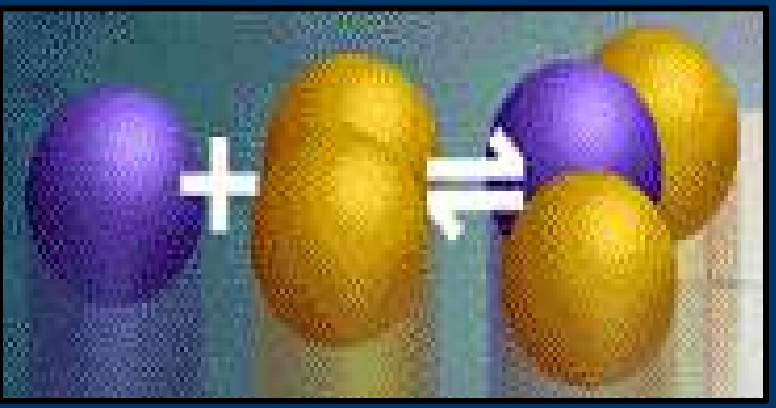
Chemical Reactions

I. Chemical Changes in Matter



Chemical Reaction
Law of Conservation of Mass
Chemical Equations

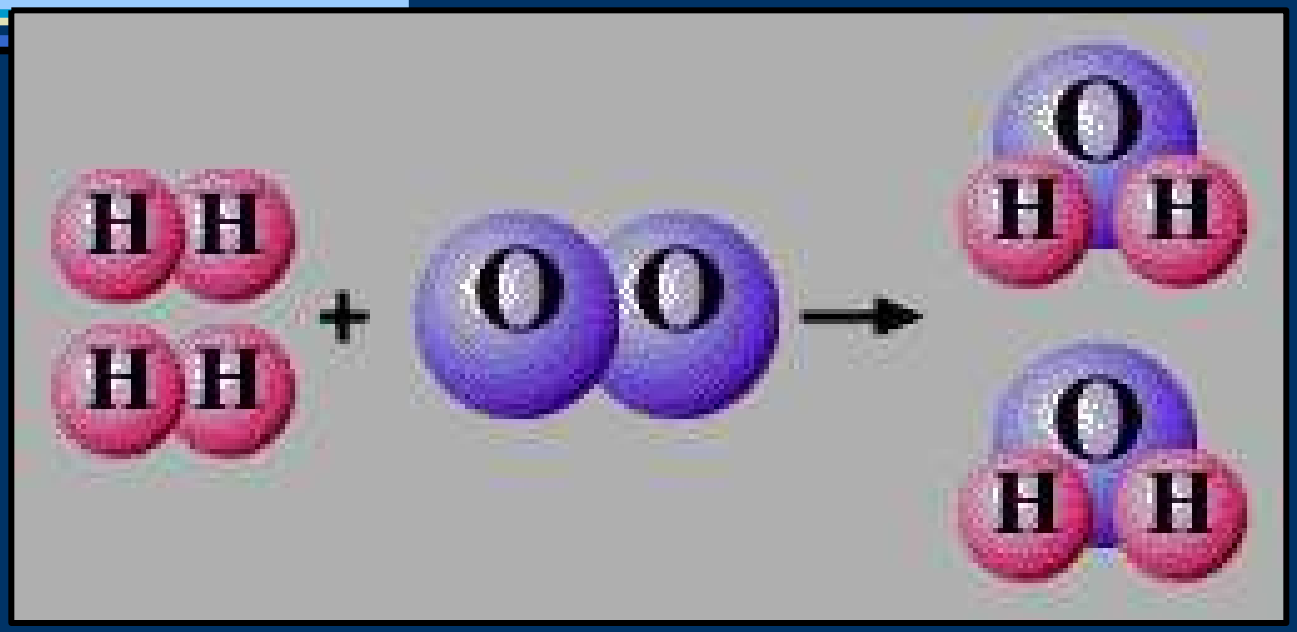
A. Chemical Reaction

- A change in which one or more substances are converted to different substances.

