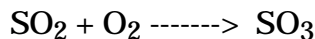


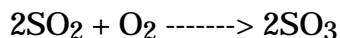
## Reaction Types

### I. Synthesis (or Direct Combination) Reactions

1. In these reactions, two different molecules or atoms unite to form a single substance.
2. Write the correct formula on the right hand side of the arrow. Whenever a product is a gas, indicate this fact by placing an up arrow directly after the formula.



3. Balance the equation by inspection, making sure that there is the same number of atoms of each element on both sides of the arrow.

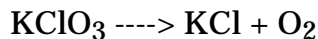


Complete and balance the following equations:

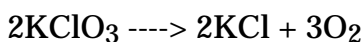
1.  $\text{SO}_2 + \text{H}_2\text{O} \text{ -----} >$
2.  $\text{S}_8 + \text{O}_2 \text{ -----} >$
3.  $\text{Al} + \text{O}_2 \text{ -----} >$
4.  $\text{Fe} + \text{Cl}_2 \text{ -----} >$
5.  $\text{Al} + \text{N}_2 \text{ -----} >$
6.  $\text{Cu} + \text{Br}_2 \text{ -----} >$
7.  $\text{Zn} + \text{O}_2 \text{ -----} >$
8.  $\text{NO} + \text{O}_2 \text{ -----} >$
9.  $\text{As} + \text{Cl}_2 \text{ -----} >$
10.  $\text{N}_2 + \text{H}_2 \text{ -----} >$
11.  $\text{Hg} + \text{O}_2 \text{ -----} >$
12.  $\text{C} + \text{O}_2 \text{ ---} >$
13.  $\text{SO}_3 + \text{H}_2\text{O} \text{ ---} >$
14.  $\text{I}_2 + \text{Cl}_2 \text{ ---} >$
15.  $\text{Si} + \text{S}_8 \text{ ---} >$
16.  $\text{K} + \text{Cl}_2 \text{ ---} >$
17.  $\text{Sb} + \text{S}_8 \text{ ---} >$
18.  $\text{Cu} + \text{O}_2 \text{ ---} >$
19.  $\text{Cs} + \text{O}_2 \text{ ---} >$
20.  $\text{Ag} + \text{O}_2 \text{ ---} >$

### II. Decomposition Reactions

1. In these reactions, a single substance is broken down into two or more simpler substances. (Reverse of direct combination reactions)
2. Write the correct formula for the decomposition products on the right hand side of the arrow. Denote all gaseous products with an up arrow.



3. Balance the equation by inspection as in direct combination reactions.

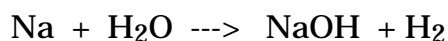


Complete and balance the following equations:

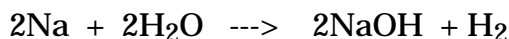
1.  $\text{MgCO}_3 \rightarrow$  +
2.  $\text{HgO} \rightarrow$  +
3.  $\text{PCl}_5 \rightarrow$  +
4.  $(\text{NH}_4)_2\text{Cr}_2\text{O}_7 \rightarrow$  +  $\text{N}_2$
5.  $\text{CuO} \rightarrow$  +
6.  $\text{Hg}_2\text{CO}_3 \rightarrow \text{HgO} +$
7.  $\text{KNO}_3 \rightarrow$  +  $\text{O}_2$
8.  $\text{H}_3\text{PO}_4 \rightarrow \text{P}_2\text{O}_5 +$
9.  $\text{H}_2\text{SO}_4 \rightarrow$  +
10.  $\text{Ca}(\text{OH})_2 \rightarrow \text{CaO} +$
11.  $\text{H}_2\text{SO}_3 \rightarrow$  +
12.  $\text{NH}_3 \rightarrow$  +
13.  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O} \rightarrow$  +
14.  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O} \rightarrow$  +
15.  $\text{Pb}(\text{NO}_3)_2 \rightarrow$  +  $\text{NO}_2$
16.  $\text{C}_6\text{H}_{12}\text{O}_6 \rightarrow \text{C} +$
17.  $\text{H}_2\text{O} \rightarrow$  electric current +
18.  $\text{Al}(\text{OH})_3 \rightarrow$  +  $\text{H}_2\text{O}$
19.  $\text{CuSO}_4 \rightarrow$  +  $\text{SO}_3$
20.  $\text{AuCl}_3 \rightarrow \text{Au} +$
21.  $\text{H}_2\text{SiO}_3 \rightarrow$  +  $\text{H}_2\text{O}$
22.  $\text{HNO}_3 \rightarrow$  +  $\text{H}_2\text{O}$

