Chapter 4
Chemical Reactions

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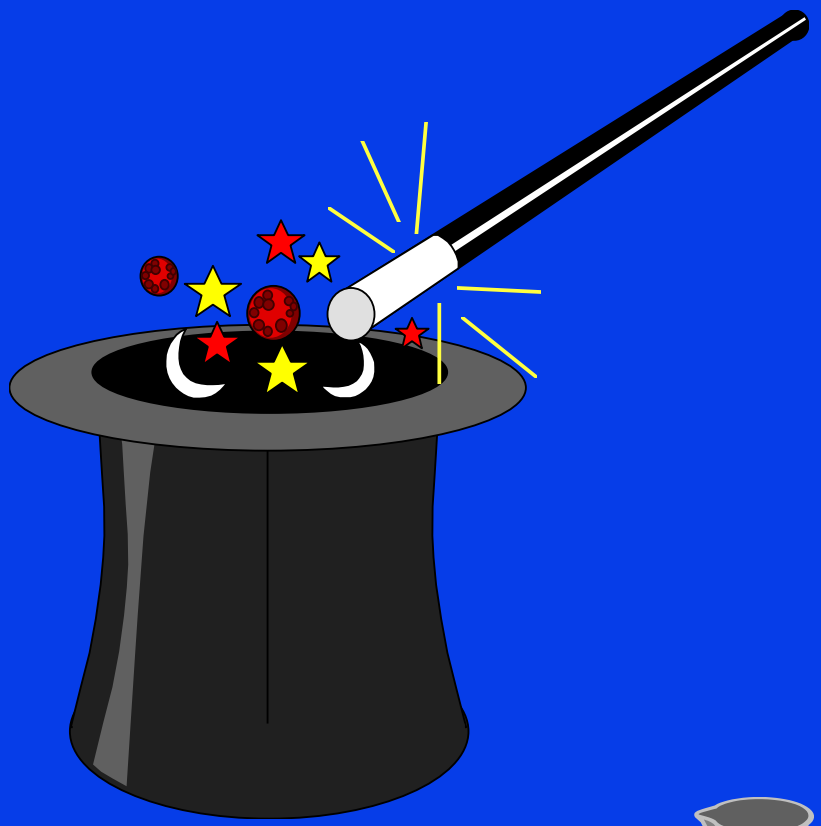
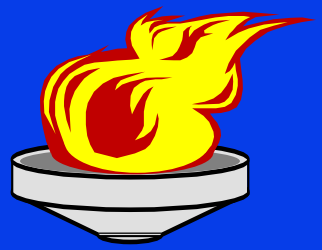
How can things change and still stay the same?

- **A physical change.**
- **A change in size, shape, or state without forming a new substance.**
- **When heat turns a solid into a liquid or a liquid into a gas.**



How do things change identity?



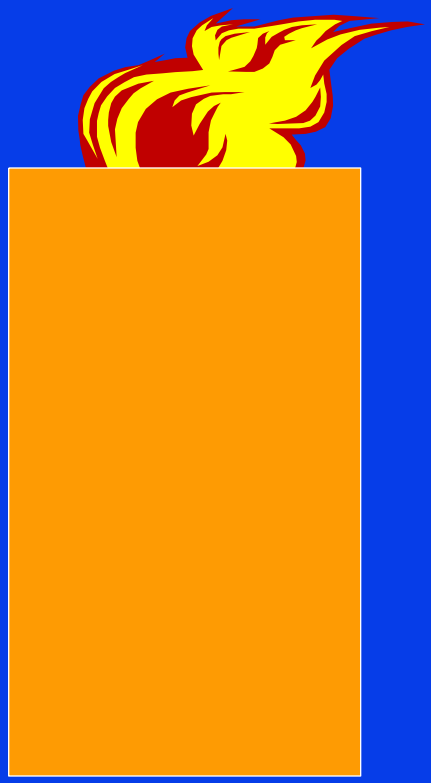
- A chemical change.
- New substances are produced with physical properties different from the starting substances.
- A color change may occur, heat and light may be given off, a gas may be produced.

