

Synthesis and Decomposition Reactions

Read from Lesson 2 Classifying Chemical Reactions in the Chemistry Tutorial Section Chapter 8 of The Physics Classroom Part a: [Decomposition and Synthesis Reactions](#) Part e: [Predicting Products](#)

Part 1: Synthesis Reactions

In a synthesis (or combination) reaction, two or more substances combine to form **one product**. This product is always a compound.

Common types of synthesis reactions are

1. Formation of a binary compound from two elements: $A + B \rightarrow AB$
e.g. $2K(s) + Br_2(l) \rightarrow 2KBr(s)$
 $N_2(g) + 2O_2(g) \rightarrow 2NO_2(g)$
2. Formation of a metal carbonate from a metal (M) oxide and carbon dioxide: $MO + CO_2 \rightarrow MCO_3$
e.g. $Li_2O(s) + CO_2(g) \rightarrow Li_2CO_3(s)$
 $CaO(s) + CO_2(g) \rightarrow CaCO_3(s)$
3. Formation of a metal hydroxide (base) from a metal (M) oxide and water: $MO + H_2O \rightarrow MOH$
e.g. $Na_2O(s) + H_2O(l) \rightarrow 2NaOH(s)$
 $MgO(s) + H_2O(l) \rightarrow Mg(OH)_2(s)$
4. Formation of an acid from a nonmetal (NM) oxide and water: $(NM)O + H_2O \rightarrow H(NM)O_x$
e.g. $CO_2(g) + H_2O(l) \rightarrow H_2CO_3(aq)$
 $P_2O_5(g) + 3H_2O(l) \rightarrow 2H_3PO_4(aq)$

When predicting the products of any chemical reaction, use these steps:

1. Write the correct formulas for the reactant(s).
2. Classify the type of reaction as synthesis, decomposition, combustion, single replacement, or double replacement.
3. Predict the products – use correct subscripts.
4. Balance the equation – use coefficients.

For the following questions, predict the product of these synthesis reactions. Write the skeleton equation (proper formulae, no coefficients). Then add coefficients to balance the chemical equation.

1. Solid strontium reacts with iodine vapor.
2. Pieces of iron (III) oxide react with steam (water vapor.)
3. Hydrogen gas reacts with oxygen gas.
4. Barium oxide reacts with carbon dioxide gas.
5. Nitrogen dioxide combines with water. (Two possible answers.)

Part 2: Decomposition Reactions

These reactions are easy to identify-decomposition reactions have **one reactant**. In a decomposition reaction, a complex compound decomposes (breaks down) into two or more simpler substances.

Common types of decomposition reactions are the breakdown of

- Binary compounds into two elements: $AB \rightarrow A + B$
e.g. $2KBr (s) \rightarrow 2K (s) + Br_2 (l)$
 $2NO_2 (g) \rightarrow N_2 (g) + 2O_2 (g)$
- Metal (M) carbonates into metal oxide and carbon dioxide: $MCO_3 \rightarrow MO + CO_2$
e.g. $Li_2CO_3 (s) \rightarrow Li_2O (s) + CO_2 (g)$
 $CaCO_3 (s) \rightarrow CaO (s) + CO_2 (g)$
- Metal (M) hydrogen carbonates into metal oxide, water, and carbon dioxide: $MCO_3 \rightarrow MO + H_2O + CO_2$
e.g. $2NaHCO_3 (s) \rightarrow Na_2O (s) + H_2O (l) + 2CO_2 (g)$
- Metal (M) chlorates into metal chloride and oxygen: $MClO_3 \rightarrow MCl + O_2$
e.g. $2LiClO_3 (s) \rightarrow 2LiCl (s) + 3O_2 (g)$
 $Ba(ClO_3)_2 (s) \rightarrow BaCl_2 (s) + 3O_2 (g)$
- Metal hydroxides (bases) (MOH) into metal (M) oxide and water: $MOH \rightarrow MO + H_2O$
e.g. $2NaOH (s) \rightarrow Na_2O (s) + H_2O (l)$
 $Mg(OH)_2 (s) \rightarrow MgO (s) + H_2O (l)$
- Acids into nonmetal (NM) oxide and water: $H(NM)O_x \rightarrow (NM)O + H_2O$
e.g. $H_2CO_3 (aq) \rightarrow CO_2 (g) + H_2O (l)$
 $2H_3PO_4 (aq) \rightarrow P_2O_5 (g) + 3H_2O (l)$

For the following questions, predict the product of these decomposition reactions. Write the skeleton equation (proper formulae, no coefficients). Then add coefficients to balance the chemical equation.

- Solid potassium hydrogen carbonate \rightarrow
- Solid diphosphorus pentoxide \rightarrow
- Solid potassium hydroxide \rightarrow
- Sulfuric acid solution \rightarrow
- Solid rubidium chlorate \rightarrow
- Carbon dioxide gas \rightarrow
- Solid strontium carbonate \rightarrow