Chemical Reactions & Writing Chemical Formulas

Chapter 15: Lect 1& 2

Chemical Change:

- Ice melting & water freezing are both examples of physical changes.
- During a physical change, a substance changes form, but remains the same substance.
- A chemical change turns 1 or more substances into different substances that usually have different properties (they now look different, smell different, act differently, etc.)
- Chemical change is really important & we use it everyday to make necessary substances like rubber, plastic, medicine, etc.

- A chemical reaction is material changing from a beginning mass to a resulting substance.
- The conclusion of a chemical reaction is that new material or materials are made, along with the disappearance of the mass that changed to make the new.
- This ***does not mean*** that new elements have been made.
- In order to make new elements, the nuclear contents must change, and that requires major amounts of energy.

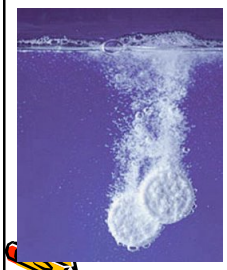
So, what is a chemical reaction?

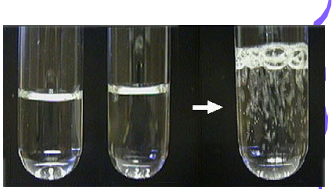
- What is a chemical reaction?
- A system of chemical changes that involve the breaking & reforming of bonds to create new substances.
- The result: a brand new substance

REACTANTS	→	PRODUCTS
- combined together - bonds break - atoms rearrange		- newly formed bonds - brand new substances

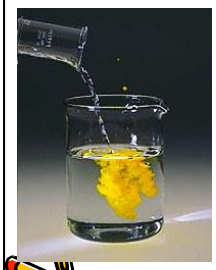
Signs of a chemical reaction

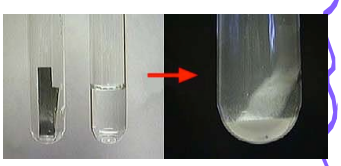
1. Bubbles - a gas formed



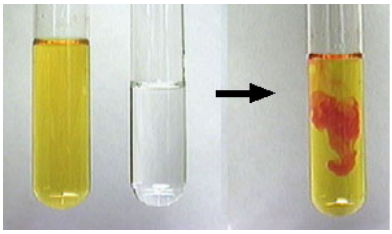


2. Precipitate - a solid formed

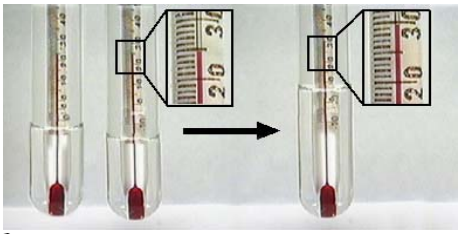




3. Color Change



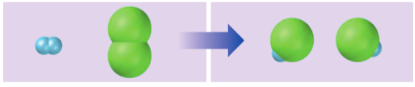
4. Temperature change - energy changed



Parts of a Chemical Reaction

- In cooking, ingredients are combined to make food.
- In chemical reactions, reactants are combined to make products.
- The **reactants** are substances that are combined & changed in the reaction.
- The **products** are the new substances that result from the reaction.

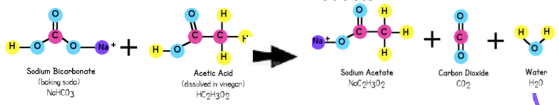
Example #1: Hydrochloric Acid



- Reactants: hydrogen (H_2- gas) + chlorine (Cl_2-gas)
- The bonds break, the elements rearrange, and form new bonds with each other.
- Products: 2 HCl

Example #2: Baking soda & Vinegar

- What is the actual reaction between baking soda & vinegar?
- Reactants:



- Now, break the bonds, rearrange the atoms, and what do you get???
- Products:

ADD IT UP: How many total atoms are there?

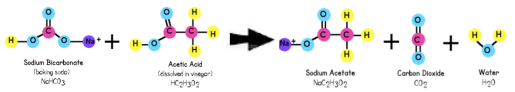
_____ Hydrogen _____ Sodium

_____ Oxygen _____ Carbon

Counting Atoms: ADD 'em up:

How many total atoms are there?