What happens to mass in chemical changes?

- candles burn
- milk sours
- toast browns
- battery acid eats away cloth
- Silver tarnishes
- steel rusting

- The mass of matter does not change during chemical changes.
- The total mass of all starting substances equals the total mass of all new substances.

When a candle burns, some of the wax melts and runs down the side. Is this a chemical change or a physical change? Why?

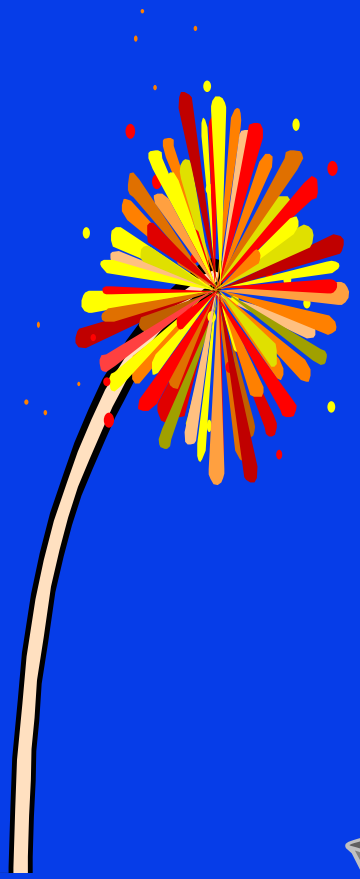


- **Does the candle change in size or shape?**
- **Does the candle become a new substance?**

Physical Change

Is lighting a match a chemical change or a physical change? Why?

- **Is a new substance produced?**
- **Does a color change occur?**
- **Is heat and light given off?**
- **Is a gas produced?**



Section 8.1
Describing Chemical Change

- **OBJECTIVES:**
  - **Write equations describing chemical reactions, using appropriate symbols**

Section 8.1
Describing Chemical Change

- **OBJECTIVES:**
  - **Write balanced chemical equations, when given the names or formulas of the reactants and products in a chemical reaction.**

All chemical reactions

- **have two parts:**
  - Reactants - the substances you start with
  - Products- the substances you end up with
- **The reactants turn into the products.**
- **Reactants → Products**

In a chemical reaction

- The way atoms are joined is changed
- Atoms aren't created or destroyed.
- Can be described several ways:

1. In a **sentence**

   Copper reacts with chlorine to form copper (II) chloride.

2. In a **word equation**

   Copper + chlorine → copper (II) chloride

Symbols in equations

- the arrow (→) separates the reactants from the products
- Read “reacts to form”
- The plus sign means “and”
- (s) after the formula = solid
- (g) after the formula = gas
- (l) after the formula = liquid

Symbols used in equations

- **(aq) after the formula - dissolved in water, an aqueous solution.**
- **↑ used after a product indicates a gas is given off (same as (g))**
- **‾ used after a product indicates a solid precipitate has formed (same as (s))**

Symbols used in equations

- ⇌ indicates a reversible reaction (more later)
- $\xrightarrow{\Delta}$, $\xrightarrow{\text{heat}}$ shows that heat is supplied to the reaction
- $\xrightarrow{Pt}$ is used to indicate a catalyst is supplied, in this case, platinum.

What is a catalyst?

- A substance that speeds up a reaction, without being changed or used up by the reaction.
- Enzymes are biological or protein catalysts.

An equation...

- Describes a reaction
- Must be balanced in order to follow the Law of Conservation of Mass
- Can only be balanced by changing the **coefficients.**
- Has special symbols to indicate physical state, and if a catalyst or energy is required.

Skeleton Equation

- Uses formulas and symbols to describe a reaction
- doesn’t indicate how many.
- All chemical equations are sentences that describe reactions.

