as products; any nitrogen in the reactant is converted to elemental nitrogen, N_2 . Many reactants, called *fuels*, contain mostly carbon and hydrogen atoms, reacting with oxygen to produce CO_2 and H_2O . For example, the balanced chemical equation for the combustion of methane, CH_4 , is as follows:

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Kerosene can be approximated with the formula $[Math Processing Error]$, and its combustion equation is:

$[Math Processing Error]$

Sometimes fuels contain oxygen atoms, which must be counted when balancing the chemical equation. One common fuel is ethanol, $[Math Processing Error]$, whose combustion equation is:

$[Math Processing Error]$

If nitrogen is present in the original fuel, it is converted to $[Math Processing Error]$, not to a nitrogen-oxygen compound. Thus, for the combustion of the fuel dinitroethylene, whose formula is $[Math Processing Error]$, we have:

$[Math Processing Error]$

✓ Example $[Math Processing Error]$: Combustion Reactions

Complete and balance each combustion equation.

1. the combustion of propane ($[Math Processing Error]$)
2. the combustion of ammonia ($[Math Processing Error]$)

Solution

1. The products of the reaction are CO_2 and H_2O , so our unbalanced equation is $[Math Processing Error]$
Balancing (and you may have to go back and forth a few times to balance this), we get $[Math Processing Error]$
2. The nitrogen atoms in ammonia will react to make N_2 , while the hydrogen atoms will react with O_2 to make H_2O : $[Math Processing Error]$
To balance this equation without fractions (which is the convention), we get $[Math Processing Error]$

? Exercise $[Math Processing Error]$

Complete and balance the combustion equation for cyclopropanol ($\text{C}_3\text{H}_6\text{O}$).

Answer

$[Math Processing Error]$



Figure $[Math Processing Error]$ A 20 lb (9.1 kg) steel propane cylinder.

Key Takeaways

- A composition reaction produces a single substance from multiple reactants.
- A decomposition reaction produces multiple products from a single reactant.
- Combustion reactions are the combination of some compound with oxygen to make oxides of the other elements as products (although nitrogen atoms react to make N_2).

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