

### Chemical Reactions

What is a chemical reaction?  
- if you forgot, look back in your notes

A **word equation** is a chemical reaction represented by the names of reactants and products  
- reactants go on the left side (*what we start with*)  
- products go on the right side (*what we get*)  
- all reactants and all products are separated by a plus sign (+)  
- an arrow points from the reactants to the products

The **reactants** are the chemicals that go **in** to a reaction  
The **products** are the chemicals that come **out** of a reaction

Chemical reactions are written like this:

all the reactants		→	all the products	
Reactants			Products	
A + B		→	C + D	
reactant 1	reactant 2		product 1	product 2

*Could these be 1 reactant? 1 product?*

*E.g.*, When iron is exposed to oxygen, it rusts and the product is iron(III) oxide  
The word equation for this reaction is:  
iron + oxygen → iron(III) oxide

## Reactants/Products

### Why are word equations important?

Word equations let us summarize what we observe.

a) Aluminum resists corrosion because it reacts with a gas found in air to form a protective coating of aluminum oxide.  
aluminum + oxygen → aluminum oxide

b) Zinc metal, used as a coating in galvanized iron, also reacts with air to form a coating that resists further corrosion.  
zinc + oxygen → zinc oxide

c) When aluminum foil is placed in a solution of copper(II) chloride, copper metal and another solution are formed.  
aluminum + copper(II) chloride → copper + aluminum chloride  
*forms, makes*

d) When sodium sulfate and calcium chloride solutions are mixed, a precipitate of calcium sulfate and another substance is formed.  
sodium sulfate + calcium chloride → calcium sulfate + sodium chloride

## Why are word equations important?

### Practice with word equations

1. Write word equations for the following reactions:  
a) Sodium reacts with chlorine to form sodium chloride.  
b) Magnesium burns in oxygen to form magnesium oxide.  
c) Calcium sulfate can be decomposed to calcium and sulfur.

(P, D) 2. Write word equations for the following reactions:  
a)  $\text{CaCl}_2$  and  $\text{Na}_2\text{SO}_4$  react to form  $\text{CaSO}_4$  and  $\text{NaCl}$ .  
b)  $\text{BaCO}_3$  reacts when heated to produce  $\text{BaO}$  and  $\text{CO}_2$ .  
c)  $\text{AgNO}_3$  reacts with  $\text{KCl}$  to produce  $\text{AgCl}$  and  $\text{KNO}_3$ .

(P, D) 3. Write word equations to represent the following chemical reactions:  
a) Carbon dioxide and water are produced in human cell respiration. The reactants are sugar and an important gas that humans need to survive.  
b) Stalactites form in caves when calcium bicarbonate reacts to form calcium carbonate, water, and carbon dioxide gas.

## Word Equation Practice

### Word Equations Questions

1. When you have a BBQ, the propane burns in oxygen to cook those delicious burgers. The word equation looks like this:  
propane + oxygen → carbon dioxide + water  
a) List all the reactants.  
b) List all the products.  
c) What does the arrow tell us?

2. Write word equations for the following reactions:  
a) Table salt (sodium chloride) can be made by reacting sodium with chlorine.  
b) Magnesium burns in oxygen to form magnesium oxide.  
c) Calcium sulfate can be decomposed to calcium and sulfur.

(P, D) 3. Write word equations for the following reactions:  
a)  $\text{CaCl}_2$  and  $\text{Na}_2\text{SO}_4$  react to form  $\text{CaSO}_4$  and  $\text{NaCl}$ .  
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## Word Equation Questions

### Word Equations Questions

1. This is the word equation for burning propane: propane + oxygen → carbon dioxide + water  
a) List all the reactants in this reaction. *propane & oxygen*  
b) List all the products in this reaction. *carbon dioxide & water*  
c) What is the purpose of the arrow in the word equation? *to divide the reactants & products*

2. Write word equations for the following reactions:  
a) Table salt (sodium chloride) can be made by reacting sodium with chlorine.  
*sodium + chlorine → sodium chloride*  
b) Magnesium burns in oxygen to form magnesium oxide.  
*magnesium + oxygen → magnesium oxide*  
c) Calcium sulfate can be decomposed to calcium and sulfur.  
*calcium sulfate → calcium + sulfur*

