Reactions
Chapter 11

Chapter 11: Reactions

A. Chemical Equations
B. Balancing Reactions
C. The Mole
D. Formula Weight
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F. Kinetics
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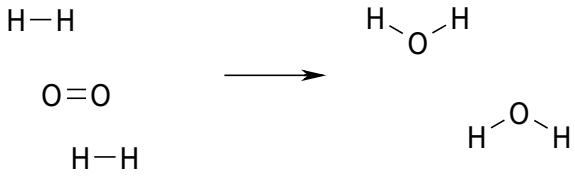
Chemical Equations

Chemical change involves a reorganization of the atoms in one or more substances.

The **Hindenburg** Reaction

- Reactants are on left, products to the right.
- Arrow indicates the change



A chemical equation

2 H_2 + O_2 → 2 H_2O

- Notice that the formula for the molecules is unchanged.
- To indicate that more than one molecule is required, use coefficients (shown in green).
- The equation is balanced.

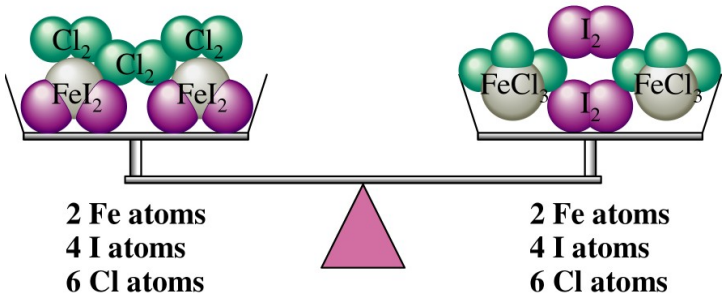
The Rules

- Change only the coefficients to balance the chemical equation.
- Balance one element at a time.
- Continue to balance the other elements in the same manner.
- Adjust coefficients to the lowest whole number common multiple.
- Check your answers.

Example

FeI_2 + Cl_2 → $FeCl_3$ + I_2

$2FeI_2 + 3Cl_2 \longrightarrow 2FeCl_3 + 2I_2$



Balancing Combustion Reactions

(fuel + oxygen gives carbon dioxide and water)

- Balance carbon first
- Hydrogen second
- Oxygen last
- Multiply by 2 if you need to**.**

___ C_3H_8 + ___ O_2 ➔ ___ CO_2 + ___ H_2O

More Balancing and Things to Avoid

___ C_4H_{10} + ___ O_2 ➔ ___ CO_2 + ___ H_2O

1 C_4H_{10} + 13/2 O_2 ➔ 4 CO_2 + 5 H_2O

2 C_4H_{10} + 13 O_2 ➔ 8 CO_2 + 10 H_2O

- Coefficients should always have the lowest whole number ratio.
- Never Change the subscripts. 8 CO_2 is not the same as C_8O_{16}.

Quantifying Chemical Reactions

Microscopic world	Macroscopic world
amu	grams
atoms or molecules	moles
1 carbon atom = 12 amu	1 mole of carbon = 12 grams
1 water molecule = 18 amu	1 mole of water = 18 grams

The mole (6.02 x 10^{23})

- A macroscopic version of the molecule defined so we can use the periodic table for the macroscopic and microscopic world.
- Defined as the number of atoms in exactly 12.0 g of carbon-12 isotope.
- This is number is called Avogadro's number after the Italian physicist Amedeo Avogadro (1776-1856).

Formula Weight

- The sum of the atomic weights of all the atoms in the molecular formula, whether ionic or molecular.
- Expressed in amu/molecule or grams/mole.
- Also called molecular weight, molar mass

Formula Weight

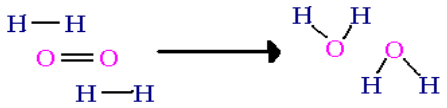
H_2O (2 x 1.0) + (1 x 16.0) = 18.0 g/mole

$Ca(OH)_2$ (1 x 40.1) + (2 x 1.0) + (2 x 16.0) = 74.1 g/mole

C_3H_8 (3 x 12.0) + (8 x 1.0) = 44.0 g/mole

A Chemical Reaction

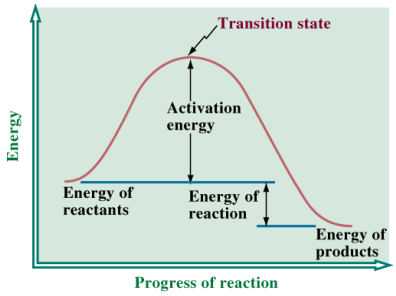
What is happening in a reaction?



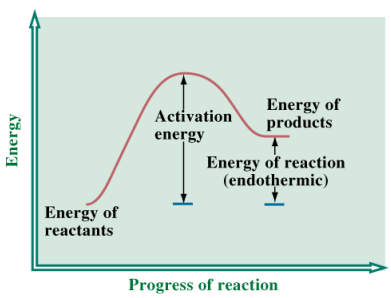
Three things are required for a reaction to occur:

- Molecules must collide.
- They must collide with enough energy to break old bonds so new ones can form.
- They must collide in the correct orientation.

Energy Diagram for exothermic reaction



Energy Diagram for endothermic reaction



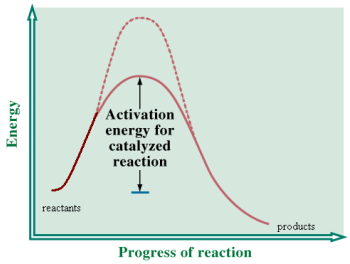
Kinetics (rate of reaction)

Three ways to increase the rate of a reaction

- Increase Concentration
  - Increases number of collisions
- Increase Temperature
  - Increases collisions & collisions that have enough energy to break old bonds
- Use a catalyst.
  - Lowers energy barrier (Activation energy)

A Catalyst

- A compound that increases the rate of a reaction without itself undergoing a permanent change at the end of the process.

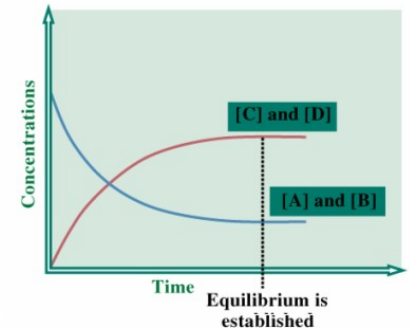


Chemical Equilibrium

- Most reactions are reversible, some are not.
- Reversible reactions are shown with a double arrow.
- An equilibrium condition exists when the rate of the forward reaction equals the rate of the reverse reaction.
- Equilibrium: The exact balancing of two processes that are opposite each other.
- Chemical equilibrium: A dynamic state where the concentrations of all reactants remain constant.

Concentrations as a solution reaches equilibrium

$aA + bB \leftrightarrows cC + dD$



Homework

1. Balance the following equation:__ C_5H_{12} + __ O_2 -> __ CO_2 + __ H_2O
2. Balance the following equation:__ C_6H_{14} + __ O_2 -> __ CO_2 + __ H_2O
3. __ $FeCl_3$ + ___ NaOH -> __ NaCl + __$Fe(OH)_3$
4. The combustion of a hydrocarbon fuel does not produce
   (A) H_2
   (B) H_2O
   (C) CO_2

Answers 1) 1,8,5,6 2) 2, 19, 12, 14 3) 1, 3, 3, 1 4) A