B.Law of Conservation of Mass

- In a chemical reaction, matter is not created or destroyed.
- Atoms can only be rearranged.
- Discovered by Lavoisier.

4H
2O



4H
2O

C. Chemical Equations

Aqueous lead(II) nitrate plus two units of aqueous potassium iodide produces solid lead(II) iodide and two units of aqueous potassium nitrate.

$$Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow PbI_2(s) + 2KNO_3(aq)$$

Coefficient - # of units of each substance

C. Chemical Equations

- **Describing Coefficients**:
  - individual atom = “atom”

$2Mg \Rightarrow$ 2 atoms of magnesium

  - covalent substance = “molecule”

$3CO_2 \Rightarrow$ 3 molecules of carbon dioxide

  - ionic substance = “unit”

$4MgO \Rightarrow$ 4 units of magnesium oxide

C. Chemical Equations

SYMBOL	MEANING
	produces, forms
+	plus, and
(s)	solid
(l)	liquid
(g)	gas
(aq)	aqueous (solid dissolved in water)
	the reactants are heated

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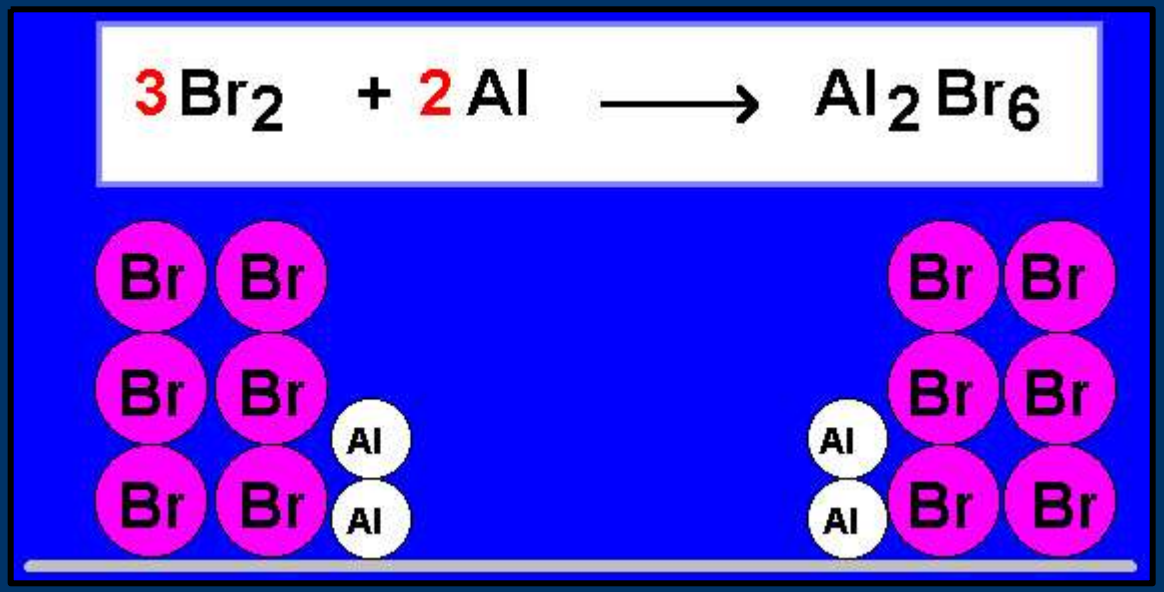
II. Balancing Equations



A. Steps for Balancing Equations

1. Write the unbalanced equation.
2. Count atoms on each side.
3. Add coefficients to make #s equal.
   Coefficient × Subscript = # Atoms
4. Reduce coefficients to lowest possible ratio, if necessary.
5. Double check atom balance!!!

B. Balancing Example

Aluminum and copper(II) chloride form copper and aluminum chloride.

$$2\,Al + 3\,CuCl_2 \rightarrow 3\,Cu + 2\,AlCl_3$$

2 ~~1~~ 2	Al	1
~~ ~~ 3		
3 ~~1~~	Cu	1
6 ~~2~~ ~~ ~~ 6	Cl	3

B. Balancing Equations Practice

Balance the following equations:

1) $HgO \rightarrow Hg + O_2$

2) $N_2 + H_2 \rightarrow NH_3$

3) $KClO_3 \rightarrow KCl + O_2$

4) $KBr + Cl_2 \rightarrow KCl + Br_2$

5) $CO + O_2 \rightarrow CO_2$

B. Balancing Equations Answers

1) $2HgO \rightarrow 2Hg + O_2$

2) $N_2 + 3H_2 \rightarrow 2NH_3$

3) $2KClO_3 \rightarrow 2KCl + 3O_2$

4) $2KBr + Cl_2 \rightarrow 2KCl + Br_2$

5) $2CO + O_2 \rightarrow 2CO_2$

C. Rates of Change

- To increase the rate (speed) of a reaction (in most cases):
  - Increase temperature
  - Increase surface area
  - Concentrated solutions
  - Increase pressure

*Massive, bulky molecules react slower

D. Catalysts

- A substance that speeds up a chemical reaction without being permanently changed itself.
  - They are **not** reactants nor products.
- *Enzymes* are proteins that are catalysts for chemical reactions in living things.

E. Inhibitors

- Substances that are used to combine with one of the reactants to prevent certain reactions from occurring.
- Ex: Food preservatives; lemon juice on cut fruit to keep it from turning brown.

F. Equilibrium Systems

- Some reactions are reversible.

  Ex: $CaCO_3$ + heat $\rightarrow$ CaO +CO_2

- Equilibrium results when rates balance.

When the reaction moving →, **equals the reaction moving ←*

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III. Types of Reactions

- Synthesis
- Decomposition
- Single-displacement
- Double-displacement
- Combustion

Five (5) Main Types of Chemical Reactions:

1) Synthesis
2) Decomposition
3) Single-displacement (replacement)
4) Double-displacement (replacement)
5) Combustion

A. Synthesis

- the combination of two (2) or more substances to form a compound.
- only **one** (1) **product** forms.

$$A + B \rightarrow AB$$

$$2P + 3Br_2 \rightarrow 2PBr_3$$

B. Decomposition

- a compound breaks down into two (2) or more simpler substances.
  - only **one** (1) **reactant**.

$$AB \rightarrow A + B$$

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

C. Single Replacement

- one element replaces another in a compound.
  - metal replaces metal (+)
  - nonmetal replaces nonmetal (-)

$$A + BC \rightarrow AC + B$$

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

D. Double Replacement

- ions in two compounds "change partners".
- cation(+) of one compound combines with anion(-) of the other

$$2KOH + CuSO_4 \rightarrow K_2SO_4 + Cu(OH)_2$$

E. Combustion

- Uses **oxygen** (O_2) as a reactant.
- Produces heat.
- Usually the products include water (H_2O) and carbon dioxide (CO_2).

$$AB + O_2 \rightarrow A + BO_2$$

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

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IV. Energy & Chemical Reactions