3. Write word equations for the following reactions:  
a)  $\text{CaCl}_2$  and  $\text{Na}_2\text{SO}_4$  react to form  $\text{CaSO}_4$  and  $\text{NaCl}$ .  
*calcium chloride + sodium sulfate → calcium sulfate + sodium chloride*  
b)  $\text{BaCO}_3$  reacts when heated to produce  $\text{BaO}$  and  $\text{CO}_2$ .  
*barium carbonate → barium oxide and carbon dioxide*  
c)  $\text{AgNO}_3$  reacts with  $\text{KCl}$  to produce  $\text{AgCl}$  and  $\text{KNO}_3$ .  
*silver nitrate + potassium chloride → silver chloride + potassium nitrate*

4. Write word equations to represent the following chemical reactions:  
a) Carbon dioxide and water are produced in human cell respiration. The reactants are sugar and an important gas that humans need to survive. *sugar + oxygen → carbon dioxide + water*  
b) Stalactites form in caves when calcium bicarbonate reacts to form calcium carbonate, water, and carbon dioxide gas. *calcium bicarbonate → calcium carbonate + water + carbon dioxide*

## Answers

### Measuring Mass in Reactions

## Measuring Mass in Reactions



How do we count atoms?

Some rules:

- The symbol of an element means one atom of that element.  
e.g., Ca =
- A subscript tells us how many atoms of the atom with the subscript.  
e.g., N<sub>2</sub> =
- A subscript outside a bracket applies to all the atoms inside the brackets.  
e.g., Ba<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub> = **3 Ba, 2 P, 8 O**
- a) A coefficient in front of an atom applies to that atom.  
e.g., 4Fe =  
b) A coefficient in front of a compound applies to all atoms in the compound  
e.g., 3NaCl = **3 Na, 3 Cl**  
c) A coefficient in front of a bracket applies to all atoms in the brackets  
e.g., 3Mg(OH)<sub>2</sub> = **3 Mg, 6 O, 6 H**

Practice

	Type of atom	# of atoms
2H <sub>2</sub> O	hydrogen	4
	oxygen	2
	iron	3
3FeSO <sub>4</sub>	sulfur	3
	oxygen	12
4Cu(NO <sub>3</sub> ) <sub>2</sub>	copper	4
	nitrogen	8
	oxygen	24

(50)4

Counting Atoms

	Type of atom	# of atoms
Na <sub>2</sub> CO <sub>3</sub>	Na	2
	C	1
	O	3
K <sub>2</sub> CrO <sub>4</sub>	K	2
	Cr	1
NH <sub>4</sub> C <sub>2</sub> H <sub>3</sub> O <sub>2</sub>	N	1
	H	7
	C	2
Pb(NO <sub>3</sub> ) <sub>2</sub>	Pb	1
	N	2
	O	6
Ca <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub>	Ca	3
	P	2
	O	8
3BaCl <sub>2</sub>	Ba	3
	Cl	6
4Al <sub>2</sub> (CO <sub>3</sub> ) <sub>3</sub>	Al	8
	C	12
	O	36
2(NH <sub>4</sub> ) <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	N	4
	H	16
	Cr	4
	O	14

Counting Atoms

Let's try one.

When exposed to oxygen, copper turns into copper(II) oxide.

1. Write the word equation and the skeleton equation.

copper + oxygen → copper(II) oxide  
 $Cu + O_2 \rightarrow CuO$

2. Count the number of atoms of each type in the reactants and the products.

Atom	Reactants	Products
Cu	1	1
O	2	1

3. Multiply each formula by coefficients to balance the number of atoms.

$2Cu + O_2 \rightarrow 2CuO$

Atom	Reactants	Products
Cu	2	2
O	2	2

Chemical Equations

Let's practice!