$NaHCO_3 + HC_2H_3O_2 \rightarrow NaC_2H_3O_2 + CO_2 + H_20$

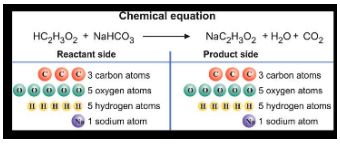


Reactants:	Products:
___5____ Hydrogen	____5___ Hydrogen
___1____ Sodium	____1___ Sodium
___5____ Oxygen	____5___ Oxygen
___3____ Carbon	____3___ Carbon

A chemical reaction **rearranges the atoms** of the reactants to form **new compounds** of the **products.**

No new atoms are created

- (not in your notes) Chemistry & More Math!
- Let's go back to our first example & add up the atoms from both sides of the equation.



- Notice that there is the exact same number of each type of atom on both sides of the equation.
- In other words, the equations are **balanced**. This proves something VERY important…

The Law of **Conservation of Mass**:

The mass of the reactants **equals** the mass of the products.

OR -

Mass is never **created** nor **destroyed**

OR

you can't get somethin' outta nothin'

BrainPop: Conservation of Mass

- Click here

BrainPop: Conservation of Mass

1. In science, a law is:
a. A rule governing what you are permitted to do
b. A generalization about how the physical universe works
c. A legal document that describes a rule of conduct
d. A statute enacted by a legislative body

2. What is true of a substance with a lot of mass?
a. It contains a lot of matter b. It has a large volume
c. It has a high density d. It has a low frequency

3. The law of conservation of mass says substances can neither be _____ nor _____.
a. Built; torn down b. Blended together; separated
c. Created; destroyed d. Condensed; extracted

4. How is weight different from mass?
a. Weight changes depending on gravity; mass stays constant throughout the universe
b. Weight is measured in grams; mass is measured in newtons
c. Weight can be converted to energy; mass cannot

5. Sodium and chlorine combine to form sodium chloride, or table salt. Sodium and chlorine are:
a. Producers b. Products **c. Reactionaries** d. Reactants

6. When sodium and chlorine combine to form sodium chloride, sodium chloride is the:
a. Originator b. Reactant **c. Product** d. Produce

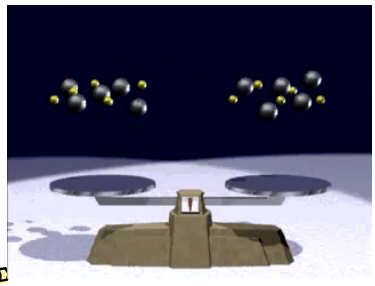
7. 4 gm of hydrogen & 32 gm of oxygen will combine to form:
a. 36 grams of water b. 28 grams of hydroxide
c. 32 grams of oxygen d. 36 grams of deuterium

8. In a chemical reaction, 4 gm of sodium must combine with how many grams of chlorine to produce 10 gm of table salt?
a. 4 grams **b. 6 grams** c. 8 grams d. 10 grams

9. What was Antoine Lavoisier's contribution to the law of conservation of mass? [Lavoisier]
a. He was the first person to think of it
b. He was the first person to propose it in a scientific way
c. He came up with a widely-read, precise description
d. He was the first person to perform a chemical reaction

10. Which of the following describes a chemical reaction?
a. Oxygen interacts with iron to form rust
b. Ice melts into water
c. Carbon dioxide freezes to make dry ice
d. Rocks split apart over many years due to weathering

2. Law of Conservation of Mass



Chemical Formulas/Equations:

- A molecule or compound consists of at least **two atoms that are chemically bonded**.
- The chemical formula of a molecule or compound states how **many atoms of each element** are in one of its molecules.
- This formula is similar to an algebraic formula in its use of symbols.
- The description of a compound with numbers and symbols is called a chemical formula.. Some formula can be quite complex.

- **A chemical equation is a way to describe what goes on in a chemical reaction**, the actual change in a material.
- Chemical equations are written with the **symbols** of materials to include elements, ionic or covalent compounds, aqueous solutions, ions, or particles.

- There is an **arrow** pointing to the right that indicates the action of the reaction.
- The materials to the left of the arrow are the ***reactants***, or materials that are going to react.
- The materials to the right of the arrow are the ***products,*** or materials that have been produced by the reaction.

