

## ChemQuest 35

# Intro. to Chemical Reactions

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Hour: \_\_\_\_\_

## Formula Review

1. Write the formulas for the following compounds:

a) dinitrogen pentoxide:  $N_2O_5$       b) calcium phosphide:  $Ca_3P_2$

c) copper(II) phosphate:  $Cu_3(PO_4)_2$       d) lithium sulfate:  $Li_2SO_4$

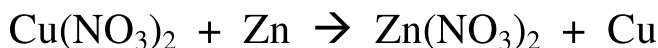
2. Write the names for the following compounds:

a)  $Ca(CN)_2$  : calcium cyanide      b)  $P_2O_3$  : diphosphorus trioxide

c)  $FeCO_3$  : Iron(II) carbonate      d)  $K_3N$  : Potassium nitride

## Chemical Reactions: What they look like...

Here is what a chemical reaction looks like when it is written:



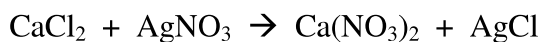
There is a sentence that you can write to describe what happens above:

*Copper(II) nitrate reacts with zinc metal and yields zinc nitrate and copper metal.*

Take a minute to notice the relationship between the sentence and the symbols in the reaction. Now, try a few yourself.

## Critical Thinking Questions

3. Given the following reaction, write the sentence that goes along with it...



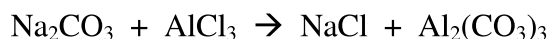
**Calcium chloride reacts with silver nitrate and yields calcium nitrate and silver chloride.**

4. Given the following sentence, use chemical symbols to write a reaction that represents it...

*Nickel(II) nitrate reacts with sodium carbonate and yields nickel(II) carbonate and sodium nitrate.*



5. Given the following reaction, write the sentence that goes along with it...



**Sodium carbonate reacts with aluminum chloride and yields sodium chloride and aluminum carbonate.**

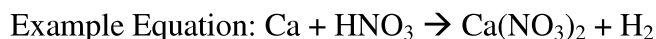
6. Write an equation to go along with the following sentence.

*Lithium reacts with water to produce lithium hydroxide and hydrogen*

**Li + H<sub>2</sub>O → LiOH + H<sub>2</sub> (note: students won't know that hydrogen is diatomic, but they will find out in the next information section. If they write "H" instead of "H<sub>2</sub>" it is ok for now.)**

## **Information:** Introduction to Reactions

During a chemical reaction, new substances are formed. Reactants are transformed into different products. Atoms are never created or destroyed, but they are rearranged. A chemical equation represents what happens during a reaction. The following is an example of a chemical equation:



This equation describes the reaction of calcium (Ca) with nitric acid (HNO<sub>3</sub>) to produce calcium nitrate (Ca(NO<sub>3</sub>)<sub>2</sub>) and hydrogen gas (H<sub>2</sub>). You may notice that there are more total atoms on the right side than there are on the left side of the equation. If this seems strange to you, don't worry about it now; we'll fix this later.

Note in the above equation that hydrogen gas is written as H<sub>2</sub> and not simply as H. There are a few elements that exist as diatomic molecules. If a substance is diatomic then the substance must always be bonded to something. A hydrogen atom is diatomic and so it must be bonded to something else like in HCl or HNO<sub>3</sub>. If nothing is available for it to bond to, it will bond to itself by forming H<sub>2</sub>. All of the diatomic substances are listed below:

Br    I    N    Cl    H    O    F

When by themselves these elements exist as Br<sub>2</sub>, I<sub>2</sub>, N<sub>2</sub>, Cl<sub>2</sub>, H<sub>2</sub>, O<sub>2</sub>, and F<sub>2</sub>. By the way, you can remember these by recalling a made-up name: Mr. Brinclhof.

## Critical Thinking Questions

7. Consider the bromine atoms in this reaction:  $\text{LiBr} + \text{P} \rightarrow \text{Li}_3\text{P} + \text{Br}_2$ .

a) Why is bromine written as  $\text{Br}_2$  on the right side?

Bromine is a diatomic molecule and always needs to be bonded to something; even bonding to itself works.

b) The correct formula for lithium bromide is  $\text{LiBr}$ . Why doesn't bromine need a "2" in the formula?

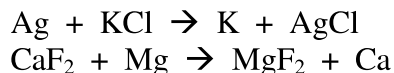
$\text{Li}^{+1}$  and  $\text{Br}^{-1}$  bond together as  $\text{LiBr}$  so that the overall charge of the compound is neutral.