- $H_2 + Cl_2 \rightarrow 2HCl$
- $HgO \rightarrow Hg + O_2$
- $Na + Cl_2 \rightarrow NaCl$
- $H_2O \rightarrow H_2 + O_2$
- $Al + Br_2 \rightarrow AlBr_3$
- $Hf + N_2 \rightarrow HfN_4$
- $Cr_2O_3 \rightarrow Cr + O_2$
- $CuO + H_2 \rightarrow Cu + H_2O$
- $N_2H_4 + O_2 \rightarrow H_2O + N_2$
- $F_2 + H_2O \rightarrow HF + O_2$
- $H_3PO_4 + NaOH \rightarrow Na_3PO_4 + H_2O$
- $Cu + AgNO_3 \rightarrow Cu(NO_3)_2 + Ag$
- $Ca(NO_3)_2 + KOH \rightarrow Ca(OH)_2 + KNO_3$
- $Al + Pb(NO_3)_2 \rightarrow Al(NO_3)_3 + Pb$

P. D) 15. sodium reacts with water to produce sodium hydroxide and hydrogen gas

P. D) 16. chlorine and sodium bromide react to form bromine and sodium chloride

P. D) 17. copper combines with sulfur to form copper(II) sulfide

Balancing Practice

**Balancing Questions**

- Write a balanced chemical equation for each of the following:
  - hydrogen + oxygen form water
  - nitrogen + hydrogen form ammonia (NH<sub>3</sub>)
  - hydrogen sulfide forms hydrogen + sulfur
  - magnesium + oxygen form magnesium oxide
  - calcium + water form calcium hydroxide + hydrogen gas
 (P. D) f) copper(II) oxide + hydrogen form copper + water  
 (P. D) g) lead(II) nitrate + potassium iodide form lead(II) iodide + potassium nitrate  
 (P. D) h) lead(II) sulfide + oxygen form lead + sulfur dioxide
- a) How can you tell the following equation is not balanced?  
 $N_2 + H_2 \rightarrow NH_3$   
 b) Imagine a friend tried to balance the equation as shown below. What would you say is wrong with the way it is balanced?  
 $N_2 + H_3 \rightarrow N_3H_3$
- Nitrogen oxides are a group of air pollutants produced by internal combustion engines in automobiles. These pollutants are formed by the reaction of atmospheric nitrogen (N<sub>2</sub>) and oxygen (O<sub>2</sub>) to form various combinations, including NO, NO<sub>2</sub>, N<sub>2</sub>O, N<sub>2</sub>O<sub>3</sub>, and N<sub>2</sub>O<sub>5</sub>.
  - Write balanced chemical equations to show the formation of each of these compounds.
  - By using a catalytic converter and keeping engines properly tuned so that the right amount of oxygen enters the combustion cylinder at the right temperature, the formation of nitrogen oxides (NOx) can be greatly reduced. Why do you think this is important?
- (P. D) 4. Imagine that you are an engineer trying to determine how much air has to be supplied to burn gasoline in a car engine. Assuming that gasoline is heptane (C<sub>7</sub>H<sub>16</sub>), the word equation is  
 heptane + oxygen → carbon dioxide + water vapour
  - Write the skeleton equation for the reaction.
  - Balance the equation by adding coefficients as necessary.
  - How many molecules of oxygen are required for every molecule of heptane that burns?

Balancing Questions

**Balancing Reactions Quiz**

If you're sitting on the left, answer the odd-numbered questions. If you're sitting on the right, answer the even-numbered questions.

Gold

- Na + F<sub>2</sub> → NaF
- Li + Cl<sub>2</sub> → LiCl
- K + O<sub>2</sub> → K<sub>2</sub>O
- H<sub>2</sub> + O<sub>2</sub> → H<sub>2</sub>O
- CO + O<sub>2</sub> → CO<sub>2</sub>
- Na + O<sub>2</sub> → Na<sub>2</sub>O
- Cl<sub>2</sub> + NaBr → Br<sub>2</sub> + NaCl
- Te + H<sub>2</sub>O → TeO + H<sub>2</sub>

Platinum, Diamond

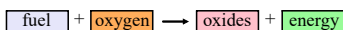
- Re + Br<sub>2</sub> → ReBr<sub>3</sub>
- Ni + Cl<sub>2</sub> → NiCl<sub>2</sub>
- Fe + HCl → FeCl<sub>2</sub> + H<sub>2</sub>
- Zn + CrCl<sub>3</sub> → CrCl<sub>2</sub> + ZnCl<sub>2</sub>
- Ga + H<sub>2</sub>SO<sub>4</sub> → Ga<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub> + H<sub>2</sub>
- PbCl<sub>2</sub> + HNO<sub>3</sub> → Pb(NO<sub>3</sub>)<sub>2</sub> + HCl
- copper(II) sulfide and oxygen react to produce copper(II) oxide and sulfur
- aluminum and iron(III)oxide produce iron and aluminum oxide