Chemical formulas

- Chemical formulas are designations of **molecules and compounds in shorthand notation**, similar to that used in Algebra.
- This is a way to show the exact number of atoms & compounds in a chemical reaction.
- We write the chemical equation for baking soda & vinegar as follows:
- $NaHCO_3 + HC_2H_3O_2 \text{ ------> } NaC_2H_3O_2 + CO_2 + H_2O$

CHEMICAL EQUATIONS

- Click here

Brain Pop: Chemical Equations

1. **Which of the following is a chemical reaction?**
a. Sodium and chlorine atoms bond to form salt molecules b. Ice melts to form water
c. Carbon dioxide freezes to form dry ice d. Salt and water mix to form salt water

2. In the equation $2H_2 + O_2 \rightarrow 2H_2O$, what are the reactants?
a. Hydrogen atoms **b. Hydrogen and oxygen molecules** c. Water molecules d. Ice crystals

3. Sulfuric acid is made of two hydrogen atoms (H), one sulfur atom (S), and four oxygen atoms (O). What is its molecular formula? a. 2H4SO b. $H4S_2O$ **c. H_2SO4** d. H_2S_2O4

4. What is the best synonym for the word "stoichiometry?"
a. Combining atoms **b. Balancing chemical equations** c. Discovering new chemical formulas
d. Breaking the chemical bonds that hold molecules together

5. The chemical symbol "Ni" most likely represents: a. Carbon b. Antimony c. Lead **d. Nickel**

6. How do the products of chemical reactions compare to their reactants?
a. The products usually weigh more than the reactants
b. The products often have completely different properties than the reactants
c. The products usually have more atoms than the reactants
d. The products are usually more toxic than the reactants

7. What's the problem with this chemical equation: $H_2 + O_2 = H_2O$?
a. There's a missing hydrogen in the reactants **b. There's a missing oxygen in the product**
c. There's an additional oxygen in the product d. There's an additional hydrogen in the reactants

8. What's the easiest way to balance a chemical equation?
a. Trial and error b. Using the periodic table c. Complex algebra d. Calculus

9. Which reactant is missing from the following equation? $X + PO4 \rightarrow H_3PO_4$
a. One hydrogen atom b. One phosphorus atom **c. Three hydrogen atoms** d. One oxygen atom

10. What is the product of the following equation? $2Na + S2O3 \rightarrow$ a. NaS_2O_3 b. NaS_4O_3 c. $Na_2S_2O_3$ **d. Na_2S2O_3**

EXAMPLES OF CHEMICAL CHANGES shown in chemical formulas:

- Chemical reactions, also called chemical changes, are not limited to happening in a chemistry lab.
- Here are some examples of chemical reactions with the corresponding chemical equations:

EXAMPLES OF CHEM CHANGES shown in chemical formulas:

- 1. A silver spoon tarnishes. The silver reacts with sulfur in the air to make silver sulfide, the black material we call tarnish.
- 2 Ag + S --> **Ag_2S**
- 2. An iron bar rusts. The iron reacts with oxygen in the air to make rust.

4 Fe + 3 O2 --> **$2\ Fe_2O_3$**

EXAMPLES OF CHEM CHANGES shown in chemical formulas:

- 3. Methane burns. Methane combines with oxygen in the air to make carbon dioxide and water vapor.
- $CH_4 + 2\ O_2$ --> **$CO_2 + 2\ H_2O$**
- 4. An antacid (calcium hydroxide) neutralizes stomach acid (hydrochloric acid).
- $Ca(OH)_2 + 2$ HCl --> **$CaCl_2 + 2\ H_2O$**

- **Salt**: 2Na + Cl_2 --> 2NaCl
- the poisonous green chlorine gas is combined with the explosive metal sodium to form the white salt crystals we use in our food.

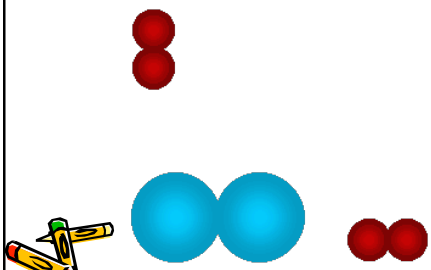
Complex formulas

- Just as in Algebra, you can use parentheses to separate parts in a complex formula. One example is the formula for nitroglycerin, a highly explosive substance.
- **$C_3H_5(NO_3)_3$**
- This formula shows that nitroglycerin consists of 3 atoms of C, 5 atoms of H and then 3 NO_3 nitrate ions. If the parentheses were not used, you might have a formula like:
- **$C_3H_5N_3O_9$**

Complex formulas

- The number of atoms for each element would be correct, but it wouldn't help to describe the true structure of the nitroglycerin molecule.
- Remember that molecules are 3-dimensional collections of atoms. In more complex molecules--especially in organic substances--the configuration becomes important.

- Carbon dioxide is CO_2, which means there is one atom of carbon and two atoms of oxygen in the molecule.