Convert these to equations

- **Solid iron (III) sulfide reacts with gaseous hydrogen chloride to form iron (III) chloride and hydrogen sulfide gas.**
- **Nitric acid dissolved in water reacts with solid sodium carbonate to form liquid water and carbon dioxide gas and sodium nitrate dissolved in water.**

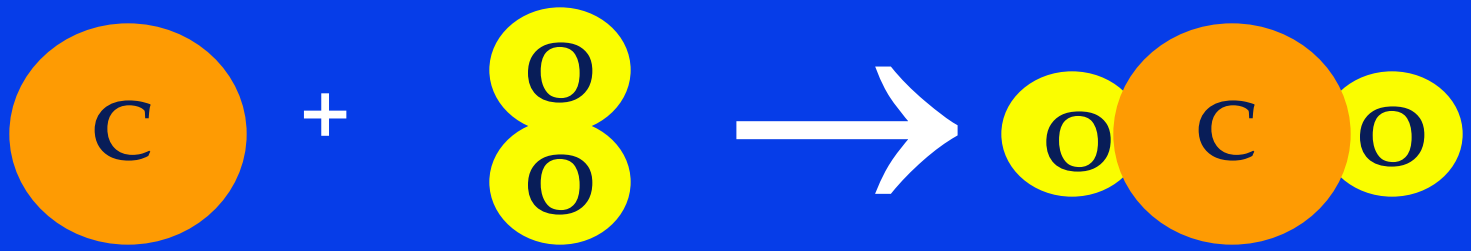
Now, read these:

- $Fe(s) + O_2(g) \rightarrow Fe_2O_3(s)$
- $Cu(s) + AgNO_3(aq) \rightarrow Ag(s) + Cu(NO_3)_2(aq)$
- $NO_2(g) \xrightarrow{Pt} N_2(g) + O_2(g)$