Balancing Quiz

There are five main types of chemical reactions:

1. Combustion

"the explosive relationship"

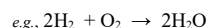
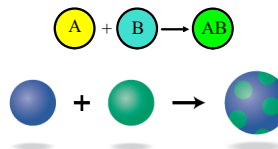
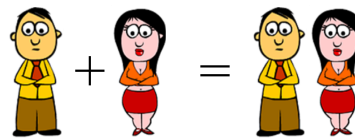


- usually called **burning**
- a very rapid reaction of a substance with oxygen to produce **oxides**
- energy is produced, mainly in the form of heat and light
- when hydrocarbons burn (i.e., react with oxygen) they always produce **carbon dioxide** and **water** e.g. **propane**
- when oxygen is a reactant and the products are carbon dioxide and water, it is a combustion reaction
- e.g.  $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$  Is this balanced?

Types of Reactions

2. Synthesis  
"the hook-up"

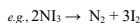
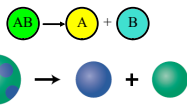
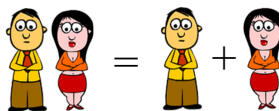
- two or more smaller compounds combine to form a larger compound



Synthesis

3. Decomposition  
"the break-up"

- opposite of synthesis reactions.  
- a larger compound breaks into elements or smaller compounds



Must know

1. recognize the types
2. make prod. compds
3. balance



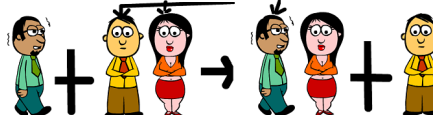
Decomposition

4. Single Displacement  
"the semi-switcheroo"

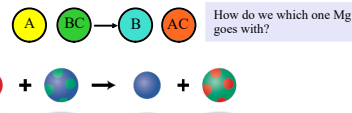
- one element trades places with another element in a compound.  
- a metal switches with the other metal or the nonmetal switches with the other nonmetal

In a single-replacement reaction this girl leaves her guy for Joe.

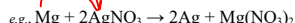
Poor Frank



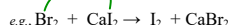
Now Joe and Mary are together



How do we know which one Mg goes with?



Mg becomes + so it goes with the -



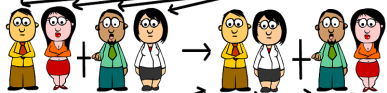
How do we know which one Br goes with?

Single Displacement

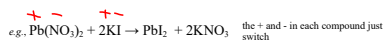
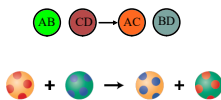
5. Double Displacement  
"the full switcheroo"

- two elements switch places with each other  
- the cation of one pairs up with the anion of the other

(+) (-)  
In double replacement Joe and Mary and Joah and Sue are together but they switch off



So now Joe and Sue are together and Joah and Mary are together



How do we know which ones go together?

- remember charges
- naming
- balance
- special 7

Double Displacement

Let's Practice

1. Identify the type of reaction for each of the following:
  - a) sodium iodide → sodium + iodine
  - b) bromine + sodium iodide → iodine + sodium bromide
  - c) hydrogen + oxygen → water vapour
  - d) zinc + hydrogen chloride → hydrogen + zinc chloride
  - e) calcium + magnesium chloride → magnesium + calcium chloride
  - f) sodium bromide + calcium iodide → sodium iodide + calcium bromide
  - g) calcium + water → hydrogen + calcium hydroxide
  - h) aluminum + copper(II) chloride → copper + aluminum chloride
  - i) zinc carbonate → zinc oxide + carbon dioxide
  - j) iron + oxygen → iron(III) oxide
  - k) copper + silver nitrate → silver + copper(II) nitrate
  - l) lithium nitrate + sodium hydroxide → lithium hydroxide + sodium nitrate
2. Write balanced skeleton equations for each of the equations in question 1. (Gold group do a-g)