8. Name the "reactants" from the reaction in question 7.

Lithium bromide and phosphorus

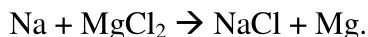
## Information: Single Replacement Reactions

There are several types of reactions that follow predictable patterns. The first kind is called a single replacement reaction. See if you can figure out the pattern in each of the following reactions.



## Critical Thinking Questions

9. Answer the questions that follow based on this chemical equation:



a) Why can't  $\text{NaMg}$  be produced?

$\text{Na}^{+}$  cannot bond with  $\text{Mg}^{2+}$  because they are both positive.

b) Why can't  $\text{NaCl}_2$  be produced?

$\text{Na}^{+}$  only requires one  $\text{Cl}^{-}$ .  $\text{NaCl}_2$  is not a neutral compound.

c) Are  $\text{NaCl}$  and  $\text{Mg}$  the only products that can be produced?

Yes.

10. Given the following equation:  $\text{Li} + \text{Ca}_3(\text{PO}_4)_2 \rightarrow \text{Li}_3\text{PO}_4 + \text{Ca}$ .

a) Why can't  $\text{CaLi}_2$  be produced?

$\text{Ca}^{2+}$  and  $\text{Li}^{+}$  won't bond because they are both positive.

b) Why can't  $\text{Li}_3\text{P}$  be produced?

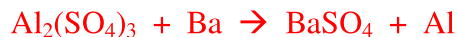
Although  $\text{Li}_3\text{P}$  is neutral, there is no  $\text{P}^{3-}$  in the equation. There is only  $\text{PO}_4^{3-}$  and we will almost never be breaking up polyatomic ions like  $\text{PO}_4^{3-}$ . Don't mess with polyatomic ions!

c) Are  $\text{Li}_3\text{PO}_4$  and  $\text{Ca}$  the only substances that can be produced?

Yes.

11. Write chemical equations for the following reactions.

a) Aluminum sulfate reacts with barium to produce barium sulfate and aluminum.



b) Magnesium reacts with copper(I) nitrate to produce magnesium nitrate and copper.



c) Sodium reacts with calcium phosphide to produce sodium phosphide and calcium.



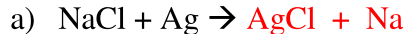
d) Phosphorus reacts with sodium chloride to produce sodium phosphide and chlorine.



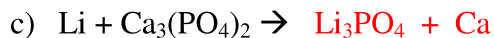
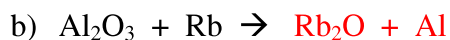
12. Each of the reactions you wrote in question 11 follows a similar pattern. The same pattern is followed by all of the equations in this section. Describe this pattern.

A single atom reacts with a compound and replaces one of the atoms in that compound.

13. Complete the following reactions:



(note: order is not important, so you could also write  $\text{Na} + \text{AgCl}$ )



## ChemQuest 36

# More Chemical Reactions!

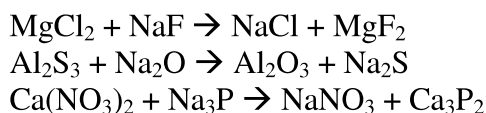
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## Information: Double Replacement Reactions

In the previous ChemQuest, you learned about single replacement reactions in which a single atom replaces an ion from another reactant. Study what happens in the following reactions. They are called double replacement reactions.



## Critical Thinking Questions

1. What is the difference between single replacement reactions and double replacement reactions?

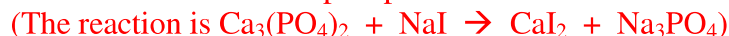
In single replacement reactions, one of the reactants is made of only one kind of atom. In double replacement reactions, both reactants contain more than one kind of atom.

2. Complete the following reactions by providing the formulas for the missing compound(s).



3. Name the two products in the reaction between calcium phosphate and sodium iodide.

Calcium iodide and sodium phosphate



4. Explain why when you mix the following reactants, no reaction occurs:  $\text{Na}_2\text{SO}_4 + \text{NaCl} \rightarrow$   
 Both reactants contain sodium. Therefore, if the sodium atoms replaced each other, the same products would be formed—no change would occur.

### **Information:** Combustion Reactions

Another type of reaction is a combustion reaction. During combustion, a hydrocarbon reacts with oxygen. The products for complete combustion are always the same—water and carbon dioxide and energy. The following equation is an example of the combustion of a hydrocarbon.