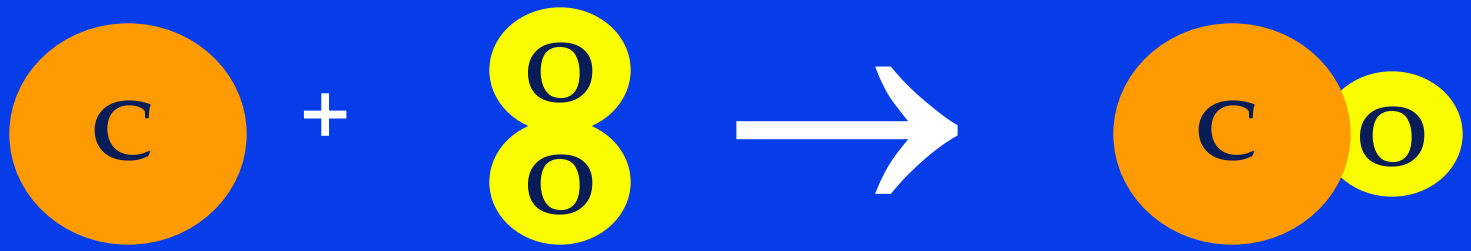
Balancing Chemical Equations

Balanced Equation

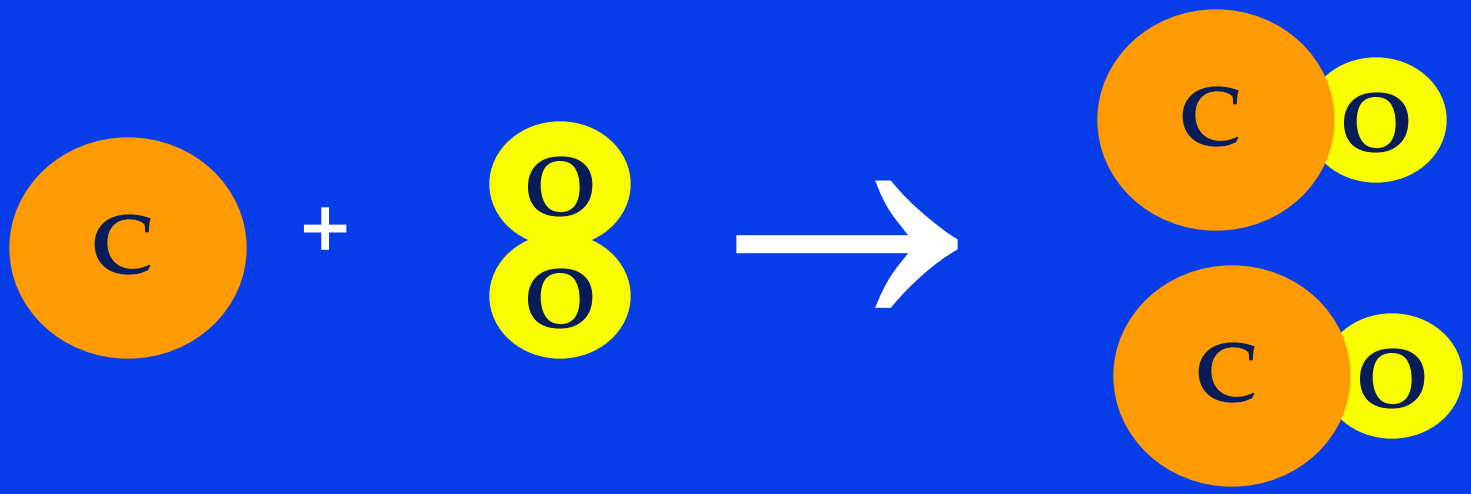
- **Atoms can't be created or destroyed**
- **All the atoms we start with we must end up with**
- **A balanced equation has the same number of each element on both sides of the equation.**



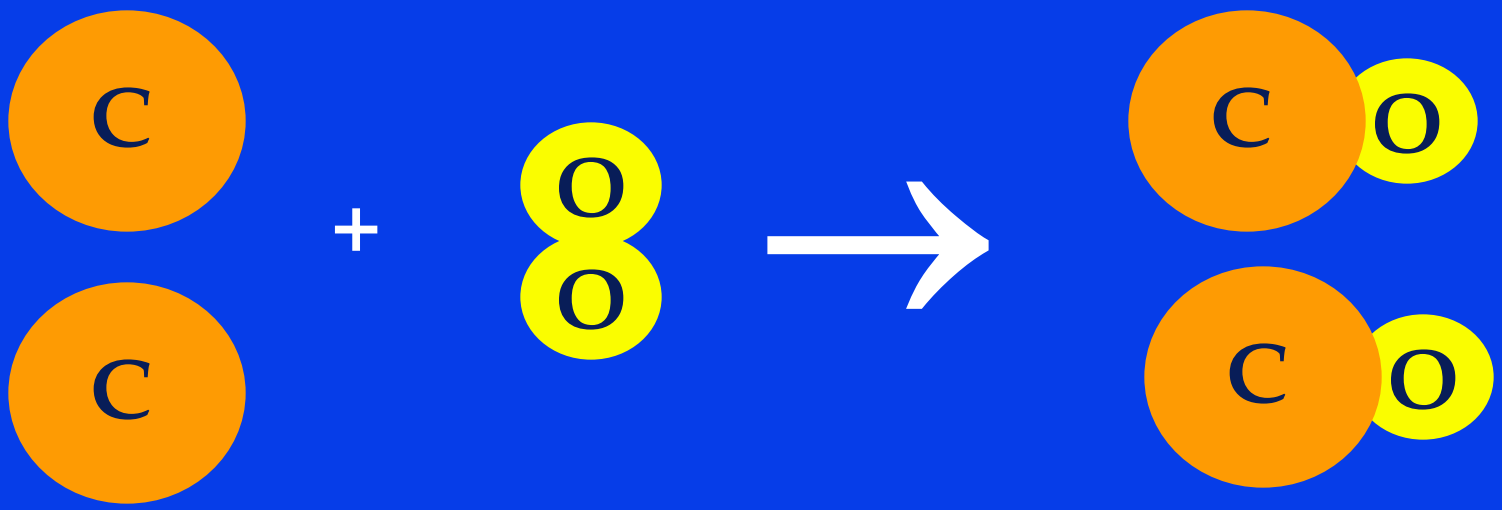
- $C + O_2 \rightarrow CO_2$
- This equation is already balanced
- What if it isn't?