Practice

Let's Practice

- a) sodium iodide → sodium + iodine (D)  
 $2\text{NaI} \rightarrow 2\text{Na} + \text{I}_2$
- b) bromine + sodium iodide → iodine + sodium bromide (SR)  
 $\text{Br}_2 + 2\text{NaI} \rightarrow \text{I}_2 + 2\text{NaBr}$
- c) hydrogen + oxygen → water vapour (S)  
 $\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O}$
- d) zinc + hydrogen chloride → hydrogen + zinc chloride (SR)  
 $\text{Zn} + 2\text{HCl} \rightarrow \text{H}_2 + \text{ZnCl}_2$
- e) calcium + magnesium chloride → magnesium + calcium chloride (SR)  
 $\text{Ca} + \text{MgCl}_2 \rightarrow \text{Mg} + \text{CaCl}_2$
- f) sodium bromide + calcium iodide → sodium iodide + calcium bromide (DR)  
 $2\text{NaBr} + \text{CaI}_2 \rightarrow 2\text{NaI} + \text{CaBr}_2$
- g) calcium + water → hydrogen + calcium hydroxide (SR)  
 $\text{Ca} + 2\text{H}_2\text{O} \rightarrow \text{H}_2 + \text{Ca(OH)}_2$
- h) aluminum + copper(II) chloride → copper + aluminum chloride (SR)  
 $2\text{Al} + 3\text{CuCl}_2 \rightarrow 3\text{Cu} + 2\text{AlCl}_3$
- i) zinc carbonate → zinc oxide + carbon dioxide (D)  
 $\text{ZnCO}_3 \rightarrow \text{ZnO} + \text{CO}_2$
- j) iron + oxygen → iron(III) oxide (S)  
 $4\text{Fe} + 3\text{O}_2 \rightarrow 2\text{Fe}_2\text{O}_3$
- k) copper + silver nitrate → silver + copper(II) nitrate (SR)  
 $\text{Cu} + 2\text{AgNO}_3 \rightarrow 2\text{Ag} + \text{Cu(NO}_3)_2$
- l) lithium nitrate + sodium hydroxide → lithium hydroxide + sodium nitrate (DR)  
 $\text{LiNO}_3 + \text{NaOH} \rightarrow \text{LiOH} + \text{NaNO}_3$

Practice Answers

Reaction Types Questions

1. Consider the five types of reactions we've studied. They all involve elements and compounds as reactants. Which type of reaction is described by each of the following?
    - a) Two reactants that are compounds.
    - b) One reactant is an element and one is a compound.
    - c) The reactants are a fuel and oxygen.
    - d) Both reactants are elements.
    - e) The single reactant is a compound.
    - f) These two reaction types seem to be the opposite of one another.
  2. Identify each of the following reactions as one of the types of reactions we studied:
    - a) sodium iodide → sodium + iodine
    - b) zinc carbonate → zinc oxide + carbon dioxide
    - c) barium + sulfur → barium sulfide
    - d) bromine + sodium iodide → iodine + sodium bromine
    - e) Sodium bromide + calcium iodide → sodium iodide + calcium bromide
    - f) iron + oxygen → iron(III) oxide
    - g) calcium + water → hydrogen + calcium hydroxide
    - h) barium nitrate + sodium sulfide → barium sulfide + sodium nitrate
    - i) lithium carbonate → carbon dioxide + lithium oxide
    - j) lead(II) oxide → lead + oxygen
  3. Write a balanced skeleton equation for each of the reactions in question 4. (Gold group write balanced skeleton equations for a-e only.)
- (P, D) 4. a) What is the meaning of the term "combustion"?  
 b) During a combustion reaction, if there is not enough oxygen present, a substance cannot burn completely. This is called incomplete combustion. One of the products is carbon monoxide - a deadly, odorless, tasteless, colorless gas. Knowing this, why should automobiles and gas barbecues never be operated in enclosed spaces like garages?
- (P, D) 5. Polymers are long-chain molecules that are made up of many smaller repeating units called monomers. For example, polyethylene (used to make plastic bags, containers and bottles) is made up of hundreds of ethylene molecules linked together. What kind of reaction is polymerization? Use a word equation to explain it.

Reaction Types Questions

Reaction Types Quiz

If you're sitting on the left, answer the odd-numbered questions. If you're sitting on the right, answer the even-numbered questions.

Name the type of reaction (from the five types we learned) and balance the equation.

Reaction Types Quiz

Predicting products

How do we predict the products of a chemical reaction?