Number of molecules

- To show the **number of molecules,** a full sized number is located in front of the molecule.
- This is called a **coefficient.**
- For example 4 molecules of carbon dioxide is designated as: $4CO_2$
- This means there are a total of 4 ***C*** atoms and 8 ***O*** atoms in the combination.
- A way to remember this--taken from Algebra--is to think of it as 4 x (CO_2).

BALANCING EQUATIONS

- Now comes the fun part, balancing the reaction.
- The **Law of Conservation of Mass** states that **in a chemical reaction there is no loss of mass**.
- Each type of element will have the same amount before the reaction and after the reaction, or as reactant and product.
- But you can't change the materials that participate in the reaction, so you must write an integer coefficient in front of (to the left of) each material in the reaction to make sure every type of atom has the same number on each side of the reaction.

THE 4 RULES OF CHEMICAL REACTIONS

- 1. Chemical reactions are processes in which **atoms are rearranged** into different combinations of molecules.
- 2. Reactants interact, change bonds, and **form products with different chemical properties.**
- 3. In a reaction, the **number of atoms stays the same**, no matter how they are arranged, so their total mass stays the same.
- 4. Chemical reactions **usually liberate/release or absorb heat.** (which we will talk about more tomorrow!

In conclusion

- The number of atoms of each element in a chemical formula is designated by the small number behind each element symbol.
- If there is no number, it is assumed there is only one of that element.
- A large number in front of a compound designates how many units there are of that compound.
- Parentheses can be used to designate a special structure, where other molecules are attached to the larger, complex molecule.

3. Everybody sing….

Don't Break The Law

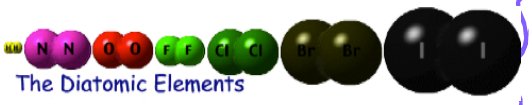
Music & Lyrics © 2007, Mark Rosengarten

To react or not to react?
THAT is the question!

Chapter 15: Part 2

Diatomic Elements Info!

- Diatomic elements are nonmetal elements that form a covalent bond between two atoms.
- The diatomic elements are: hydrogen, nitrogen, oxygen, fluorine, chlorine, bromine and iodine.
- They always travel in pairs of atoms and therefore you must write then as:
- H_2 N_2 O_2 F_2 Cl_2 Br_2 and I_2



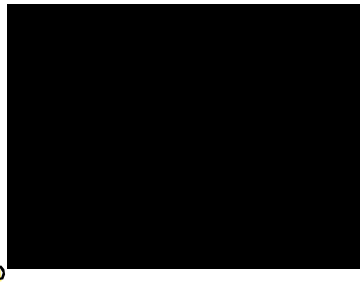
The Diatomic Elements

- Chemical changes are a result of chemical reactions.
- All chemical reactions involve a change in substances and a change in energy.
- Neither matter or energy is created or destroyed in a chemical reaction---only changed.
- There are so many chemical reactions that it is helpful to classify them into 5 general types:

Types of Reactions

- **Synthesis: A + B -> AB**
- **Decomposition: AB -> A + B**
- **Single Replacement: A + BC -> AC + B**
- **Double Replacement: AB + CD -> AD + CB**
- **Combustion:**
- Here is a short explanation and examples of each type of reaction

4. 5 types of chemical reactions

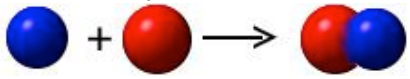


1. Synthesis (Composition)

- In a synthesis reaction two or more simple substances combine to form a more complex substance.
- Two or more reactants yielding one product is another way to identify a synthesis reaction.
- In the simplest type of synthesis reaction, **two elements combine to form a compound**.

1. Synthesis

- Hydrogen + oxygen yields water:
  $2H_2 + O_2 \rightarrow 2H_2O$
- Magnesium + nitrogen yields magnesium nitride
  $3Mg + N_2 \rightarrow Mg_3N_2$
- Iron + sulfur yields iron(II) sulfide
  $Fe + S \rightarrow FeS$
- Barium + phosphorus yields barium phosphide
  $3Ba + P \rightarrow Ba_3P$



The chemical equation for a synthesis reaction looks like:

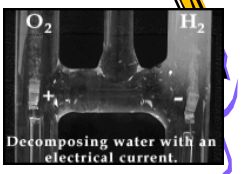
- **reactant + reactant -------> product**

2. Decomposition

- In a decomposition reaction, **a larger substance breaks apart and forms two or more simpler substances.**
- A decomposition reaction is the opposite of a synthesis reaction.
- In fact many synthesis reactions can be reversed into a decomposition reaction.
- When you burn hydrogen gas, the hydrogen combines with oxygen to produce water.