### III. Single Replacement

1. In these reactions, a free element reacts with a compound to form another compound and release one of the elements of the original compound in the elemental state.
2. Write the correct formulae for the products formed on the right hand side of an up arrow



3. Balance the equation by inspection as previous examples.



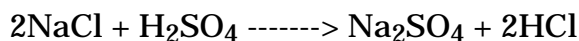
Complete and balance the following equations:

1.  $\text{Al} + \text{Fe}_2\text{O}_3 \rightarrow$  +
2.  $\text{Cu}_2\text{S} + \text{O}_2 \rightarrow \text{Cu} +$
3.  $\text{Zn} + \text{H}_2\text{SO}_4 \rightarrow$  +
4.  $\text{Sb}_2\text{S}_3 + \text{Fe} \rightarrow$  +
5.  $\text{SiC} + \text{Cl}_2 \rightarrow$  +  $\text{C}$
6.  $\text{H}_2 + \text{HgO} \rightarrow$  +
7.  $\text{Fe} + \text{NH}_3 \rightarrow$  +  $\text{H}_2$
8.  $\text{NaBr} + \text{Cl}_2 \rightarrow$  +
9.  $\text{K} + \text{HgCl}_2 \rightarrow$  +
10.  $\text{Mg} + \text{PbSO}_4 \rightarrow$  +

11.  $\text{ZnI}_2 + \text{Br}_2 \text{-----}>$  +
12.  $\text{H}_2 + \text{CuO} \text{-----}>$  +
13.  $\text{Ca} + \text{HCl} \text{-----}>$  +
14.  $\text{H}_2\text{O} + \text{Fe} \text{-----}>$  +
15.  $\text{Fe} + \text{CuCl}_2 \text{-----}>$  +
16.  $\text{Na} + \text{H}_2\text{O} \text{-----}>$  +
17.  $\text{Zn} + \text{FeCl}_3 \text{-----}>$  +
18.  $\text{Cs} + \text{H}_2\text{SO}_4 \text{-----}>$  +
19.  $\text{Fe}_2\text{O}_3 + \text{H}_2 \text{-----}>$  +
20.  $\text{Zn} + \text{CuSO}_4 \text{-----}>$  +
21.  $\text{Fe} + \text{CuSO}_4 \text{-----}>$  +
22.  $\text{Fe} + \text{H}_2\text{O} \text{-----}>$   $\text{Fe}_3\text{O}_4$  +

#### IV. Double Replacement (also called metathesis)

1. In these reaction, the reactants switch "partners"



2. It is important that the formulae of the products be written correctly. If they are correct, balancing the equation by inspection is a simple task; if not, the equation will never balance.
3. In these reaction, there is never a change in oxidation state.
4. It is a simple task to write the equation, but, what is more important does the reaction takes place? For example :

Does a mixture of NaCl and  $\text{H}_2\text{SO}_4$  react to give  $\text{Na}_2\text{SO}_4$  and HCl, or rather, does a mixture of  $\text{Na}_2\text{SO}_4$  and HCl react to give NaCl and  $\text{H}_2\text{SO}_4$ . If we go into the laboratory and mix NaCl and  $\text{H}_2\text{SO}_4$  we find that HCl is formed. Obviously we cannot test every reaction before we write the equation, but fortunately, there are certain conditions under which a reaction goes to completion (i.e goes in one direction only). These are summarized below.

A reaction tends to go to completion if:

- a. One of the product is a gas and is allowed to escape.
- b. An unionized substance such as  $\text{H}_2\text{O}$  or  $\text{NH}_3$  is formed.
- c. An insoluble substances is formed.

The first two of these are obvious if we are able to recognize which substances are gases. The most common inorganic gases are  $\text{H}_2$ ,  $\text{Cl}_2$ ,  $\text{O}_2$ ,  $\text{N}_2$ ,  $\text{H}_2\text{S}$ , HF, HCl, HBr, HI, CO,  $\text{CO}_2$ ,  $\text{SO}_2$ ,  $\text{SO}_3$ ,  $\text{NH}_3$ , NO,  $\text{N}_2\text{O}$ ,  $\text{NO}_2$  and HCN.

The most difficult aspect of reactions of this type is the ability to recognize insoluble substances. In order to become adept at this it is necessary to know by memory the following solubility rules.