1. Figure out the reaction type.
2. Predict the products.
3. Balance.

Let's try one:

Lithium and oxygen react.

Which reaction type is it?  
 - the reactants are both elements (single)  
 - synthesis

Write the equation.

Is it balanced?

Try this one:

Chlorine gas reacts with sodium iodide.

Which reaction type is it?  
 - reactants are an element and a compound (a single and a couple)  
 - single replacement

Write the equation.

Is it balanced?

What about this one?

Methane burns in the presence of oxygen.

Which reaction type is it?  
 - something is burning  
 - must be combustion

Write the equation.

Is it balanced?

Can you solve this one?

Copper (II) oxide is heated.

Which reaction type is it?  
 - only one reactant is complex  
 - must be decomposition

Write the equation.

Is it balanced?

One more:

Barium chloride and potassium iodide react.

Which reaction type is it?  
 - both reactants are compounds (complex)  
 - must be double replacement

Write the equation.

Is it balanced?

Predicting products

Predict the Products Practice

Predict the products to write balanced chemical equations for each of the following. (Gold group complete 1-16)

1. Magnesium is burned in oxygen.
2. Zinc sulfide is heated in the presence of oxygen.
3. Nitrogen and hydrogen react to form ammonia (NH<sub>3</sub>).
4. Sulfur trioxide decomposes.
5. Silver reacts with oxygen.
6. Bromine reacts with potassium iodide.
7. Silver oxide decomposes.
8. Potassium bromide decomposes.
9. Potassium and nitrogen react together.
10. Calcium chloride reacts with sodium sulfide.
11. Magnesium oxide decomposes.
12. Aluminum is reacted with sulfur.
13. Aluminum is oxidized by oxygen.
14. Coal (assume C) is burned to produce heat.
15. Steel wool (Fe) is burned.
16. Aluminum reacts with fluorine.
17. Barium chloride reacts with sodium sulfate.
18. Iron and silver acetate react.
19. Magnesium hydroxide and calcium phosphate react.
20. Ammonium sulfide reacts with iron(II) nitrate.
21. Aluminum sulfate and calcium phosphate are reacted together.
22. Barium carbonate and hydrogen chloride react.
23. Silver acetate is mixed with potassium chromate.
24. Ammonium phosphate reacts with barium hydroxide.
25. Iron(III) bromide decomposes.
26. Silver and copper(II) nitrate react.
27. Potassium and zinc nitrate react.
28. Lead(II) sulfate and potassium iodide react.
29. Aluminum reacts with iron(III) oxide.
30. Lead(II) nitrate is reacted with sodium carbonate.
31. Lead(II) chloride is reacted with lithium sulfate.
32. Aluminum nitrate reacts with sodium hydroxide.
33. Aluminum and copper(II) chloride react.
34. Copper pipes react with chlorine in drinking water.

Practice

Predicting Products Quiz

If you're sitting on the left, answer the odd-numbered questions. If you're sitting on the right, answer the even-numbered questions.

Write balanced chemical equations for each reaction.

<p>Gold</p> <ol style="list-style-type: none"> <li>1. Barium reacts with sulfur.</li> <li>2. Magnesium and oxygen react.</li> <li>3. Lithium oxide and calcium sulfide react.</li> <li>4. Lithium bromide reacts with calcium.</li> <li>5. Sodium chloride decomposes.</li> <li>6. Sodium sulfide and magnesium chloride react.</li> <li>7. Hydrogen chloride and magnesium react.</li> <li>8. Potassium fluoride decomposes.</li> <li>9. Magnesium is burned in oxygen.</li> <li>10. Sodium is burned in oxygen.</li> </ol>	<p>Platinum, Diamond</p> <ol style="list-style-type: none"> <li>1. Copper(II) sulfide and oxygen react.</li> <li>2. Iron(II) sulfide is mixed with hydrogen chloride.</li> <li>3. Sodium sulfate and calcium chloride mix.</li> <li>4. Sodium and sulfur react.</li> <li>5. Calcium oxide decomposes.</li> <li>6. Silver and copper (II) nitrate react.</li> <li>7. Potassium and bromine react.</li> <li>8. Sodium is burned in oxygen.</li> <li>9. Magnesium is burned in oxygen.</li> <li>10. Sodium chloride decomposes.</li> </ol>
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Quiz