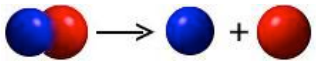
2. Decomposition

- $2H_2 + O_2 \rightarrow 2H_2O$
  Synthesis Reaction
- With an electrical current, water can be decomposed into hydrogen and oxygen gas.
- $2H_2O \rightarrow 2H_2 + O_2$
  Decomposition Reaction



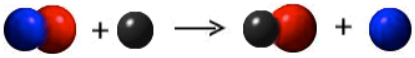
Decomposing water with an electrical current.

- For example, water can be broken down into hydrogen gas and oxygen gas. The chemical equation for this decomposition reaction looks like:
- **reactant -------> product + product**



3. Single Replacement

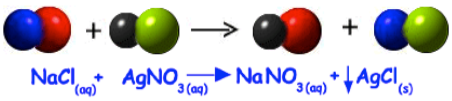
- In a single replacement reaction a single uncombined element replaces another in a compound. **Two reactants yield two products.**
- For example when zinc combines with hydrochloric acid, the zinc replaces hydrogen.



- The chem. equation for this single replacement reaction looks like: **reactant + reactant---> product + product**
- In a single replacement reaction, a more active element replaces a less active element in a compound.

4. Double Replacement

- In a double replacement reaction, two metal ions (in aqueous compounds) switch places.

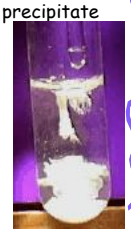


$NaCl_{(aq)} + AgNO_{3(aq)} \rightarrow NaNO_{3(aq)} + \downarrow AgCl_{(s)}$

- In a double replacement reaction parts of two compounds switch places to form two new compounds.
- Two reactants yield two products.
- For example when silver nitrate combines with sodium chloride, two new compounds--silver chloride and sodium nitrate are formed because the sodium silver switched places.

4.Double Replacement

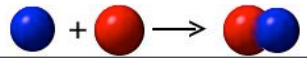
- The chemical equation for this double replacement reaction looks like:
  reactant + reactant--> product + product
- One of the products is insoluble and forms a solid.
- This solid, called a **precipitate**, is more dense than the surrounding solution and falls to the bottom of the test tube. An arrow down is used to identify a precipitate (because the precipitate sinks)
- In a reaction between sodium chloride solution NaCl (aq) and silver nitrate solution $AgNO_3$ (aq) the products are sodium nitrate
- $NaNO_3$ (aq) solution and silver chloride solid AgCl (s).



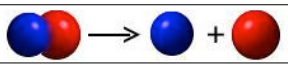
Combustion

- Combustion (or **burning)** is the sequence of exothermic chemical reactions between a fuel and an oxidant accompanied by the production of heat and conversion of chemical species.
- The **release of heat** can result in the production of light in the form of either glowing or a flame.
- Fuels of interest often include organic compounds (especially hydrocarbons) in the gas, liquid or solid phase.

#1. Synthesis Summary

Definition	Two or more substances combine to form a new substance
Equation	A + B --> AB
Looks Like	
Example	$4Fe + 3O_2 \rightarrow 2Fe_2O_3$
Extra Info	Also called **composition** & **addition** reactions

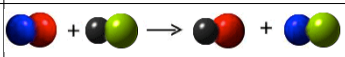
2. Decomposition Summary

Definition	A single compound is broken down into two or more smaller compounds
Equation	AB --> A + B
Looks Like	
Example	$H_2CO_3 \rightarrow H_2O + CO_2$
Extra Info	Large compounds can also decompose into several other compounds.

#3. Single-Replacement

Definition	One element replaces a similar element in a compound.
Equation	AB + C --> AC + B
Looks Like	
Example	$2HCl + Zn \rightarrow ZnCl_2 + H_2$
Extra Info	Here, more-reactive elements replace less-reactive ones - so sometimes it is impossible to reverse this reaction.

#4. Double-Replacement

Definition	Ions in two compounds switch places.
Equation	AB + CD --> AC + BD
Looks Like	
Example	$NaCl + AgNO_3 \rightarrow NaNO_3 + AgCl$
Extra Info	Often, a solid combines with a liquid & forms a precipitate in this reaction.

#5. Combustion

Definition	A complex series of exothermic reactions between fuel & oxygen which produces energy.
Equation	Fuel + Oxygen --(heat)--> Energy
Looks Like	**FIRE**
Example	$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ + energy
Extra Info	Cars are powered by a combustion reaction which uses petroleum.

5. Summary