- $C + O_2 \rightarrow CO$
- We need one more oxygen in the products.
- Can't change the formula, because it describes what it is (carbon monoxide in this example)



- Must be used to make another CO
- But where did the other C come from?



- Must have started with two C
- $2\ C + O_2 \rightarrow 2\ CO$

Rules for balancing:

1. **Assemble, write the correct formulas for all the reactants and products**
2. **Count the number of atoms of each type appearing on both sides**
3. **Balance the elements one at a time by adding coefficients (the numbers in front)**
4. **Check to make sure it is balanced.**

Never

- **Never change a subscript to balance an equation.**
  - If you change the formula you are describing a different reaction.
  - H_2O is a different compound than H_2O_2
- **Never put a coefficient in the middle of a formula**
  - **2 NaCl is okay, Na2Cl is not.**

Example

$$H_2 + O_2 \rightarrow H_2O$$

Make a table to keep track of where you are at

Example

$$H_2 + O_2 \rightarrow H_2O$$

R		P
2	H	2
2	O	1

Need twice as much O in the product

Example

$$H_2 + O_2 \rightarrow 2\ H_2O$$

R		P
2	H	2
2	O	1

Changes the O

Example

$$H_2 + O_2 \rightarrow 2\ H_2O$$

R		P
2	H	2
2	O	1 2

Also changes the H

Example

$$H_2 + O_2 \rightarrow 2\ H_2O$$

	R		P
2	H	2	4
2	O	1	2

Need twice as much H in the reactant

Example

$$2\,H_2 + O_2 \rightarrow 2\,H_2O$$

	R		P
2	H	2	4
2	O	1	2

Recount

Example

$$2\,H_2 + O_2 \rightarrow 2\,H_2O$$

R			P	
4	2	H	2	4
	2	O	1	2

The equation is balanced, has the same number of each kind of atom on both sides

Example

$$2\,H_2 + O_2 \rightarrow 2\,H_2O$$

R			P	
4	2	H	2	4
	2	O	1	2

This is the answer

Not this

Balancing Examples

- $\_AgNO_3 + \_Cu \rightarrow \_Cu(NO_3)_2 + \_Ag$
- $\_Mg + \_N_2 \rightarrow \_Mg_3N_2$
- $\_P + \_O_2 \rightarrow \_P_4O_{10}$
- $\_Na + \_H_2O \rightarrow \_H_2 + \_NaOH$
- $\_CH_4 + \_O_2 \rightarrow \_CO_2 + \_H_2O$

Write and balance

- $Na + O_2 \rightarrow Na_2O_2$
- $Al + S_8 \rightarrow Al_2S_3$
- **Remember that the first step is to write the correct formulas**
- **Then balance by using coefficients only**

Section 8.2
Types of Chemical Reactions

- **OBJECTIVES:**
  - **Identify a reaction as combination, decomposition, single-replacement, double-replacement, or combustion**

Section 8.2
Types of Chemical Reactions

- **OBJECTIVES:**
  - **Predict the products of combination, decomposition, single-replacement, double-replacement, and combustion reactions.**

Reactions

- **Come in 5 major types.**

Types of Reactions

- There are millions of reactions.
- Can't remember them all
- Fall into several categories.
- We will learn 5 major types.
- Will be able to predict the products.
- For some, we will be able to predict whether they will happen at all.
- Will recognize them by the reactants

#1 - Combination Reactions

- **Combine - put together**
- **2 substances combine to make one compound.**
- **$Ca + O_2 \rightarrow CaO$**
- **$SO_3 + H_2O \rightarrow H_2SO_4$**
- **We can predict the products if they are two elements.**
- **$Mg + N_2 \rightarrow$ __?__**