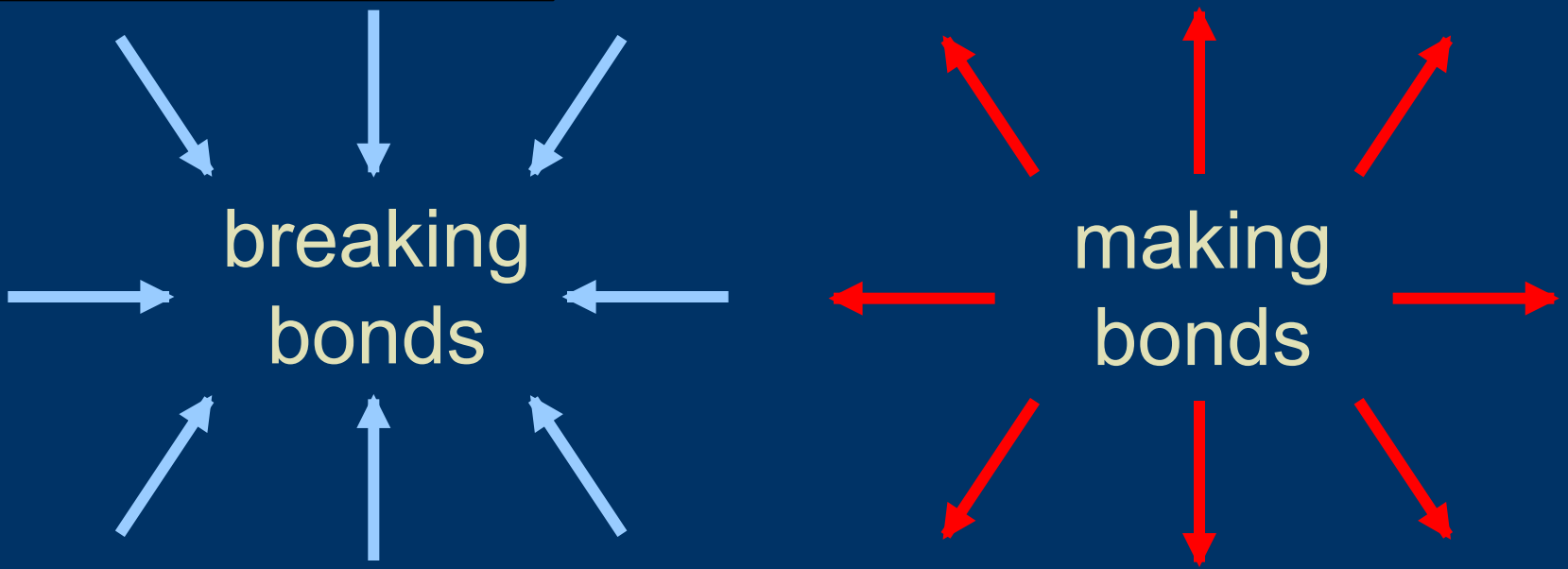
Signs of reactions
Energy Changes
Endothermic Reactions
Exothermic Reactions

5 Signs of a Chemical Reaction

- Production of a gas
- Production of a precipitant
- Change in color
- Change in odor
- Production of light or heat

A. Energy Changes

- During a chemical reaction…
  - energy is used to break bonds.
  - energy is released when new bonds are formed.



B. Endothermic Reaction

- reaction that **absorbs** energy.
- energy required to break old bonds outweighs energy released by making new bonds.

$$2Al_2O_3 + \text{energy} \rightarrow 4Al + 3O_2$$

process used to obtain aluminum from aluminum ore.

C. Exothermic Reaction

- reaction that **releases** energy.
- energy released by making new bonds outweighs energy req'd to break old bonds.

$$H_2(l) + O_2(l) \rightarrow H_2O(g) + \text{energy}$$

reaction that powers the space shuttle lift-off.

Identify each as endothermic or exothermic

1. Container gets warm
2. Container gets cold
3. Ice forms
4. Steam is released
5. $H_2 + CO_2 \rightarrow H_2O + CO + 394\ kJ$
6. $N_2O_4 + 57.2\ kJ \rightarrow 2NO_2$

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V. Law of Conservation of Mas

application
examples

Conservation of mass explained

- In all chemical reactions mass is conserved
- The mass of reactants MUST equal the mass of products.
- This fact can be used to determine the amount of a missing reactant or product.

Conservation of mass explained

Mass of reactants = mass of products

1) 14 g Al and 23 g O produces _____ grams of Aluminum oxide.

2)25 g water breaks down into 19 grams of oxygen and ____ g Hydrogen

3)_____ g water break down into 82 g oxygen and 21 g hydrogen.