Unit 6

On completion of the unit you should be able to:

1. balance chemical equations.
2. interpret balanced equations in terms of moles, mass units and number of particles.
3. given the number of moles (or mass or number of particles) of one substance calculate the number of moles (or mass or number of particles) of another substance in the balanced equation.
4. define limiting and excess reactants.
5. identify the following types of reactions:
   - synthesis
   - decomposition
   - combustion
   - single-replacement
   - double-replacement
   - neutralization
6. define endothermic and exothermic reactions.
7. define acids and bases.

Recognize these types of reactions

Write this type of reaction

Today's focus.

6.5 Types of Reactions

Five major classes of chemical reactions

1. Combination or Synthesis reactions
2. Decomposition Reactions
3. Combustion reactions

6.6 Endothermic and exothermic reactions

Bill Nye The Science Guy on Chemical Reactions

Learn to *recognize* Synthesis reactions

- synthesis
- decomposition
- combustion
- single-replacement
- double-replacement
- neutralization

Combination or Synthesis reactions

Combination or synthesis reactions include reactions of the general form:

where a single more complex compound is formed from the reaction of two or more substances.

Example

Synthesis of ammonia: N_2 (g) + 3 H_2 (g) ⟶ 2 NH_3 (g)

Synthesis of water: 2 H_2 (g) + O_2 (g) → 2 H_2O (l)

Synthesis of potassium chloride: 2 K (s) + Cl_2 (g) → 2 KCl (s)

Synthesis of iron (III) oxide (rust): 4 Fe (s) + 3 O_2 (g) → 2 Fe_2O_3 (s)

Learn to *recognize* Decomposition reactions

- synthesis
- decomposition
- combustion
- single-replacement
- double-replacement
- neutralization

Decomposition reactions

(Redirected from Decomposition Reactions)

Decomposition reactions include reactions of the general form:

$AB \longrightarrow A + B$

where a single compound breaks down into two or more simpler substances.

Examples

1. The decomposition of potassium chlorate, $KClO_3$.

   $2\ KClO_3\ (s) \longrightarrow 2\ KCl\ (s) + 3\ O_2\ (g)$

2. The decomposition of water, H_2O.

   $2\ H_2O\ (l) \longrightarrow 2\ H_2\ (g) + O_2\ (g)$

Decomposition of magnesium chloride: $MgCl_2\ (s) \rightarrow Mg\ (s) + Cl_2\ (g)$

Decomposition of iron (II) sulfide: $FeS\ (s) \rightarrow Fe\ (s) + S\ (s)$

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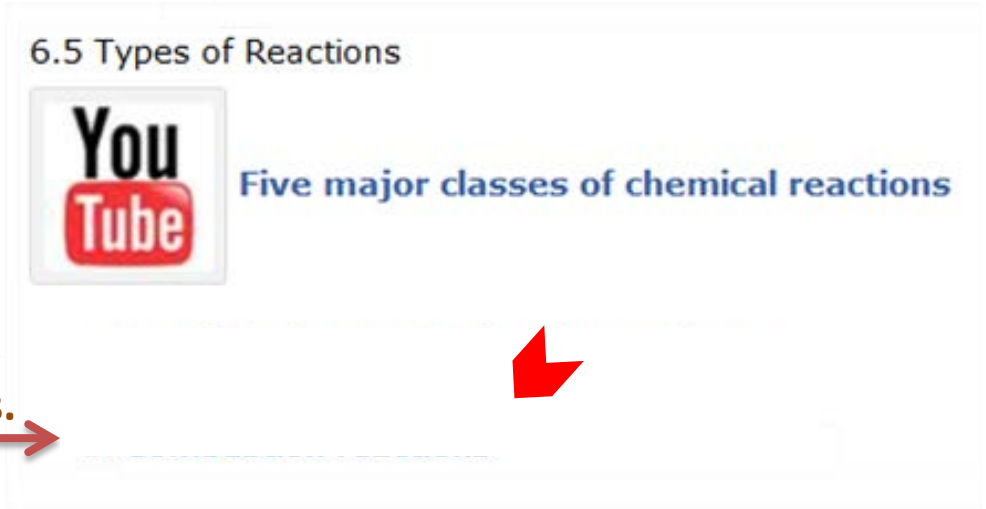
1. Learn to write combustion reactions.

Today's focus.



2. Watch the ONLINE LECTURE 1 – Combustion Reactions; How to find an empirical formula from a combustion reaction

- synthesis
- decomposition
- combustion
- single-replacement
- double-replacement
- neutralization

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Today's focus.

Double-replacement reactions

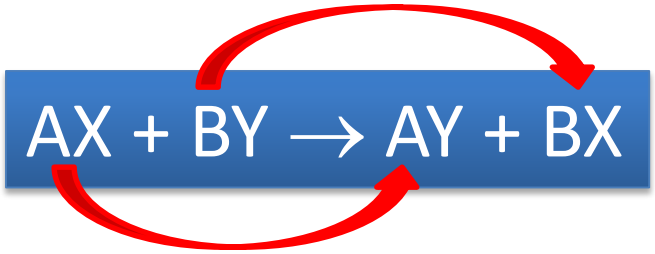
- synthesis
- decomposition
- combustion
- single-replacement
- double-replacement
- neutralization

1. Learn to *predict* Double-replacement reaction
   If and when a reaction occurs, what are the products?

2. Learn to *write* Double-replacement reaction:
   (i) Balanced chemical reaction
   (ii) Net ionic reaction
   (iii) Identify spectator ions in the reaction

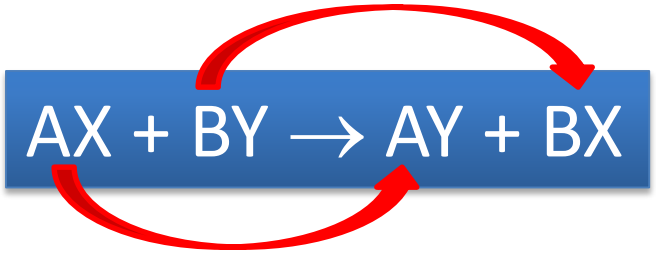
Double-replacement reactions

Double-replacement reaction



Double-replacement reactions

Double-replacement reaction



Driving force for a double-replacement to occur is the formation of a compound as a product of the reaction.

The compound can be in (s), (l), or (g) states.

(i) Formation of a solid or a precipitate.

Check the Solubility Rules table

(ii) Formation of a liquid, H_2O (l), water.

(iii) Formation of a gas, H_2S (g), dihydrogen sulfide gas.

Double-replacement reactions

$$AX + BY \rightarrow AY + BX$$

Double-replacement reactions

$AX + BY \rightarrow AY + BX$

	Soluble	Not soluble
Nitrates, NO_3^-	ALL	-
Acetates, $C_2H_3O_2^-$	ALL	-
Chlorides, Cl^-	ALL, except	$AgCl$, Hg_2Cl_2, $PbCl_2$.
Sulfates, SO_4^{2-}	ALL, except	$BaSO_4$, $SrSO_4$, $PbSO_4$
salts of groupIA	ALL	
salts of ammonium, NH_4^+	ALL	
acids	ALL	
oxides, O^{2-}	group IA, group IIA (Ca, Sr, Ba)	ALL
hydroxides, OH^-	group IA, Ca, Sr, Ba of group IIA	ALL
sulfides, S^{2-}	group IA, group IIA, $(NH_4)_2S$	ALL
phosphates, PO_4^{3-}	group IA, $(NH_4)_3PO_4$	ALL
carbonates, CO_3^{2-}	group IA, $(NH_4)_2CO_3$	ALL

This is a REFERENCE table. Not to be memorized.

You are responsible to know how to use it.

Double-replacement reactions

$AX + BY \rightarrow AY + BX$

	Soluble	Not soluble
Nitrates, NO_3^-	ALL	-
Acetates, $C_2H_3O_2^-$	ALL	-
Chlorides, Cl^-	ALL, except	$AgCl$, Hg_2Cl_2, $PbCl_2$
Sulfates, SO_4^{2-}	ALL, except	$BaSO_4$, $SrSO_4$, $PbSO_4$
salts of groupIA	ALL	
salts of ammonium, NH_4^+	ALL	
acids	ALL	
oxides, O^{2-}	group IA, group IIA (Ca, Sr, Ba)	ALL
hydroxides, OH^-	group IA, Ca, Sr, Ba of group IIA	ALL
sulfides, S^{2-}	group IA, group IIA, $(NH_4)_2S$	ALL
phosphates, PO_4^{3-}	group IA, $(NH_4)_3PO_4$	ALL
carbonates, CO_3^{2-}	group IA, $(NH_4)_2CO_3$	ALL

Soluble column

-Means compounds produced with these anions will dissolve in water.