### **Critical Thinking Questions**

5. Complete the following reactions by supplying the missing compound in each blank.



6. Write a combustion reaction for  $\text{C}_5\text{H}_{10}$ .



### **Information:** Synthesis and Decomposition Reactions

Two other types of reactions are synthesis and decomposition. During a synthesis reaction, several reactants combine to make a single product. During a decomposition, one reactant *decomposes* into two or more products. The following table shows some examples of these types of reactions.

Synthesis	Decomposition
$\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O}$	$\text{H}_2\text{O} \rightarrow \text{H}_2 + \text{O}_2$
$\text{Na} + \text{Cl}_2 \rightarrow \text{NaCl}$	$\text{NaCl} \rightarrow \text{Na} + \text{Cl}_2$

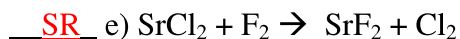
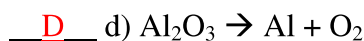
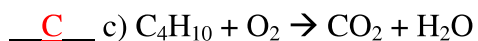
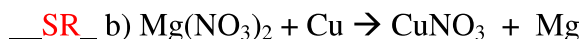
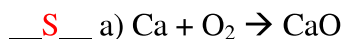
### **Critical Thinking Questions**

7. Every synthesis reaction has  $\frac{1}{\text{how many?}}$  product and every decomposition reaction has  $\frac{1}{\text{how many?}}$  reactant.

8. Write a synthesis reaction for sodium metal reacting with chlorine gas to form sodium chloride. (Remember that chlorine is diatomic.)



9. Categorize each of the following reactions as single replacement (SR), double replacement (DR), synthesis (S), decomposition (D) or combustion (C).



10. Write an equation for the combustion of  $\text{C}_3\text{H}_6$ .



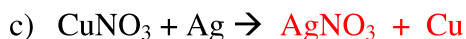
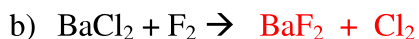
(Combustion reactions always involve combining with  $\text{O}_2$  to form  $\text{CO}_2$  and  $\text{H}_2\text{O}$ .)

11. Write an equation for the decomposition of calcium oxide.

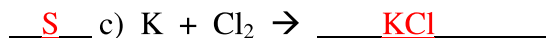


## Practice Problems

1. Complete the following reactions.



2. Fill in the blanks for the missing reactant or product and then in the blank to the left of each equation indicate whether the reaction is a single replacement (SR), double replacement (DR), synthesis (S), decomposition (D) or combustion (C).



## ChemQuest 37

# Balancing Equations

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Hour: \_\_\_\_\_

## Introduction Questions

1. Write the equation for the reaction of sodium and chlorine to form sodium chloride.



2. Write the equation for the reaction of calcium nitride and sodium chloride to produce calcium chloride and sodium nitride.



## Information: Subscripts and Coefficients

A subscript is a small number that tells you how many atoms are in a compound. For example, in  $\text{CaCl}_2$  the two is the subscript and it tells us that there are two chloride ions bonded to one calcium.

A coefficient also tells us how many atoms or compounds there are, but in a different way. For example in the expression “3  $\text{H}_2\text{O}$ ” the three is the coefficient. The three tells us that there are three molecules of water present. In the expression “3  $\text{H}_2\text{O}$ ” there are a total of 6 hydrogen atoms and 3 oxygen atoms.

## Critical Thinking Questions

3. Verify that in  $4\text{Ca}_3(\text{PO}_4)_2$  there are 32 oxygen atoms present.

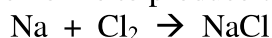
**Multiply the subscripts by each other and then by the coefficient:  $4 \times 2 \times 4 = 32$**

4. How many oxygen atoms are in each of the following:

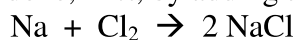
3 a)  $\text{Al}_2\text{O}_3$     3 b)  $3 \text{Na}_2\text{O}$     16 c)  $4 \text{Na}_2\text{SO}_4$     30 d)  $5 \text{Mg}(\text{NO}_3)_2$

## Information: How To Balance Equations

Consider the reaction of sodium and chlorine to produce sodium chloride from question one:



Remember that when chlorine is by itself it is always written as  $\text{Cl}_2$ . On the reactant side of the reaction (left side) there are a total of two atoms of chlorine, but on the product side there is only one atom of chlorine. Atoms cannot simply disappear. In order for the equation to make sense, we need to balance the equation. This can be done, first, by adding a “2” to the product side:



Now the equation reads that one atom of Na reacts with one molecule of  $\text{Cl}_2$  to produce two units of NaCl. However, now the Na atoms are not balanced because there is one atom of the reactant side, but two atoms of Na on the product side. This can be fixed by adding another two:

