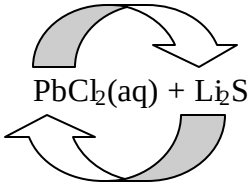
Name _____ **Chemistry** **____/____/____**

More Chemical Reactions

Today we will take a look at a few more types of chemical reactions. Specifically we will look at double displacement, synthesis, decomposition and combustion.

Double Displacement

In the single displacement problems that we studied last class, one single element displaced another that was in a compound. In a double displacement problem, we begin with two compounds and we switch the cations of each**. There is no need to check the activity series when solving double displacement reactions**. All you need to remember is to switch cations and cross charges when writing the new formulas. See below for an example.



$PbCl_2(aq) + Li_2SO_4(aq) \rightarrow PbSO_4(aq) + 2LiCl(aq)$

One more note, **if a multivalent (an element with more than one charge) element (like lead above) is used, you must use the same charge once you switch the cations**. In other words, if we use lead(II) as a reactant, we must also use lead(II) as a product. You cannot switch to lead(IV). The general pattern of a double displacement reaction is **AB + CD → CB + AD**

Don't forget, once you switch cations, you must again write the charges as superscripts and then cross them. See the example below.

Example #1: Predict the product when aqueous lead(II) nitrate reacts with aqueous sodium chromate.

Description of Action	Action
1. Write the formulas and states for the reactants.	**1.** $Pb(NO_3)_2(aq) + Na_2CrO_4(aq) \rightarrow$
2. Identify the cations in each compound. Mine are in bold.	**2.** $\mathbf{Pb}(NO_3)_2(aq) + \mathbf{Na}_2CrO_4(aq) \rightarrow$
3. On the products side, write each cation, and its charge, with the other anion, and its charge. **Leave all subscripts behind unless it is part of the polyatomic ion**. Remember if you are using a multivalent cation, you must use the same charge on each side. Write the states for each product. All ionic compounds are aqueous.	**3.** $Pb(NO_3)_2(aq) + Na_2CrO_4(aq) \rightarrow Na^{1+}(NO_3)^{1-}(aq) + Pb^{2+}(CrO_4)^{2-}(aq)$ Note: because we are using lead(II) on the reactants side we must use lead(II) on the products side.
4. Cross charges.	**4.** $Pb(NO_3)_2(aq) + Na_2CrO_4(aq) \rightarrow Na_{1}(NO_3)_{1+}(aq) + Pb_{2}(CrO_4)_{2+}(aq)$
5. Remove all + signs, - signs and ones. Reduce if possible.	**5.** $Pb(NO_3)_2(aq) + Na_2CrO_4(aq) \rightarrow NaNO_3(aq) + PbCrO_4(aq)$
6. Balance the equation.	**6.** $Pb(NO_3)_2(aq) + Na_2CrO_4(aq) \rightarrow 2NaNO_3(aq) + PbCrO_4(aq)$

Now you try one. Write the balanced equation for the reaction of aqueous ferrous oxide and aqueous zinc phosphate.

Description of Action	Action
1.	**1.**
2.	**2.**
3.	**3**
4.	**4.**
5.	**5.**
6.	**6.**

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Synthesis

In a synthesis equation we start out with two separate elements on the reactants side and then combine them to form a compound on the products side. The general pattern of a synthesis reaction is: **A + B → AB**. Look at the example below.

$$2Na(s) + Cl_2(g) \rightarrow 2NaCl(cr)$$

Example #2: Determine the products when solid gold reacts with oxygen gas.

Description of Action	Action
1. Write the formulas for the given reactants. Don't forget to write a subscript of two with elements that are diatomic. Include the states for each element and compound.	**1.** $Au(s) + O_2(g) \rightarrow$
2. On the products side, write the cation with its charge and the anion with its charge. If a multivalent element is being used, you can use whatever charge you want. Write the states for your product. Ionic compounds in synthesis reactions are usually crystalline.	**2.** $Au(s) + O_2(g) \rightarrow Au^{1+}O^{2-}(cr)$ Gold is multivalent. It can have a charge of 1+ or 3+. One is fun, so I picked that one.
3. Cross those charge, remove + signs, - signs and ones. You know the routine.	**3.** $Au(s) + O_2(g) \rightarrow Au_2O(cr)$
4. Balance it!	**4.** $4Au(s) + O_2(g) \rightarrow 2Au_2O(cr)$

Now you try one. Write the equation for the synthesis of solid iron and chlorine gas.

Description of Action	Action
1.	**1.**
2.	**2.**
3.	**3.**
4.	**4.**

Decomposition

A decomposition equation is the opposite of a synthesis equation. You are given a compound as the reactant. To find the product, you split the compound into the individual elements, usually. The general pattern of a decomposition equation is: **AB → A + B**. Look at the example below.

$$2NaCl(cr) \rightarrow 2Na(s) + Cl_2(g)$$

These are very easy. You do not have to cross charges, use the activity series, or any of that silliness. All you have to remember is to use a subscript of two with diatomic elements.

Example #3: Determine the products as crystalline zinc oxide decomposes.

Description of Action	Action
1. Write the formula for the reactant.	**1.** $ZnO(cr) \rightarrow$
2. Write the products for the equation by writing first the cation and then the anion on the products side. Don't forget to write a subscript of two with diatomic elements.	**2.** $ZnO(cr) \rightarrow Zn(s) + O_2(g)$
3. Balance the equation.	**3.** $2ZnO(cr) \rightarrow 2Zn(s) + O_2(g)$

Try one. Write the equation for the decomposition of crystalline lithium chloride.

Description of Action	Action
1.	**1.**
2.	**2.**
3.	**3.**

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Other Decomposition Reactions

There are three other decomposition reactions that I want you to know. All are pretty easy, but they are a little more complex than the one above. The first is the **decomposition of a hydrate**. As we learned last chapter, hydrates are compounds that readily absorb water into their crystal structure. **When a hydrate decomposes, water is removed.** See below for the decomposition of barium iodide dihydrate.

$$BaI_2 \cdot 2H_2O(cr) \rightarrow BaI_2(cr) + 2H_2O(l)$$

Another decomposition reaction is the **decomposition of carbonates**. **When a carbonate decomposes, carbon dioxide gas is produced. The other product is the metal oxide.** You must still remember to cross charges between the metal and oxygen. Finish the equation by balancing it. See below the decomposition of calcium carbonate.

$$CaCO_3(cr) \rightarrow CaO(cr) + CO_2(g)$$

The last type of decomposition reaction I want you to know is the **decomposition of a chlorate. When a chlorate decomposes, oxygen gas is produced. The other product is a metal chloride.** For example, the decomposition of magnesium chlorate is shown below.

$$Mg(ClO_3)_2(cr) \rightarrow MgCl_2(cr) + 3O_2(g)$$

Note that once the oxygen gas is removed you are left with the ionic compound magnesium chloride. You should still go thorough the steps of crossing charges. For magnesium chloride I still had to cross magnesium's (2+) with chlorine's (1-) to get $MgCl_2$.

Combustion

To combust is to burn. In every combustion equation a carbon compound reacts with oxygen (O_2) to produce water (H_2O or HOH) and carbon dioxide (CO_2). Combustion reactions that the pattern of : **$C_xH_y + O_2(g) \rightarrow CO_2(g) + H_2O(g)$**

$$2C_8H_{18}(l) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(g)$$

Example #4: Write the equation for the combustion of liquid hexane, C_6H_{12}.

Description of Action	Action
1. Write the given reactant.	**1.** $C_6H_{12}(l)$
2. Add oxygen, O_2, as a reactant.	**2.** $C_6H_{12}(l) + O_2(g) \rightarrow$
3. Your **products** are **ALWAYS H_2O** and **CO_2** so write them in on the products side.	**3.** $C_6H_{12}(l) + O_2(g) \rightarrow CO_2(g) + H_2O(g)$
4. Balance the equation.	**4.** $C_6H_{12}(l) + 9O_2(g) \rightarrow 6CO_2(g) + 6H_2O(g)$

Your turn. Write the equation for the combustion of liquid propene C_3H_6.

Description of Action	Action
1.	**1.**
2.	**2.**
3.	**3.**
4.	**4.**

In Summary:

Single Displacement: A + BC → AC + B or A + BC → BA + C (Cations replace cations, anions replace anions.)
Double Displacement: AB + CD → CB + AD (Just switch cations)
Synthesis: A + B → AB (Combine cation and anion. Don't forget to cross charges)
Decomposition Regular: AB → A + B (Separate the two elements in the compound.)
Decomposition Hydrates: $AB \bullet xH_2O \rightarrow AB + xH_2O$ (Remove water from the ionic compound and write it after the plus sign.)
Decomposition Carbonates: $A(CO_3) \rightarrow AO + CO_2$ (Produce a metal oxide and carbon dioxide gas.)
Decomposition Chlorates: $A(ClO_3) \rightarrow ACl + O_2$ (Produce a metal chloride and oxygen gas.)
Combustion: $C_xH_y + O_2 \rightarrow CO_2 + H_2O$ (Carbon compound + oxygen gas; carbon dioxide gas and water vapor are produced.)

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Homework- Write the balanced chemical equation using the elements and compounds below as your reactants.

Double Displacement (All compounds are aqueous)**:**

1. zinc bromide and silver nitrate
2. barium chloride and potassium fluoride
3. aluminum nitrate and sodium hydroxide
4. iron(II) bromide and aurous chloride
5. hydrogen chloride and sodium hydroxide
6. barium chloride and hydrogen phosphate

Synthesis (All products are crystalline)**:**

1. hydrogen and oxygen
2. sodium and bromine
3. aluminum and chlorine
4. potassium and iodine
5. silver and oxygen
6. iron and sulfur

Decomposition (All reactants are crystalline)**:**

1. calcium chloride
2. sodium sulfide
3. gold(III) oxide
4. ferrous fluoride
5. potassium nitride
6. cupric chlorate
7. copper(II) sulfate pentahydrate
8. calcium carbonate

Combustion (All compounds are liquid except CH_4 which is a gas**):**

1. CH_4
2. C_4H_{10}
3. C_6H_6
4. C_4H_8
5. C_7H_{16}
6. C_5H_{10}

Modified True/False. If a statement is true, circle true. If a statement is false, circle false and rewrite the statement making it true.:

1. **True or False** (Circle One) When solving double displacement equations, you must look at the activity series to see if the reaction can occur.
2. **True or False** (Circle One) In order for a combustion reaction to occur, oxygen is needed as a reactant.
3. **True or False** (Circle One) Decomposition reactions never have compounds in their products.
4. **True or False** (Circle One) In the decomposition of a hydrate, the water is removed from the hydrate and is written as a separate product.
5. **True or False** (Circle One) In the decomposition of a chlorate, carbon dioxide is always one of the products.
6. **True or False** (Circle One) When using a multivalent cation , you can use a different charge in your reactant and your product.

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