1. All nitrates and acetates are soluble.
2. All chlorides, bromides, and iodides are soluble except those of  $\text{Pb}^{2+}$ ,  $\text{Ag}^+$ , and  $\text{Hg}_2^{2+}$ .
3. All sulfates are soluble except those of  $\text{Ba}^{2+}$ ,  $\text{Sr}^{2+}$ , and  $\text{Pb}^{2+}$ .  $\text{CaSO}_4$ ,  $\text{Ag}_2\text{SO}_4$ , and  $\text{Hg}_2\text{SO}_4$  are slightly soluble.
4. All hydroxides are insoluble except those of group I in the periodic table,  $\text{NH}_4^+$ , and  $\text{Ba}^{2+}$ .  $\text{Ca}(\text{OH})_2$  and  $\text{Sr}(\text{OH})_2$  are slightly soluble.

5. All carbonates and phosphates are insoluble except those of group I and  $\text{NH}_4^+$ . Many hydrogen phosphates are soluble.
6. All sulfides are insoluble except those of Group I and Group II in the periodic table and  $\text{NH}_4^+$ .

Complete and balance the following equations:

1. Indicate all gaseous products by an up arrow and all unionized or insoluble products by a down arrow.
2. If the reaction doesn't take place, indicate the reason.

1.  $\text{FeBr}_2 + \text{K}_2\text{CO}_3 \rightarrow$
2.  $\text{Ag}_2\text{S} + \text{CuCl}_2 \rightarrow$
3.  $\text{Pb}(\text{NO}_3)_2 + \text{HI} \rightarrow$
4.  $\text{Ba}(\text{ClO}_3)_2 + \text{H}_2\text{SO}_4 \rightarrow$
5.  $\text{CuS} + \text{KCl} \rightarrow$
6.  $\text{Na}_3\text{PO}_4 + \text{MgSO}_4 \rightarrow$
7.  $\text{Pb}(\text{NO}_3)_2 + \text{H}_2\text{SO}_4 \rightarrow$
8.  $\text{FeCl}_2 + \text{H}_2\text{S} \rightarrow$
9.  $\text{KCl} + \text{H}_2\text{SO}_4 \rightarrow$
10.  $\text{HCl} + \text{NaOH} \rightarrow$
11.  $\text{FeBr}_3 + \text{Ba}(\text{OH})_2 \rightarrow$
12.  $\text{FeCl}_3 + \text{Na}_3\text{PO}_4 \rightarrow$
13.  $\text{Hg}_2\text{Cl}_2 + \text{HCl} \rightarrow$
14.  $\text{CaS} + \text{HCl} \rightarrow$
15.  $\text{H}_2\text{O} + \text{K}_2\text{SO}_4 \rightarrow$
16.  $\text{NH}_4\text{Cl} + \text{KOH} \rightarrow$
17.  $\text{NaNO}_3 + \text{KC}_2\text{H}_3\text{O}_2 \rightarrow$
18.  $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2 + \text{KI} \rightarrow$
19.  $\text{NH}_4\text{OH} + \text{BaCl}_2 \rightarrow$
20.  $\text{Ca}(\text{NO}_3)_2 + \text{Na}_2\text{SO}_4 \rightarrow$
21.  $\text{Na}_2\text{CO}_3 + \text{AgNO}_3 \rightarrow$
22.  $\text{Zn}(\text{C}_2\text{H}_3\text{O}_2)_2 + \text{K}_2\text{CO}_3 \rightarrow$
23.  $\text{Hg}_2(\text{NO}_3)_2 + \text{K}_2\text{SO}_4 \rightarrow$
24.  $\text{Pb}(\text{NO}_3)_2 + \text{Al}(\text{NO}_3)_3 \rightarrow$
25.  $\text{H}_2\text{S} + \text{Cd}(\text{C}_2\text{H}_3\text{O}_2)_2 \rightarrow$
26.  $\text{BaBr}_2 + \text{Na}_2\text{SO}_4 \rightarrow$
27.  $\text{H}_2\text{SO}_4 + \text{CaCl}_2 \rightarrow$
28.  $\text{AgNO}_3 + \text{HCl} \rightarrow$
29.  $\text{CaCO}_3 + \text{HCl} \rightarrow$
30.  $\text{FeS} + \text{HCl} \rightarrow$
31.  $\text{NaOH} + \text{Al}_2(\text{SO}_3)_3 \rightarrow$
32.  $\text{NaCl} + \text{H}_2\text{SO}_4 \rightarrow$
33.  $\text{H}_2\text{S} + \text{CuSO}_4 \rightarrow$
34.  $\text{KCl} + \text{Hg}_2\text{SO}_4 \rightarrow$
35.  $\text{NH}_4\text{Cl} + \text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2 \rightarrow$