

CHEMICAL REACTIONS

1. Physical and Chemical Changes

Physical changes are changes in which the identity of a substance does not change. Chemical composition of substances remain unchanged. Breaking of a glass, cutting of a sheet of paper, dissolving of salt in water, freezing of water...etc are physical changes.

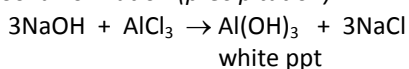
- No new substance is formed.
- Some physical changes are reversible.

Changes that cause to produce new substances are called *chemical changes*. The rusting of iron, boiling of an egg, spoiling fruits, burning of coal...etc. are chemical changes. Chemical changes usually irreversible.

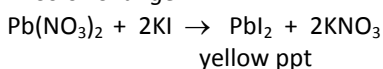
2. Understanding Chemical Changes

Evidence of a Chemical Reaction

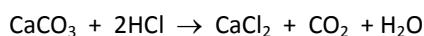
Solid Formation (precipitation)



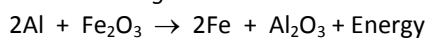
2. Color Change



3. Gas Release



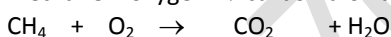
4. Heat Exchange



3. Chemical Equations

- A chemical equation shows the chemical formulas and relative amounts of all reactants and products.
- A substance that undergoes a reaction is called a **reactant**.
- When reactants undergo a chemical change, each new substance formed is called a **product**.

methane + oxygen → carbon dioxide + water



Symbol	Meaning
(s), (l), (g)	substance in the solid, liquid, or gaseous state
(aq)	substance in aqueous solution (dissolved in water)
→	“produces” or “yields,” indicating result of reaction
⇌	reversible reaction in which products can reform into reactants; final result is a mixture of products and reactants
$\xrightarrow{\Delta}$ or $\xrightarrow{\text{heat}}$	reactants are heated; temperature is not specified
$\xrightarrow{\text{Pd}}$	name or chemical formula of a catalyst, added to speed a reaction

In chemical reactions following properties remain constant.

- Types and number of reacting atoms,
- Total mass of substances.
- Total number of protons, neutrons, and electrons.

In chemical reactions following properties may change.

- Number of electrons and electronic configurations of atoms.
- Total number of moles, molecules and volumes.
- Physical properties like color, odor, taste and states.

4. Balancing Chemical Equations

Conservation of Mass

- The law of conservation of mass states that mass is neither created nor destroyed during chemical reactions. Total mass is constant in a chemical reaction. This is known as Lavoisier’s Law.
- The number of atoms for each element must be the same on the reactants’ side and on the products’ side.
- A coefficient multiplies the number of atoms of each element in the formula that follows.
 - H₂O: 2 hydrogen atoms, 1 oxygen atom
 - 2H₂O: 4 hydrogen atoms, 2 oxygen atoms

Below are some tips for balancing equations:

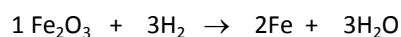
- Take the coefficients of the most complex compound as one.
- Balance the elements found in this most complex compound first.
- Balance the elements last that is free in reactants or products.
- Balance oxygen and hydrogen atoms at the end.

Never change the subscripts

Sample Problem A

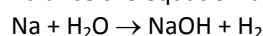
Balance the equation for the reaction of iron(III) oxide with hydrogen to form iron and water.

Sample Problem A Solution

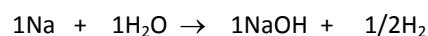


Sample Problem B

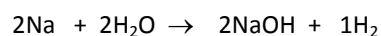
Balance the equation below with integer numbers.



Sample Problem B Solution



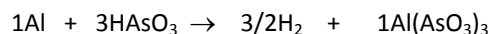
Then,



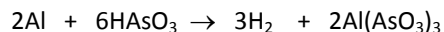
Sample Problem C

Aluminum reacts with arsenic acid, HAsO₃, to form H₂ and aluminum arsenate. Write a balanced equation for this reaction.

Sample Problem C

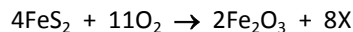


Then,



Sample Problem D

Find the unknown substance represented by X in the following balanced equation.

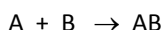


5. Types of Chemical Reactions

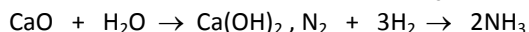
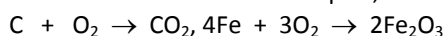
A. Combination (Synthesis) Reactions

- Whenever two or more substances combine to form a single product, the reaction is called a synthesis reaction.

- Combination reactions can be illustrated;



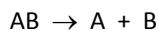
- Here are some examples;



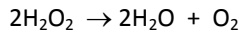
B. Decomposition (Analysis) Reactions

- In a decomposition reaction a single compound breaks down, often with the input of energy, into two or more elements or simpler compounds.

- Decomposition reactions can be illustrated;



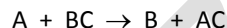
- Here are some examples;



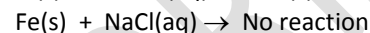
C. Single Displacement Reactions

- In a displacement reaction a single element reacts with a compound and displaces another element from the compound.

- Displacement reactions can be illustrated;



- Single displacement reactions mostly take place due to activity differences of elements. A more active element displaces a less active one.



Activity of Some Metals

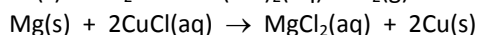
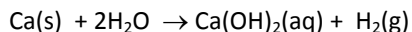
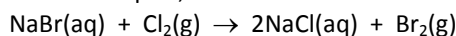
Li Rb K Ba Sr Ca Na Mg Al Mn Zn Cr Cd Fe Co Ni Sn

Pb H Cu Hg Ag Pt Au (Activity Decreases →)

Activity of Some Nonmetals

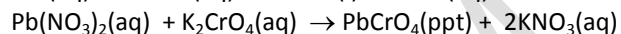
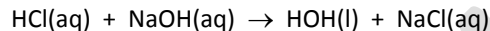
F Cl Br I (Activity Decreases →)

Some examples;



D. Double Displacement (Metathesis) Reactions

- In a double-displacement reaction two compounds in aqueous solution appear to exchange ions and form two new compounds.
- One of the products must be a solid precipitate, a gas, or a molecular compound, such as water.
- Double displacement reactions can be illustrated;
 $\text{AB} + \text{CD} \rightarrow \text{AD} + \text{CB}$
- Some examples;



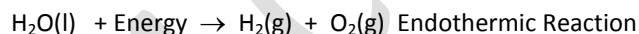
E. Endothermic and Exothermic Reactions

A reaction which absorbs energy is endothermic reaction and which release energy is exothermic reaction

- Some examples;



Exothermic Reaction



F. Combustion Reactions

A combustion reaction is a reaction of a carbon-based compound with oxygen.

- Some examples;