-Physical state is (aq)

Not soluble column

-Means compounds Produced with these anions will NOT dissolve in water. (i.e. precipitate forms)

-Physical state is (s)

Double-replacement reactions

$AX + BY \rightarrow AY + BX$

Let's test if the following reactions will occur. If a reaction occurs, write: (i) the balanced chemical reaction
(ii) the net ionic reaction
(iii) identify the spectator ion(s)

Reactants: ❯ / ❯	K_2CO_3 (aq)	NaCl (aq)	Na_3PO_4 (aq)
$Mg(NO_3)_2$ (aq)	1		
$Ca(NO_3)_2$ (aq)			
$Sr(NO_3)_2$ (aq)		2	
$Ba(NO_3)_2$ (aq)			

Double-replacement reactions

$AX + BY \rightarrow AY + BX$

Let's consider if the following reactions will occur:

1 $K_2CO_3\,(aq) + Mg(NO_3)_2\,(aq) \rightarrow ?$

Step 1: What are the potential products formed?

Potential products would be: KNO_3 and $MgCO_3$.

Make sure the formulae are chemically correct.

Step 2: Determine the physical states of the products.

Check to see whether the products would be:

(i) A solid (i.e. precipitate), (ii) A liquid, water (iii) A gas, H_2S (g)

Using the Solubility Rules table:

	Soluble	Not soluble
Nitrates, NO_3^-	ALL	-
carbonates, CO_3^{2-}	group IA, $(NH_4)_2CO_3$	ALL

$KNO_3(aq)$ $MgCO_3(s)$

Formation of a solid is the driving force for this reaction to occur!

Double-replacement reactions

$AX + BY \rightarrow AY + BX$

Let's consider if the following reactions will occur:

1 $K_2CO_3\ (aq) + Mg(NO_3)_2\ (aq) \rightarrow ?$

Make sure the reaction is balanced.

Step 3: Write the balanced chemical reaction.

$K_2CO_3\ (aq) + Mg(NO_3)_2\ (aq) \rightarrow 2\,KNO_3\ (aq) + MgCO_3\ (s)$

Step 4: Write the net ionic reaction.

$2K^+\ (aq) + CO_3^{2-}\ (aq) + Mg^{2+}\ (aq) + 2NO_3^-\ (aq) \rightarrow$

$2K^+\ (aq) + 2NO_3^-\ (aq) + MgCO_3\ (s)$

$CO_3^{2-}\ (aq) + Mg^{2+}\ (aq) \rightarrow MgCO_3\ (s)$

Step 5: Identify the spectator ions.

$K^+\ (aq)$ and $NO_3^-\ (aq)$

Double-replacement reactions

$AX + BY \rightarrow AY + BX$

Let's test if the following reactions will occur. If a reaction occurs, write: (i) the balanced chemical reaction
(ii) the net ionic reaction
(iii) identify the spectator ion(s)

Reactants: → / ↓	K_2CO_3 (aq)	NaCl (aq)	Na_3PO_4 (aq)
$Mg(NO_3)_2$ (aq)	1 ✔		
$Ca(NO_3)_2$ (aq)			
$Sr(NO_3)_2$ (aq)		2	
$Ba(NO_3)_2$ (aq)			

Double-replacement reactions

$AX + BY \rightarrow AY + BX$

Let's consider if the following reactions will occur:

2 $Sr(NO_3)_2(aq) + NaCl\ (aq) \rightarrow ?$

Step 1: What are the potential products formed?

Potential products would be: $SrCl_2$ and $NaNO_3$.

Make sure the formulae are chemically correct.

Step 2: Determine the physical states of the products.

Check to see whether the products would be:

(i) A solid (i.e. precipitate), (ii) A liquid, water (iii) A gas, H_2S (g)

	Soluble	Not soluble
Nitrates, NO_3^-	ALL	-
Chlorides, Cl^-	ALL, except	AgCl, Hg_2Cl_2, $PbCl_2$.

$SrCl_2(aq)$ $NaNO_3(aq)$

Potential products all stay in solution. No reaction will occur!

Double-replacement reactions

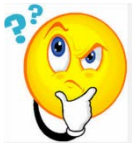
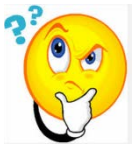
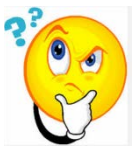
$AX + BY \rightarrow AY + BX$

Finish the rest of this matrix. If a reaction occurs, write:

(i) the balanced chemical reaction

(ii) the net ionic reaction

(iii) identify the spectator ion(s)

Reactants:	K_2CO_3 (aq)	NaCl (aq)	Na_3PO_4 (aq)
$Mg(NO_3)_2$ (aq)	1 ✔		
$Ca(NO_3)_2$ (aq)			
$Sr(NO_3)_2$ (aq)		2 ✔	
$Ba(NO_3)_2$ (aq)			

Try some practice problems in Maple TA.

Use Dimensional Analysis in ALL your calculations!!