#2 - Decomposition Reactions

- decompose = fall apart
- one reactant falls apart into two or more elements or compounds.
- $NaCl \xrightarrow{\text{electricity}} Na + Cl_2$
- $CaCO_3 \xrightarrow{\Delta} CaO + CO_2$
- Note that energy is usually required to decompose

#2 - Decomposition Reactions

- **Can predict the products if it is a binary compound**
- **Made up of only two elements**
- **Falls apart into its elements**
- **$H_2O \xrightarrow{\text{electricity}}$**
- **$HgO \xrightarrow{\Delta}$**

#2 - Decomposition Reactions

- If the compound has more than two elements you must be given one of the products
- The other product will be from the missing pieces
- $NiCO_3 \xrightarrow{\Delta} CO_2 + ?$
- $H_2CO_3(aq) \rightarrow CO_2 + ?$

#3 - Single Replacement

- One element replaces another
- Reactants must be an element and a compound.
- Products will be a different element and a different compound.
- $Na + KCl \rightarrow K + NaCl$
- $F_2 + LiCl \rightarrow LiF + Cl_2$

#3 Single Replacement

- **Metals replace other metals (and hydrogen)**
- **K + AlN →**
- **Zn + HCl →**
- **Think of water as HOH**
- **Metals replace one of the H, combine with hydroxide.**
- **Na + HOH →**

#3 Single Replacement

- We can tell **whether** a reaction will happen
- Some chemicals are more "active" than others
- More active replaces less active
- There is a list on page 217 - called the Activity Series of Metals
- Higher on the list replaces lower.

#3 Single Replacement

- Note the * concerning Hydrogen
- H can be replaced in acids by everything higher
- Li, K, Ba, Ca, & Na replace H from acids and water
- $Fe + CuSO_4 \rightarrow$
- $Pb + KCl \rightarrow$
- $Al + HCl \rightarrow$

#3 - Single Replacement

- **What does it mean that Hg and Ag are on the bottom of the list?**
- **Nonmetals can replace other nonmetals**
- **Limited to F_2 , Cl_2 , Br_2 , I_2 (halogens)**
- **Higher replaces lower.**
- **F_2 + HCl $\rightarrow$**
- **Br_2 + KCl $\rightarrow$**

#4 - Double Replacement

- Two things replace each other.
- Reactants must be two ionic compounds or acids.
- Usually in aqueous solution
- $NaOH + FeCl_3 \rightarrow$
- The positive ions change place.
- $NaOH + FeCl_3 \rightarrow Fe^{+3}\ OH^{-} + Na^{+1}\ Cl^{-1}$
- $NaOH + FeCl_3 \rightarrow Fe(OH)_3 + NaCl$

#4 - Double Replacement

- **Has certain "driving forces"**
  - **Will only happen if one of the products:**
    - **doesn't dissolve in water and forms a solid (a "precipitate"), or**
    - **is a gas that bubbles out, or**
    - **is a covalent compound (usually water).**

How to recognize which type

- **Look at the reactants:**
  - **E + E =Combination**
  - **C =Decomposition**
  - **E + C =Single replacement**
  - **C + C =Double replacement**

Reactions

- Synthesis
- Decomposition
- Single Replacement
- Double Replacement
- Combustion

Reactions

Synthesis occurs when two or more elements come together to form a new compound

Reactions

Single Replacement When a compound and an element come together and a new compound is formed an an different element is left alone

Reactions

Double Replacement happens when two compounds come together and form two new compounds

Reactions

Decomposition occurs when a compound turns into less complex compounds or elements

Reactions

Combustion occurs when an element or compound combines with oxygen to form new compounds and gives off energy

#5 - Combustion

- Means “add oxygen”
- A compound composed of only C, H, and maybe O is reacted with oxygen
- If the combustion is complete, the products will be CO_2 and H_2O.
- If the combustion is incomplete, the products will be CO (possibly just C) and H_2O.